POTENTIAL OF BLOCKCHAIN TECHNOLOGY ON THE REAL ESTATE SECTOR

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MASTER OF SCIENCE

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A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN DIGITAL INNOVATION AND FINANCIAL TECHNOLOGY

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บทคัดย่อ

งานวิจัยนี้แสดงให้เห็นถึงความสามารถในการเปลี่ยนแปลงของเทคโนโลยีบล็อกเชนในภาคอสังหาริมทรัพย์ โดยเฉพาะอย่างยิ่งเมื่อพิจารณาถึงอุปสรรคที่เกิดจากการระบาดใหญ่ของ COVID-19 หลังจากภาวะการหยุดชะงักของอุตสาหกรรมอสังหาริมทรัพย์หลังเกิดวิกฤต บล็อกเชนได้กลายเป็นอีกแนวทางที่โดดเด่น โดยให้ความโปร่งใสที่เพิ่มขึ้น กำจัดตัวกลางการลงทุนแบบดั้งเดิม และแนะนำโทเค็นดิจิทัลเป็นกลไกการระดมทุนที่เป็นนวัตกรรมใหม่สำหรับภาคอสังหาริมทรัพย์ แต่ยังคงมีโครงการที่สำเร็จและที่ยังดำเนินการอยู่อาจเพราะเจออุปสรรคและแนวทางในการพัฒนา จึงตั้งสมมติฐานว่าแพลตฟอร์มสังคมออนไลน์มีความคิดเห็นที่มีค่าสำหรับการการพัฒนาโครงการให้ตรงกับความต้องการของนักลงทุนและบุคคลทั่วไป โดยพิจารณาจากการวิเคราะห์ความรู้สึกที่เป็นเชิงบวก โดยใช้เครื่องมือวิเคราะห์บนพื้นฐานภาษาโปรแกรม Python การศึกษานี้ ตรวจสอบความเชื่อมั่นจาก ‘Reddit’ ซึ่งเป็นเว็บไซต์โซเชียลมีเดียยอดนิยม โดยใช้ข้อมูลในช่วงหลังโควิด-19 สำหรับการวิเคราะห์ และมุ่งเน้นที่การลงทุนด้านอสังหาริมทรัพย์ด้วยบล็อกเชน นอกจากนี้ การวิจัยยังเจาะลึกถึงบทบาทสำคัญของโทเค็นดิจิทัลในการปรับปรุงการจัดหาเงินทุนด้านอสังหาริมทรัพย์ รวมไปถึงในส่วนการอภิปายผล ได้กล่าวถึงการสร้างโทเค็นจะเสนอแนวทางการบุกเบิกในการระดมทุนสำหรับนำมาใช้ในภาคอสังหาริมทรัพย์ได้อย่างไรและความท้าทายของโทเค็นมีอะไรบ้าง โดยพื้นฐานแล้ว การวิจัยนี้มีจุดมุ่งหมายเพื่อนำเสนอข้อมูลเชิงลึกเกี่ยวกับความท้าทายและโอกาสของการใช้เทคโนโลยีบล็อกเชนร่วมกับภาคอสังหาริมทรัพย์ โดยงานวิจัยนี้ทำหน้าที่เป็นข้อมูลอ้างอิงที่สำคัญอย่างยิ่ง ซึ่งเป็นแนวทางสำหรับพัฒนาโครงการที่เกี่ยวข้องกับภาคอสังหาริมทรัพย์ในอนาคตได้ต่อไป

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ABSTRACT

This research illustrates the transformative potential of blockchain technology in the real estate sector, particularly considering challenges stemming from the widespread outbreak of COVID-19. After the crisis-induced stagnation in the real estate industry, blockchain has emerged as a notable solution, enhancing transparency, eliminating traditional investment intermediaries, and introducing digital tokens as a novel fundraising mechanism for real estate. While some projects have found success and others continue to evolve, they may encounter obstacles and need to navigate new developmental paths. It's hypothesized that online social platforms offer invaluable insights that can help tailor projects to align with the preferences of investors and the broader public. This is particularly evident when focusing on positive sentiment, analyzed using Python-based tools. This study examines sentiments from 'Reddit', a renowned social media platform, utilizing post-COVID-19 data and emphasizing blockchain-powered real estate investments. Furthermore, the research delves into the pivotal role of digital tokens in revolutionizing real estate financing, elucidating how token creation introduces innovative methods for fundraising in real estate and the challenges associated with tokens. In essence, this research seeks to shed light on the challenges and opportunities inherent in merging blockchain technology with the real estate sector. This study stands as a vital reference, shaping the direction of future projects and endeavors within the real estate realm.

Keywords: Blockchain, Real Estate, Investment, Tokenization, Sentiment Analysis

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LIST OF ABBREVIATIONS

API	Application Programming Interface
DeFi	Decentralized Finance
DEX	Decentralized Exchange
ICO	Initial Coin Offering
IDO	Initial Dex Offering
CF	Cash Flow
EDA	Exploratory Data Analysis
NPV	Net Profit Value
PP	Payback Period
IRR	Internal Rate of Return
ROI	Return on Investment
APR	Annual Percentage Rate
KYC	Know Your Customer
NLP	Natural Language Processing
NLTK	Natural Language Toolkit
NBC	Naive Bayes Classifier
USD	United States Dollar
URL	Uniform Resource Locator

CHAPTER 1

INTRODUCTION

1.1 Rationale Background

In the face of the COVID-19 pandemic, the traditionally structured real estate sector encountered a slew of unforeseen challenges, transforming the ways properties were bought, sold, and managed. Historically, the real estate industry had been known for its complex and established systems, with issues like a lack of liquidity, limited transparency, accessibility barriers, transaction inefficiencies, and an over-reliance on centralization. These long-standing processes were not necessarily efficient or adaptable to swift change. However, as the pandemic persisted, it brought to light the urgent need for inventive strategies and solutions [1][2].

Prior to the advent of the COVID-19 pandemic, the real estate industry faced several challenges. Key among these were difficulties in securing funding, complexities associated with investments, and an intricate regulatory landscape [3]. The pandemic further exacerbated these challenges, prompting a paradigm shift in the traditional real estate sector. In the light of the mounting pressures and evolving demands, there has been an increased emphasis on innovation and the integration of new financial technologies. A noteworthy development in this regard has been the adoption of blockchain in real estate. This technology promises to alleviate several industry pain points, such as issues related to intermediaries, access to capital, and streamlining investments. FinTech innovations generate positive value for innovators, financial customers, and society. The benefits and determinants of FinTech applications vary across different financial sectors, highlighting the need for further exploration [4].

Furthermore, online social media has a significant impact on blockchain investment. Social media channels such as Twitter and Reddit are linked to the capitalization of blockchain startups, with higher search volume and positive sentiment [5]. Furthermore, online social networking combined with media reports improves investment efficiency in Chinese listed firms, particularly in non-state-owned enterprises

(SOEs) [6]. These findings highlight the importance of online social media in the context of blockchain investment, as it can provide valuable information, influence investor decisions, and enhance investment efficiency.

However, there is a clear need for tools and resources to guide developers in making informed decisions and ensuring that projects align with the broader needs and trends of the real estate industry. The real estate development process is complex and unpredictable, making it crucial for developers to have methodologies that can effectively model and understand information flow. Incorporating sustainability concerns into decision-making processes is becoming increasingly important, particularly in the real estate industry where projects have a significant impact on the environment and society. Developers' optimal development timing can vary based on their heterogeneity and different marginal costs, highlighting the need for strategies that consider these factors [7][8].

Given the aforementioned context, it becomes imperative to devise an instrument capable of gauging social media sentiments, particularly those highlighting the advantages or challenges associated with the integration of blockchain into the real estate sector. By scrutinizing these assets, a comprehensive understanding of an individual's genuine requirements can be attained. This data will subsequently serve as foundational evidence to guide the progression and refinement of the project.

Considering the pervasive influence of social media on public perception, this research seeks to develop a tool for sentiment analysis. Specifically, the tool aims to discern and categorize keywords and examine the interrelationships between them in social media commentary. Furthermore, it intends to differentiate sentiments, ascertaining whether the emergent sentiment is of a positive or negative nature. Such a tool has significant potential utility for stakeholders and developers within the real estate industry.

Additionally, given the discernible knowledge gap among the general populace concerning investment in the real estate sector via blockchain, this research elucidates the mechanism of digital tokenization. By leveraging a decentralized platform, it offers a streamlined approach to investment and will critically evaluate the prospective merits and demerits associated with such investment modalities, thereby providing a comprehensive overview for potential investors.

1.2 Purpose of the Study

The objectives of this thesis are as followed:

1.2.1 To analyze the challenges and difficulties of pain points in current real estate projects that prompt the employ of blockchain technology.

1.2.2 To examine tools for effective sentiment analysis in social media discourse pertaining to the real estate sector. This involves identifying and categorizing key keywords, analyzing relationships within the discourse, and distinguishing between positive and negative sentiments.

1.2.3 To illustrate the mechanics and advantages of utilizing digital tokens as an investment strategy in the real estate sector.

1.2.4 To provide guidance on decision-making, highlighting the benefits and potential challenges of blockchain-based real estate investment methods.

1.3 Advantages of the Study

1.3.1 The study explores how blockchain technology and digital tokens could revolutionize real estate investments.

1.3.2 Sentiment analysis on social media platforms provides insights into the benefits of using blockchain-based digital tokens in real estate, aiding informed investment decisions, and practical considerations for implementing blockchain in real estate are discussed.

1.3.3 Integration of smart contracts enhances security in real estate fundraising processes, ensuring investor safety.

1.3.4 Digital tokens offer advantages like fractional ownership, asset tokenization, efficient fundraising, and streamlined property transactions, making real estate investments more accessible.

1.3.5 Blockchain technology improves property management, enhancing transparency and overall efficiency in the real estate sector.

1.4 Scope of the Study

This document investigates the relationship between social media sentiment on Reddit and the perspectives of users and investors pertaining to real estate blockchain, especially in the post-COVID-19 era. Moreover, it delves into the challenges and impediments faced by projects that incorporate blockchain technology within the real estate sector. The research particularly emphasizes the utilization of IDO digital tokens for fundraising, set within the context of a simulated real estate housing project.

1.5 Operational Definition

1.5.1 Decentralization

Decentralization refers to the distribution of authority, decision-making, or control from a central entity or governing body to multiple independent or semi-autonomous units, individuals, or nodes within a network or organization. It aims to reduce reliance on a single central authority and empower local or distributed entities to make decisions or take actions based on their specific functions or responsibilities [9].

1.5.2 Blockchain

A 'blockchain' is a type of data structure that allows individual digital transactions to be shared with anyone. It is like a chain, linking the next data group to everyone. It's essential that everyone on the network knows who owns and has rights to that information. When a block of data is saved in the blockchain, it becomes very difficult to change. When someone wants to add information, anyone in the network with a copy of the blockchain can run algorithms to verify transactions. This new transaction will be permitted only when most people on the network agree that it is correct [10].

1.5.3 Smart contract

A smart contract is a self-executing contract with the terms of the agreement directly written into code. It operates on a blockchain and automatically executes and enforces the agreed-upon conditions and actions when predefined criteria are met [11].

1.5.4 Token

A token in the context of blockchain and cryptocurrency is a digital representation of an asset, utility, or value that can be transferred, stored, or traded within a blockchain ecosystem. Tokens can serve various purposes, including access to services, voting rights, or representing ownership of physical or digital assets [12].

1.5.5 Fundraising

Fundraising refers to the process of collecting funds or financial resources, typically through donations, contributions, or investment, to support a specific cause, project, organization, or initiative. It is a crucial activity for non-profit organizations, startups, and various ventures to secure the necessary capital for their operations and growth [13].

1.5.6 Sentiment Analysis

Sentiment analysis, also known as opinion mining, is the process of using natural language processing and computational techniques to determine and evaluate the sentiment, emotional tone, or subjective opinion expressed in text data, typically in the form of reviews, social media posts, or comments. It involves classifying the text as positive, negative, or neutral to gain insights into public opinion, customer feedback, or user sentiment about a particular topic, product, service, or event [14].

1.5.7 Python

Python is a high-level, interpreted programming language known for its clear syntax, readability, and versatility. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python was developed by Guido van Rossum and first released in 1991[15].

1.5.8 NLTK

The Natural Language Toolkit (NLTK) is a leading platform for building Python programs to work with human language data. It provides easy-to-use interfaces to over 50 corpora and lexical resources such as WordNet, along with a suite of text processing libraries for classification, tokenization, stemming, tagging, parsing, and semantic reasoning. NLTK is intended to support research and teaching in NLP or computational linguistics [16].

1.5.9 Real Estate

Real estate refers to tangible property, including land and any structures or improvements attached to it, such as buildings, houses, and commercial spaces. It encompasses both residential and commercial properties and is a significant asset class, subject to various uses like ownership, leasing, and development [17].

1.5.10 Initial DEX Offering (IDO)

Initial DEX Offering (IDO) refers to a method of token fundraising on a decentralized exchange (DEX). It represents an evolution of initial coin offerings (ICOs) and security token offerings (STOs). In an IDO, the project's tokens are instantly available on the DEX, allowing for immediate trading, providing liquidity, and potentially reducing the risks of price manipulation [18].

CHAPTER 2

LITERATURE REVIEW

In this research study, the author investigated on the topic of 'Potential of Blockchain Technology in the Real Estate Sector' to obtain a comprehensive understanding of the research. As a result, the author collected theoretical data and relevant research on this subject, categorizing it into three parts as follows:

2.1 The context of the study

- 2.1.1 Definition of blockchain in real estate
- 2.1.2 Real estate sector in the before COVID-19
- 2.1.3 Real estate sector in the post-COVID-19
- 2.1.4 Reddit social media platform

2.2 Theoretical concepts

- 2.2.1 Python-based web scraping tools
- 2.2.2 Sentiment analysis
- 2.2.3 Blockchain
- 2.2.4 Smart contract
- 2.2.5 Token offering

2.3 Literature review and related research

2.1 The context of the study

2.1.1 Definition of blockchain in real estate

Blockchain in real estate" refers to the application of blockchain technology to streamline, secure, and transform processes within the real estate sector. This technology offers a decentralized ledger system that significantly improves transparency, reduces fraud, and expedites transactions by eliminating the need for intermediaries. In real estate, blockchain facilitates property transactions, title management, and more efficient leasing

processes. Tokenizing real estate assets through blockchain provides opportunities for fractional ownership, enabling investors to purchase portions of properties. This democratizes real estate investment, making it accessible to a broader audience [19]. Moreover, the use of smart contracts on the blockchain can automate rental and sale agreements, ensuring conditions are met and facilitating immediate, secure payments [20]. The decentralized nature of blockchain aids in authenticating property records, streamlining title transfers, and verifying ownership [21]. As blockchain's integration in the real estate sector matures, it offers the potential to transform the industry, introducing heightened trust, efficiency, and inclusivity [22].

2.1.2 Real estate sector in the before COVID-19

Prior to the outbreak of the Covid-19 pandemic, the real estate sector had been experiencing gradual shifts in its traditional investment mechanisms. Smith and Searle [23] pointed out that the industry predominantly relied on paper-based processes, centralized databases, and manual verifications, involving several intermediaries such as brokers, bankers, and attorneys in the transaction process. Furthermore, Liu et al. [24] highlighted that while these traditional methods were established, they often led to inefficiencies, delays, and potential inaccuracies in property data recording and transactions.

With the burgeoning digital era, numerous industries began to explore the potential of blockchain technology, with the real estate sector being no exception. Petrov[25] discussed how blockchain promised to make property transactions faster, more transparent, and more secure. The decentralized ledger characteristic of blockchain, emphasized by Tan et al. [26], held the potential to significantly reduce the need for intermediaries, thus simplifying the transaction process. Additionally, White [27] noted that this technology could guarantee the accuracy of property titles, eliminating the risks associated with fraudulent claims or disputes.

From an investment perspective, the tokenization of real estate assets began gaining traction, paving the way for increased liquidity, and democratizing real estate investments. Zhang and Wen [28] posited that through tokenization, smaller investors could venture into the market by acquiring fractional ownership of properties. Davis and Pryke [29] observed in their research that this not only stimulated capital flow but also

diversified investment portfolios. In a similar vein, Torres et al. [30] suggested that tokenized assets could be traded on secondary markets, thereby enhancing liquidity in what had traditionally been an illiquid market.

Despite the palpable enthusiasm around the potential of blockchain, the industry confronted challenges in its adoption. Regulatory uncertainty was a notable barrier, with regulators grappling to align with the swift pace of technological advancements, as elaborated by Johnson [31]. Moreover, even as blockchain promised transparency, Gray and Larsson [32] raised concerns pertaining to privacy and the potential vulnerability of public ledgers.

2.1.3 Real estate sector in the post-COVID-19

The COVID-19 pandemic has left a significant mark on the real estate market. There was a substantial drop in global real estate capital flows in 2020, but a strong rebound was observed in 2021 [33]. In China, the epidemic had far-reaching effects across the entire real estate sector, influencing investment, sales, and regional development plans [34]. In Turkey, the pandemic exposed the limited ability of real estate investment tools to hedge against inflation, emphasizing the importance of implementing measures to address inflation [35]. In the United States, researchers utilized machine learning and ensemble methods to assess the pandemic's impact on housing prices. Among the models used, “LightGBM” demonstrated superior predictive capabilities for the real estate market [36]. Real estate companies like Evergrande Group and Greenland Group had to diversify their sales channels in response to the pandemic, as it influenced both the number of prospective homebuyers and the revenues of housing enterprises [37]. Moreover, the real estate market is a sector that involves the buying, selling, and renting of properties, including land, buildings, and homes. The COVID-19 pandemic had a significant impact on the global real estate market, leading to changes in property prices and preferences for housing structures and locations [38].

The outlook for the real estate industry post-COVID-19 is anticipated to be influenced by several factors. The pandemic has had a notable impact on the real estate market, resulting in decreases in sales and revenue. Nevertheless, there are signs indicating that the sector will rebound and enter a new phase of development [39]. The recovery is expected to be more rapid in second-tier cities due to their strong urban

infrastructure, large populations, housing demand, and economic resilience [40]. Real estate firms should explore diverse sales channels to adjust to the evolving market conditions [41]. Furthermore, investors should consider emerging risk factors like concerns about inflation, geopolitical tensions, worries about economic growth, rising debt costs, and supply chain challenges when making investment choices. Therefore, the potential of the real estate industry post-COVID-19 hinges on its ability to adapt to the new economic landscape and implement effective strategies for recovery and expansion.

2.1.4 Reddit social media platform

During the COVID-19 pandemic, Reddit, a widely used social media platform, experienced significant shifts in user behaviour and content dynamics. The pandemic profoundly influenced the platform's overall activity, leading to a marked rise in user engagement. This spike in activity spanned diverse Reddit communities and languages, not being confined to any demographic. A noteworthy observation was that long-standing users began incorporating COVID-related terms and phrases into their discussions and posts more frequently, underscoring the escalating significance of pandemic-related topics in online conversations. Alongside behavioural changes among existing users, the pandemic ushered in a wave of newcomers to Reddit. These new users demonstrated patterns of interests, engagement levels, and retention rates that diverged from those who had joined the platform pre-pandemic. This contrast underscored the unique challenges and opportunities stemming from this new user influx [42].

Researchers delved into Reddit's content, with a keen focus on obesity-related discussions. They discerned distinct psycholinguistic features across various content categories, such as misinformation, stigma, positivity, and factual data. The nuanced variations in language and tone of these categories signalled the potential for the development of automated tools. Such tools could pinpoint harmful or questionable content, aiding in cultivating a safer and more positive online space with reduced human oversight [43]. Reddit is a social media platform that has been studied in various contexts. Reagle found that many authors delete their submissions on Reddit, with motivations including privacy concerns and resolving their issues [44]. Botzer et al. focused on moral judgments in the subreddit and found that positive moral valence in posts led to more upvotes, certain subreddits attracted more negative judgments, and men and older users

were judged negatively more often [45]. Fottner et al. created a dataset of sentiment information from financial subreddit posts, which can be used for financial forecasting and sentiment analysis [46]. Liu et al. used Reddit to identify language markers associated with different symptoms of depression and developed prediction models based on linguistic features and embeddings to detect specific symptom discourse [47] [Fig 2.1].

Figure 2.1 Reddit Social Media Platform [48]

In summary, the COVID-19 pandemic left an indelible mark on Reddit, shaping user behaviour, engagement levels, and the nature of discussions. The research underscored that certain psycholinguistic aspects of content, especially around delicate topics, could be harnessed for automated moderation, potentially bolstering the platform's capacity to foster a constructive and safe online community.

2.2 Theoretical concepts

2.2.1 Python-based web scraping tools

Python is widely used for creating web scraping tools because it bears a resemblance to human language and offers an extensive library ecosystem [49]. Numerous academic papers have addressed Python's role in web scraping. Xie, for instance, delves into the implementation of web crawlers in Python, highlighting its popularity and efficiency in saving time and extracting data from web pages [50].

Python's abundant libraries and coding efficiency render it highly suitable for web scraping and the extraction of desired information from websites [51].

Scraping data from Reddit using Python involves analysing the sentiments of users' comments on posts and predicting the divergence of sentiments towards news articles [52]. This analysis provides insights into user behaviour, interaction dynamics, and bias towards different issues on the platform [53]. Additionally, sentiment analysis can be used to determine public opinions on various topics by mining data from social networking sites like Reddit. The methodology includes data gathering, cleaning, analysis, and visualization using Python libraries. The Python programming language, along with the BeautifulSoup library, can be used to build a web scraping application for extracting data from e-commerce websites. The application can help companies identify unauthorized sellers and report violations. Python's extensive community and library resources make it suitable for web scraping tasks [54].

2.2.2 Sentiment analysis

Sentiment analysis, often referred to as opinion mining, involves extracting and evaluating sentiments and opinions expressed within a text. Pang and Lee were among the pioneering researchers who delved into the intricate task of discerning sentiment orientation in movie reviews, emphasizing challenges related to subjectivity and context [55]. With the proliferation of social media platforms, sentiment analysis has become an essential tool for businesses and researchers to gauge public sentiment about products, services, or topics of interest. Loria highlighted that natural language processing (NLP) tools and algorithms have been fundamental in automating sentiment extraction from vast textual data [56]. In addition, the natural language toolkit, often abbreviated as NLTK, comprises a collection of libraries and software programs designed for both symbolic and statistical natural language processing (NLP) in English. This toolkit is implemented in the Python programming language and was originally developed by Steven Bird and Edward Loper at the University of Pennsylvania's Department of Computer and Information Science. NLTK includes graphical demonstrations and sample datasets. Additionally, it comes with a comprehensive book that elucidates the fundamental concepts underpinning the language processing tasks that the toolkit supports, along with a practical guide [57]. NLTK is primarily designed to facilitate research and education in

NLP and closely related fields, such as empirical linguistics, cognitive science, artificial intelligence, information retrieval, and machine learning. It has proven to be a valuable resource in educational settings, serving as both a teaching aid and a self-study tool. Furthermore, NLTK serves as a versatile platform for the development and prototyping of research systems. Currently, it is used in courses at 32 universities in the United States and 25 countries worldwide. The functionalities of NLTK encompass classification, tokenization, stemming, tagging, parsing, and semantic reasoning [58]. However, due to the dynamic nature of language, idiomatic expressions, and the use of sarcasm, sentiment analysis remains an evolving challenge. Kumar and Sebastian pointed out that integrating deep learning techniques, especially neural networks, has improved sentiment detection accuracy over traditional machine learning models [59]. Beyond business, sentiment analysis has been employed in political arenas as well. Tumasjan et al. showcased its applicability in predicting political election outcomes based on Twitter data [60]. Despite such advancements, Cambria et al. noted ongoing debates about the effectiveness of sentiment analysis in certain complex contexts, emphasizing the need for more context-aware sentiment analysis tools [61].

2.2.3 Blockchain technology

Blockchain-related documents have written that the technology of the past few years [62] in which it has had an impact on the traditional digital fundraising system (crowdfunding) because "blockchain" is a new financial transaction method [63] that allows digital asset transfers (Peer-to-Peer) without intermediaries [64], in which the structure and functionality of blockchain is a decentralized public account [65] that stores all interpersonal transactions. A blockchain operates in a decentralized network environment consisting of processes such as digital signatures, hash encryption, and a decentralized consensus algorithm that validates all transactions on the network [66]. Moreover, "blockchain" is a technology created to support the digital currency that operated from 2008 to 2009, and the world's first digital currency is "Bitcoin" by Satoshi Nakamoto [Fig. 2.2].

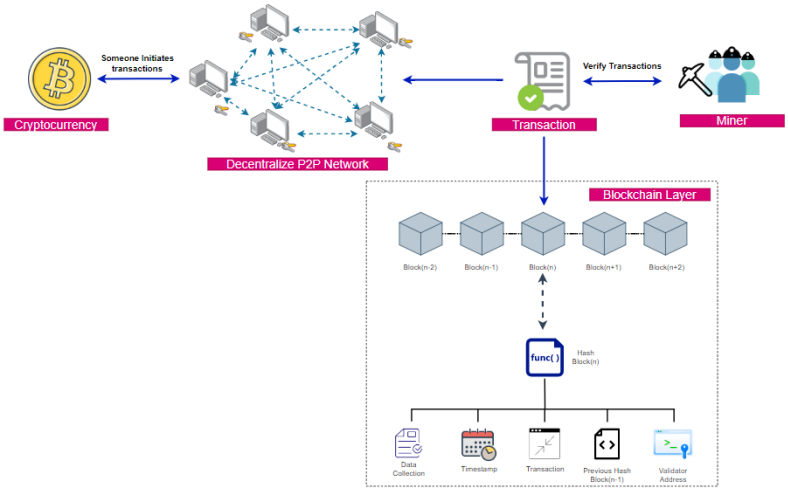


Figure 2.2 Blockchain Architecture of Bitcoin [67]

The blockchain is the place which data transactions are stored in blocks that form a chain shared by all network users. In addition to transactions, each block includes a hash pointer created by hash functions, which transfers the entire block's contents to the hash pointer. Tschorsch and Scheuermann [68] reported that to save storage space, the transactions in a block could be organized into a “Merkle tree”. The primary purpose of hash functions is to ensure the tamper-proof nature of the chain, preventing any unauthorized access or tampering.

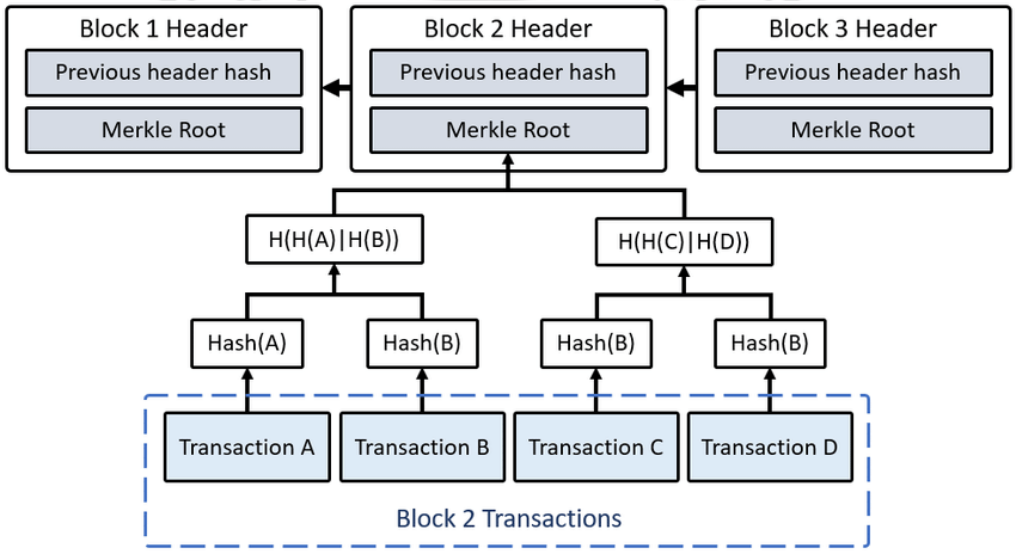


Figure 2.3 Structure Merkle Root of Blockchain [69]

The blockchain is an ever-growing series of blocks, interconnected through cryptographic hash pointers. As illustrated in Figure 2.3, transactions in this framework are sorted into Merkle trees, with each block header connected to its predecessor. Every block in the chain contains a batch of transactions, a timestamp, and a distinct cryptographic hash of the preceding block. Altering data within a block modifies its hash, thereby making the entire chain void. Transactions are added to blocks at regular intervals, with the mining time for a block differing based on its type; for example, Bitcoin takes an average of 10 minutes. Nodes uphold the structure of the blockchain, verifying transactions and occasionally assisting in the creation of new blocks. The blockchain's primary attributes are its decentralized nature, which makes data tampering difficult owing to the requirement for network agreement, and its capability to record and transfer data securely and transparently. In summary, a blockchain serves as a secure, decentralized digital record with the potential to innovate numerous sectors by boosting efficiency and reducing the need for middlemen [69].

2.2.4 Smart contract

In the context of [70], it was mentioned that a smart contract was a computer program capable of automatically executing conditions once the contract's terms were met. These conditions or events had been specified in advance, eliminating the need for an intermediary. The implementation of smart contracts had the potential to address issues of distrust, fraud, and contract misrepresentation that often arose when parties had differing interpretations of the contract. However, when applying Smart Contracts in conjunction with related processes, it was essential to understand the strengths and limitations of the Smart Contracts involved to ensure their proper implementation. The strengths of smart contracts were as follows:

1. Security: Smart Contracts developed using Blockchain technology were distributed to other network members, ensuring that they couldn't be lost or altered in their working conditions without permission.

2. Automation: The Smart Contract automatically executed the agreement as soon as the contract conditions were met, which had been specified in advance, without the involvement of any intermediaries.

3. Standardization: Implementing Smart Contracts in any system meant that the system had to operate under the same standard conditions or agreements defined in the Smart Contract throughout the system.

2.2.5 Token offering

Key strengths of Blockchain included its decentralization, transparency, immutability, and the ability of users on the network to verify transactions. [71] As Alassaf, et al., had said, "Blockchain technology was playing a very challenging role." Therefore, the adoption of Blockchain as a tool was used to study some of the ways it could be integrated with crowdfunding, such as the "ICO" process, which used "digital tokens" for fundraising in the project's startup period. An ICO, or "Initial Coin Offering," was a fundraising tool for businesses that were looking to invest in startup projects, new products, or new services by creating coins or tokens through Smart Contracts on blockchain technology and selling them to interested parties who believed that the project they were investing in would become successful. In addition, tokens might have some facilities for using the goods or services offered by the company or might represent a stake in the company or project [72] [Fig. 2.4].

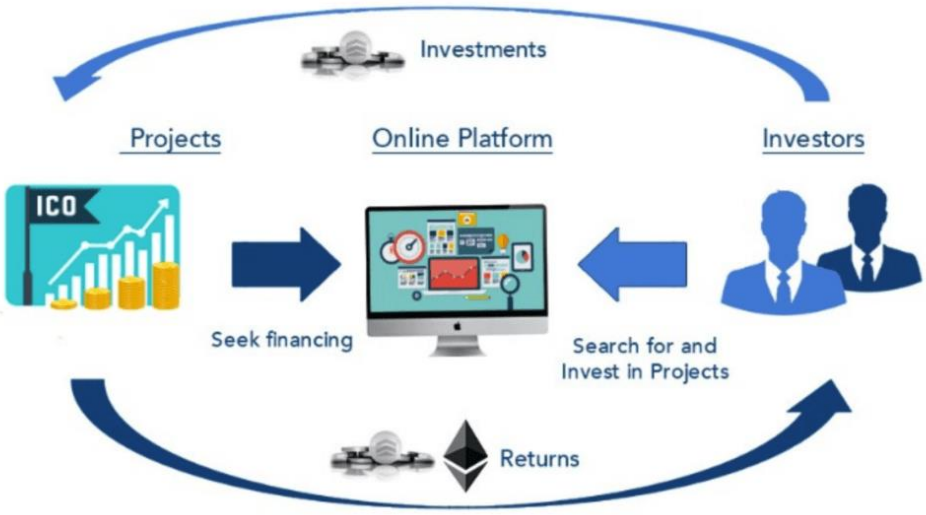


Figure 2.4 How Does the ICO Work [73]

Later, there was a method called "Initial Decentralized Exchange Offering," or "IDO," which was essentially an old notion in the crypto world that had been applied to a new industry. This was seen not only with ICOs in 2017 but also with "IEOs," or Initial

Exchange Offerings, in 2019. As a result, the rise in the number of new IDO projects was unsurprising. Apart from their unrivaled level of decentralization compared to ICOs or IDOs, the utilization of governance tokens was what distinguished IDOs, which was a permissionless, decentralized idea that transformed the funding landscape. The enrollment of coins or tokens on a decentralized liquidity market was what happened when a project established an IDO. It was a cryptocurrency asset exchange that traded tokens like cryptocurrencies and stable coins using liquidity pools [74].

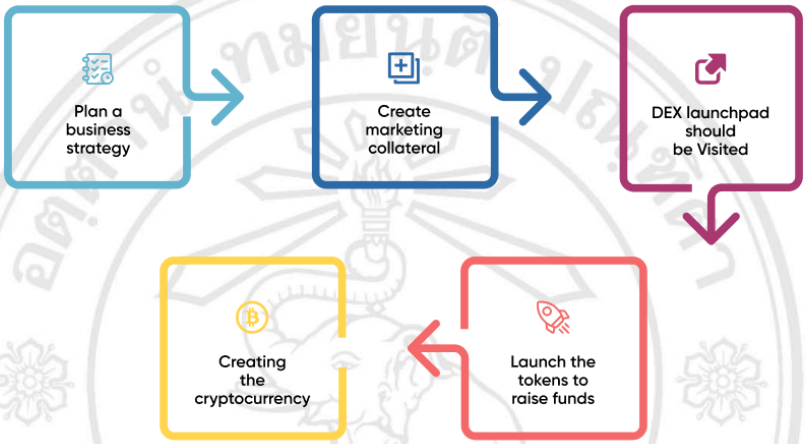


Figure 2.5 Steps to Launch an IDO [75]

The steps and processes of IDO are presented in Figure 2.5. This section guides users through the step-by-step process of launching their IDOs. To build a successful IDO, users must understand how to establish a coin, as detailed below [75]:

Step 1: Develop a business plan tailored for issuing a token offering on a Decentralized Exchange, often referred to as "DEX." This plan should address the problem the project aims to solve, outline funding needs, specify the chosen blockchain, describe a general marketing strategy, and provide a roadmap for sustaining the project.

Step 2: Produce marketing collateral. At a minimum, launching an IDO requires a website and a white paper. A well-designed and branded website can significantly boost investor confidence.

Step 3: Approach a DEX launchpad. If the project meets the platform's criteria, which typically involves consensus and a whitelist, the IDO would be accepted.

Step 4: Create the cryptocurrency. While producing tokens is accessible to anyone with some technical expertise and strong marketing skills, the real challenge lies in convincing investors of the project's real-world value and utility. Once the IDO and Token Generation Event (TGE) conclude, the DEX lists the token for trading.

Step 5: Launch the token to secure immediate funding. The project team creates a token pool, which is a reserve where investors commit funds in anticipation of their tokens. After the Token Generation Event (TGE), which follows the IDO shortly, investors receive their tokens.

2.3 Literature review and Related research

Khalid et al.'s [76] systematic review examined blockchain technology's role in the real estate sector. It explored various use cases, including property transactions, land registration, and smart contracts, as well as the potential future paths of blockchain in real estate. Ciriello [77] explored the concept of tokenizing real estate assets using blockchain technology, highlighting potential benefits such as increased market liquidity, fractional ownership, and enhanced transparency. In a similar vein, Saari et al. [78] conducted a systematic review focused on the application of smart contracts in real estate transactions, an overview of the benefits and implementation issues associated with smart contracts in the context of property transfers, rental agreements, and escrow services. The potential of smart contracts to improve transaction efficiency and reduce fraud was discussed. Baptista et al. [79] provided a thorough review of the current landscape and future directions of blockchain technology in the real estate industry. Several benefits of this technology, including increased transparency, cost reductions, and enhanced security were reviewed. Issues around scalability, regulatory frameworks, and data protection were also investigated. Moreover, an integrative reviewed to examine the potential impact of blockchain technology on the real estate industry. Several benefits of blockchain were mentioned, including increased trust, faster transactions, and reduced intermediation. Importantly, research gaps were identified, and a future research agenda was proposed for exploring blockchain's real estate implications. Sharma et al. [80] examined various applications of smart contracts across platforms and sectors, including education, voting, real estate, entertainment, IoT, supply chain, and healthcare. The deployment of these

applications and proposed potential solutions for the future were discussed. Timuçin and Biroğul [81] focused on the use of Consensus-oriented Smart Contracts (CoSC) in property transactions within the real estate industry. CoSC could enhance efficiency, transparency, and trust in multi-party transactions. Hammad et al. [82] acknowledged the potential of blockchain technology to democratize real estate investing through tokenization, which enables fractional ownership and provides accessibility to smaller investors. Shahaab et al. [83] discussed the "Registration of Overseas Entities and Beneficial Owners" (ROEBO) bill in the context of real estate, exploring how blockchain could facilitate information sharing among organizations. Similarly, Pande et al. [84] discussed blockchain applications in real estate, including fractional ownership sales, property registration databases, and commercial property purchase assistance. For instance, they proposed the Bitland project, which aimed to develop a blockchain-based network for managing investment properties. Tan and Nguyen [85] introduced the Real Estate Transaction Trace (RETT) system on the Ethereum Blockchain platform, designed to manage and track real estate transactions in Vietnam. The system's potential through a prototype was demonstrated. Laarabi et al. [86] conducted a study to evaluate the use of smart contracts in real estate, providing a classification of prevalent research topics and potential applications. Belov and Slastnikov's [87] studied a blockchain-based system for electricity consumption accounting in real estate, suggesting improvements in energy supply management. Varfolomeev et al. [88] emphasized the potential of blockchain in facilitating reliable and secure smart contracts for real estate rentals. Veuger [89] emphasized the potential of blockchain for secure and transparent property transactions and land registrations. Konashevych [90] presented a comprehensive analysis of blockchain's role in land registration and property rights protection. Pankratov et al. [91] concluded that blockchain adoption in real estate could enhance transaction integrity, streamline settlements, and increase fund security, providing insights into blockchain's future role as a valuable tool in the industry. Wouda and Opdenakker [92] suggested that a blockchain-based infrastructure could enhance real estate transactions by offering secure and transparent data storage and transfer by creating a digital audit trail for office building transactions. Proskurovska et al., [93] explored the transformative potential of blockchain in the residential real estate sector, including its impact on public and private cross-sector relationships. Chow and Tan [94] highlighted blockchain's facilitation of

tokenization for physical real estate assets, aiming to reduce costs and digitize properties.

Notably, platforms like RealX [95] [Fig. 2.6], operated by InnovestX, was a post-COVID-19 platform that leveraged blockchain technology to revolutionize real estate investments. It served as a decentralized marketplace, empowering users to engage in various activities such as buying, selling, and fractional ownership. RealX's primary goal was to democratize real estate investing by facilitating smaller capital investments and enhancing accessibility.

Figure 2.6 RealX Investment Token [96]

SiriHub Token [97] [Fig. 2.7] was a digital investment token offered through a digital token offering system (ICO Portal) called "XSpring." It demonstrated outstanding investment potential as a digital investment token based on real estate income streams (Real Estate-Backed ICO), building investor confidence.

The offering price started at 10 baht per token, with a total offering amount of 240 million tokens, which were divided into two groups as following, 1. "SiriHub A," with an offering value of 160,000,000 tokens, equal to 1,600,000,000 baht. 2. "SiriHub B," with an offering value of 80,000,000 tokens, equal to 800,000,000 baht. Each group of "SiriHub" digital token holders had different details regarding their rights and status, as stated in the prospectus. As for the benefits that SiriHub digital token holders received during their token holdings, the digital token issuer intended to allocate a quarterly share of revenue to its digital token holders.

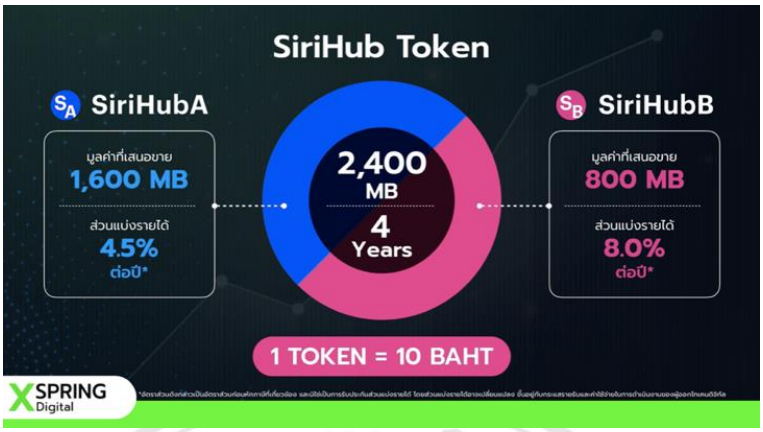


Figure 2.7 SiriHub Investment Token [98]

Moreover, the Empowa project, which is a decentralized property development platform on the Cardano network that focuses on aiding marginalized groups, it integrates emerging technology and sustainable construction to create affordable and eco-friendly homes in Africa. By promoting decentralized financing and tackling biases in financial access, Empowa not only generates wealth through property but also boosts investors' portfolios and aims to revolutionize the underserved African mortgage market [99].

2.4 Summary of the Literature Review

This literature review focused on how blockchain technology could transform the real estate industry. For a long time, the real estate sector has predominantly relied on traditional methods. These methods often resulted in slow processes and occasional inaccuracies. However, with the advent of blockchain, there is an opportunity to make transactions more transparent, secure, and efficient.

The COVID-19 pandemic brought big changes, and the review looked at how the real estate industry managed during this tough time. The pandemic made many businesses think about using more digital tools and methods.

Reddit, a widely recognized online platform, was proven in this review. The platform harbors an abundance of information originating from its diverse user base, offering a wealth of insights and perspectives that are crucial in providing a holistic view of the discussed topic. Its multifaceted forums, often referred to as 'subreddits,' encapsulate various discussions, experiences, and viewpoints shared by individuals

across the globe, rendering it a valuable resource for garnering nuanced understandings of prevailing sentiments and emerging trends within the context under scrutiny.

The review also discussed the value of understanding and using sentiment analysis, which means figuring out how people feel based on what they write online. Python can help with this by quickly checking lots of data from the internet. The review also explained ideas like blockchain, smart contracts, and token offerings. These tools can make buying and selling things, like houses, simpler and safer.

Overall, the review showed how important it is for businesses to understand and use new technology. For example, the real estate industry can benefit from blockchain, and researchers can learn a lot from online platforms like Reddit. As the world becomes more digital, it's essential for everyone to understand and use these new tools and ideas.

CHAPTER 3

METHODOLOGY

3.1 Conceptual framework

The framework for study and experimentation, which is especially adapted to the changing real estate market, is further explained in this section. The study's initiation phase involves an extensive literature review, meticulously examining the myriad challenges and significant transformations that the industry underwent during the years 2020–2023, a period predominantly influenced by the post-COVID-19 era. The choice of this timeframe was intentional and informed by the findings from the literature review. It was observed that this era marked a pivotal point in history, characterized by a rapid and widespread shift towards digital technologies and methodologies across the globe. This shift was not just a transient reaction to the pandemic but a profound and enduring transformation, reshaping how industries, including real estate, operated, and strategized. Recognizing the significance of this period, the researcher chose to focus the study on the context of real estate in the post-COVID-19 era for the research study.

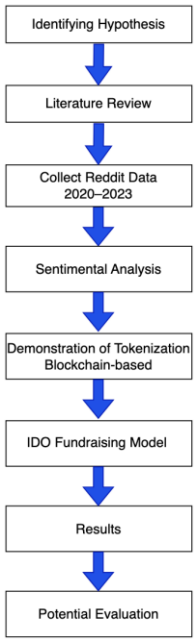


Figure 3.1 Conceptual Framework

Figure 3.1 presents the conceptual framework of this research, which concentrates on understanding the perception of blockchain investment in real estate post the COVID-19 crisis, specifically from 2020 to 2023. This understanding is primarily gleaned through the perspective of Reddit users. The focus is on gauging their sentiments towards blockchain and digital token-based fundraising. Utilizing sentiment analysis, the research aims to determine whether these perspectives lean towards a positive, neutral, or negative spectrum. Additionally, it explores the correlation between positive sentiment and heightened interest in blockchain-funded real estate investments.

A model is then developed to illustrate the potential transformation of the real estate sector through blockchain technology. This model centers on the concept of secure funding, especially through Initial DEX Offerings (IDOs), for emerging projects. The core objective is to demonstrate the mechanism of the token on blockchain towards real estate projects and the potential and challenges of blockchain-financed real estate projects.

Furthermore, the study juxtaposes this blockchain-based approach with other similar initiatives in the real estate domain, elucidating the factors that make it more appealing to investors. Therefore, the study integrates both quantitative and qualitative data, providing a comprehensive analysis of the potentialities and challenges associated with leveraging blockchain technology in the real estate sector.

3.1.1 Elements of study

The first element focused on sentiment analysis derived from social media platforms, notably Reddit. This analysis aimed to understand the wider individual's potential concerns regarding the integration of blockchain in the real estate sector, providing insights into market receptivity and highlighting recognized benefits such as 1. increased transparency and trust, 2. enhanced security and efficiency, 3. global investor connectivity, 4. tokenization of real estate assets, and 5. lower costs and more efficient transactions.

The second element explored the intricate application of blockchain within the real estate realm, with an emphasis on Token Offerings and Smart Contracts. This component introduced an estimated model for fundraising, evaluating the feasibility and potential profitability of capital generation through blockchain. This element also lights on the anticipated advantages of blockchain, encompassing aspects like fractional

ownership, efficient property transactions, and enhanced security in real estate fundraising processes.

Overall, these elements were designed to offer an in-depth quantitative assessment of blockchain's transformative capacity in the post-COVID-19 real estate environment. By integrating sentiment analysis with the technical intricacies of blockchain, this research aimed to present a comprehensive perspective on the future of blockchain-oriented real estate initiatives.

3.1.2 Expected outcomes

1. Insight into Online Social Media Sentiment: By analyzing sentiments from Reddit data, the study expected to provide comprehensive insights into the public's perspective on real estate investment. This would likely present a clear indication of the prevailing optimism or skepticism about the real estate sector post-COVID-19, thereby informing stakeholders of current investor sentiments and concerns.

2. Effectiveness of IDOs: By investigating the role of IDOs in the capital accumulation process for real estate, the study was expected to provide valuable insights. Specifically, it would likely determine the extent to which IDOs could serve as efficient fundraising tools, suggesting a potential revolution in how funds are sourced within the real estate realm. This would highlight how decentralized mechanisms could streamline transactions and mitigate challenges associated with traditional real estate intermediaries.

3.2 Evaluation framework of the study

To evaluate the current research paper, a framework has been devised that focuses on two primary dimensions: sentiment analysis sourced from Reddit and the modeling of IDO fundraising via blockchain.

3.2.1 Sentiment analysis from reddit

Following the emergence of the COVID-19 pandemic, it had been a marked shift in people's dependence on digital platforms. Given blockchain's transformative role in reshaping conventional investment strategies, particularly within the real estate sector, this research explored sentiments expressed on Reddit. The emphasis was on extracting general perceptions regarding blockchain's application in real estate, highlighting its

potential to boost transparency, trust, security, and efficiency. Moreover, the sentiment analysis seeked to capture public sentiment on blockchain's capability to enhance global investor connectivity, its role in tokenizing real estate assets, and its promised in delivering more cost-effective and streamlined transactions.

3.2.2 Analysis of the difficulties in employing blockchain

The study explored the feasibility of fundraising through an IDO launchpad, taking the 'BAAN' token as a case study. This forward-thinking approach aimed to harness the transformative capabilities of blockchain technology in the post-COVID-19 investment environment. Within this context, the research evaluated critical indicators associated with this fundraising strategy, emphasizing metrics like ROI, IRR, and APR. A 'sensitivity analysis' was also integrated to determine the robustness and adaptability of this method under various conditions. Moreover, the study investigates the challenges and complexities associated with utilizing blockchain as a pivotal mechanism for fundraising in the real estate domain.

3.3 Sentiment analysis model

An experimental study model depicting sentiments towards investing in digital tokens on the blockchain in the real estate business was showed in Figure 3.2.

Figure 3.2 Process of sentiment analysis modeling

3.3.1 Reddit steam

Data was collected from Reddit posts to explore users' perspectives on investing in digital real estate assets and blockchain technology in the post-COVID-19 era. Reddit offered a diverse user base and active communities, making it an ideal platform for collecting a range of opinions [100]. Python-based web scraping tools were used to extract data from Reddit [101]. The study focused on the intersection of digital real estate assets and blockchain in investment, with data collected from various sections on the Reddit platform. This analysis aimed to gain insights into individuals' attitudes and

opinions in this investment trend. The data spanned from 2020 to 2023, allowing us to capture discussions during the post-COVID-19 period. Combining sentiment analysis with other analytical approaches could reveal specific themes and patterns within the collected data.

This section presented information regarding the application of blockchain in real estate investment. The data collection process was conducted using the Reddit streaming API (Application Programming Interface) in conjunction with the Python programming language [101]. This approach facilitated the real-time collection of data, enabling the capture of up-to-date information and insights [102] was showed as (Fig. 3.3). The search results were organized based on their relevance within the blockchain in real estate investment on the Reddit website, such as “Increased Transparency and Trust,” “Enhanced Security and Efficiency,” “Global Investor Connectivity,” “Tokenization of Real Estate Assets,” “Lower Costs and More Efficient Transactions”. This organization allowed for effective data preprocessing in the subsequent steps of the research.

```
def writeheaders():
    f.writerow(["Number","Keyword","Title","Score","Comments","URL","Domain","Permalink","ID","Subreddit","CreatedDate"])

def writefields():
    f.writerow([startNum, search.strip(), submission.title,
                submission.score, submission.num_comments,
                submission.url, submission.domain, submission.permalink, submission.id,
                submission.subreddit, datetime.datetime.utcfromtimestamp(submission.created).strftime('%m-%d-%Y')])

reddit = praw.Reddit(client_id=clientid,
                     client_secret=clientsecret,
                     password=password,
                     user_agent='Reddit search data extractor by /u/' + username + '',
                     username=username)

print("Authentication for " + str(reddit.user.me()) + " is verified. Proceeding.\r\n")

outfilename = input("Enter a CSV filename to output the data to (e.g., reddit-data.csv)\r\n")
search = input("Enter a search (e.g., 'how do you') or multiple searches delimited with commas:\r\n")
sortsub = input("How do you want to sort results? Enter relevance, hot, top, new, or comments.\r\n")
filtersub = input("Do you want to restrict to a certain subreddit? Enter 'Yes' or 'No'.\r\n")

search_list = search.split(',')

if(filtersub.lower()=="yes"):
    subreddit = input("Enter the subreddit names delimited with commas (i.e., BigSEO):\r\n")
    subreddit_list = subreddit.split(',')
    file = open(outfilename, "w+", newline="\n", encoding="utf-8")
    f = csv.writer(file)
    writeheaders()
    for subs in subreddit_list:
        for search in search_list:
            startNum = 0
            for submission in reddit.subreddit(subs.strip()).search(search, sort=sortsub):
                startNum += 1
                writefields()
            print("Writing out posts results for the search '" + search.strip() + "' in 'r/" + subs.strip() + "'\r\n")
        file.close
else:
    file = open(outfilename, "w+", newline="\n", encoding="utf-8")
    f = csv.writer(file)
    writeheaders()
    for search in search_list:
        startNum = 0
        for submission in reddit.subreddit('all').search(search.lower(), sort=sortsub):
            startNum += 1
            writefields()
        print("Writing out posts results for the search '" + search.strip() + "' in 'r/all'\r\n")
    file.close
```

Figure 3.3 Function of reddit keyword insights search

3.3.2 Preprocessing of data

In the preprocessing of Reddit data, a data cleaning process was applied using Regular Expression in Python. This process involved correcting, modifying, and removing unwanted parts from the dataset [103]. Several steps were taken to clean the data, including removing duplicates, eliminating Unicode and hyperlinks, and removing emojis. Text normalization techniques, such as lowercase conversion, URL removal, accent removal, stop word removal, and stemming/lemmatization, were also employed to standardize the text [Fig. 3.4]. These cleaning procedures ensured that the data was in a standardized and manageable format, enabling more accurate and reliable analysis in subsequent stages of the study.

```
#Create a function to clean data
def cleanText(text):
    text = re.sub(r'https?:\/\/\S+', '', text) #Remove the hyperlinks
    text = re.sub(r'@[A-Za-z0-9]+', '', text) #Remove @mentions replace with blank
    text = re.sub(r'#', '', text) #Remove the '#' symbol, replace with blank
    text = re.sub(r'RT[\s]+', '', text) #Removing RT, replace with blank
    text = re.sub(r':', '', text) # Remove :
    return text

#Next we have to remove emoji & Unicode from the data.
def remove_emoji(string):
    emoji_pattern = re.compile("["
 u"\U0001F600-\U0001F64F" # emoticons
 u"\U0001F300-\U0001F5FF" # symbols & pictographs
 u"\U0001F680-\U0001F6FF" # transport & map symbols
 u"\U0001F1E0-\U0001F1FF" # flags (iOS)
 u"\U00002500-\U00002BEF" # chinese char
 u"\U00002702-\U000027B0"
 u"\U00002702-\U000027B0"
 u"\U000024C2-\U0001F251"
 u"\U0001f926-\U0001f937"
 u"\U00010000-\U0010ffff"
 u"\u2640-\u2642"
 u"\u2600-\u2B55"
 u"\u200d"
 u"\u23cf"
 u"\u23e9"
 u"\u231a"
 u"\ufe0f" # dingbats
 u"\u3030"
 "]+", flags=re.UNICODE)
    return emoji_pattern.sub(r'', string)
#Cleaning the text
df["Title"]= df["Title"].apply(remove_emoji)
#Show the clean text

#Cleaning the text
df["Title"]= df["Title"].apply(cleanText)
#Show the clean text
```

Figure 3.4 Function to clean social media data for analysis

3.3.3 Classification tools

a) TextBlob

TextBlob was an extensively powerful natural language processing (NLP) library for Python [104], explicitly designed to process textual data. It provided a consistent application programming interface (API) that enabled the exploration of various common NLP tasks, such as part-of-speech tagging, noun phrase extraction, sentiment analysis, and more. The Naive Bayes Classifier (NBC) was a classification technique that stems from Bayes' theorem, with the underlying assumption of

independence among predictors. Essentially, NBC postulated that the presence of a particular feature in a class was unrelated to the presence of any other feature. This assumption was mathematically represented by the following equation, which was derived from Bayes' theorem:

Where (1):

P(C|X) represents the probability of class C given the presence of feature X
P(X|C) signifies the probability of feature X given class C
P(C) denotes the prior probability of class C
P(X) represents the prior probability of feature X

$$P(C|X) = (P(X|C) * P(C))/(P(X)) \quad \text{— (1)}$$

b) SentiWordNet

SentiWordNet [105] represented the outcome of automatically annotating all synsets of WORDNET based on the concepts of "positivity", "negativity", and "neutrality". These scores indicated the level of positivity, negativity, and neutrality associated with the terms within the synset. It was important to note that different senses of the same term could exhibit distinct opinion-related properties. For instance, they could vary in their levels of positivity or negativity.

For a word, the scores could be obtained as follows:

$Pos(s)$: This denotes the positive sentiment score of synset s.

$Neg(s)$: This denotes the negative sentiment score of synset s.

$Obj(s)$: Calculated as $1 - (Pos(s) + Neg(s))$, this represents the objectivity score of synset s. **— (2)**

To determine the sentiment polarity of a sentence or a more extensive piece of text, one could aggregate the scores of its terms [106].

c) VADER

The VADER (Valence Aware Dictionary and Sentiment Reasoner) sentiment analysis tool was a lexicon and rule-based sentiment analysis tool that was specifically attuned to sentiments expressed in social media. This was a breakdown of how VADER works:

Lexicon: VADER had a built-in lexicon where words have assigned scores. These scores range from -4 to +4. For instance, the word "okay" might have a score of 0.9, "good" might be 1.9, and "excellent" could have a score of 3.9.

Rules: The tool incorporated grammatical and syntactical rules. For example:

Capitalization: Words in uppercase letters had more intensity. E.g., GOOD vs good.

Exclamation: More exclamation marked increase intensity. E.g., "Good!" vs "Good!!!".

Modifiers: Words like "very" to intensify the sentiment, while words liked "kind of" dampen the sentiment.

Compound Score: After accounting for all modifiers, boosts, and shifts, a compound score was computed. The formula for this was:

$$compound\ score = \frac{\sum_i^n score(token_i)}{\sqrt{\sum_i^n score(token_i)^{+\alpha}}^2} \quad \text{— (3)}$$

Where score $(token_i)$ was the VADER score of the ith token in the text, n was the total number of tokens, and α was a normalization constant.

This compound score was normalized between -1 and +1, where a positive score indicated a positive sentiment, a negative score indicated a negative sentiment, and scores close to 0 are considered neutral [107].

3.3.4 Sentiment analysis technique

Polarity was a sentiment analysis technique used to determine the positivity, negativity, or neutrality of a post. It evaluated the sentiment of Reddit users' texts to assess their attitudes. Sentiment analysis involved analyzing the writer's attitude and categorizing it as positive, negative, or neutral. Polarity indicated the strength of an opinion, which could be positive or negative. Strong positive emotions, such as admiration or trust, significantly influence the discussed object. Subjectivity, on the other hand, related to personal involvement with an object, varying among individuals. The research explored sentiment analysis, specifically polarity and subjectivity, to understand attitudes and emotions expressed in comments.

Researchers analyzed the sentiment of Reddit users' texts to gain insights into overall sentiment and opinions. An overview of the polarity metrics used in the analysis, with scores ranging from -1 (indicating highly negative sentiment) to +1 (indicating highly positive sentiment), was shown in (Fig. 3.5) Subjectivity metrics evaluated the level of subjectiveness or opinion in a comment. A score of 0 represented an objective statement or fact, while +1 indicates a highly subjective or opinionated comment [108].

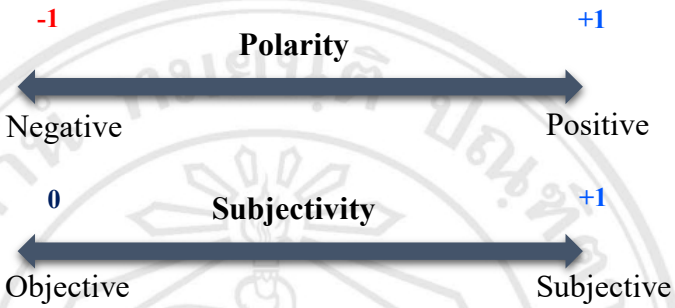


Figure 3.5 Polarity and subjectivity metrics

3.3.5 Data visualization

Sentiment analysis was conducted using the sentiment classifier, which could be either TextBlob, SentiWordNet and VADER. The objective was to identify patterns, common themes, and significant shifts in sentiment within the analyzed data. The outcomes were then compared between the results derived from the TextBlob, SentiWordNet, and VADER sentiment classifiers. Positive and negative sentiments were separately analyzed, scrutinizing the key aspects or features contributing to each sentiment. By comparing the outputs from different sentiment classifiers, insights were gained regarding their strengths, weaknesses, and the level of agreement or divergence in sentiment classification. This evaluation process allowed us to comprehend the patterns of sentiment within the analyzed data, uncover any notable shifts or trends, and gain deeper insights into the factors driving positive and negative sentiments. The combination of heat maps and comparative analysis between sentiment classifiers provided a comprehensive evaluation of the sentiment analysis results, facilitating a more nuanced understanding of the sentiment expressed in the data.

3.4 Tokenization Demonstration Project Process

The researcher would create a demonstration of the model and how blockchain could change real estate. Especially, digital token crowdfunding for new projects. The results gotten from demonstrative environment tests in a real estate investment project utilizing blockchain technology. It focused on testing digital token for fundraising through the IDO method. To examine the feasibility and efficacy of raising funds for the real estate sector using blockchain technology, the following was done:

3.4.1 Platform Development: Develop a decentralized IDO Launchpad platform on Solana Blockchain tailored for the real estate sector, which the method for decentralized platform development[109], as follows:

a) Preparation: Employ Rust for Solana's smart contracts [Fig. 3.6] and JavaScript for the web interface. Tools from the Solana Tool Suite, including the Solana CLI and Solana Web3.js, alongside Node.js and npm for frontend tasks were used [110].

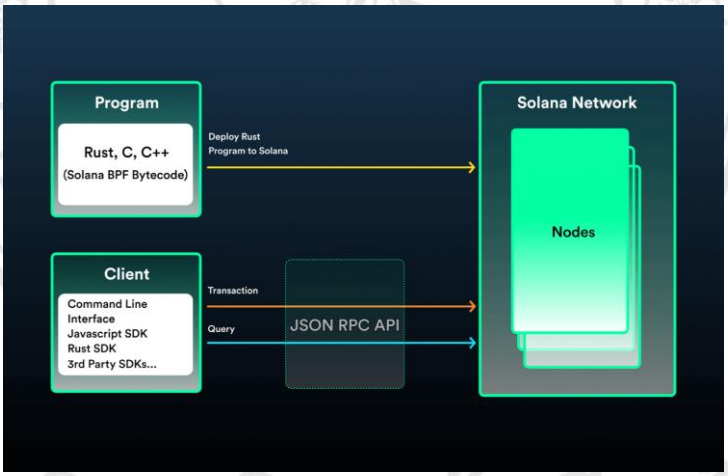


Figure 3.6 The solana developer workflows [110]

b) Contract Creation: Anchor framework to develop smart contracts that manage token functions like minting was utilized. The necessary libraries to handle real estate data on the blockchain and prioritize security in the contract code with Rust were integrated [111].

c) Interface Development: User-friendly interface was built, preferably using React.js, and implement the Solana Web3.js library for seamless blockchain interactions. Ensure transactions was secure through wallet integrations. For this study,

the DeFi wallet chosen was Phantom [Fig. 3.7], compatible with the Solana Blockchain. It was selected for its ease of use and its dedicated functionality for storing digital assets.

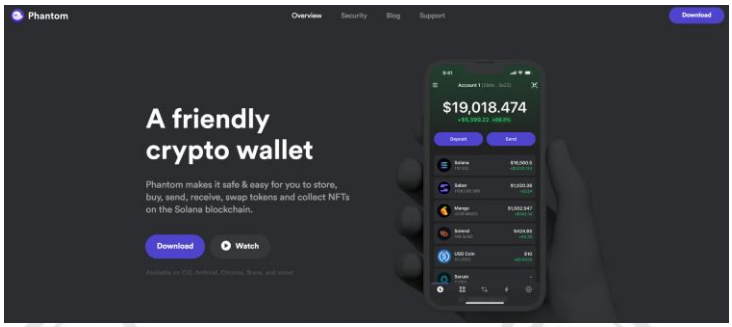


Figure 3.7 Phantom wallet [112]

d) Quality Assurance: Deploy the contracts on Solana's testnet first [113], conducted thorough testing to identify potential issues, and simulate IDO processes to evaluate platform readiness.

3.4.2 Token Creation: Design and introduce a distinct digital token specific to the real estate project, such as the "BAAN token."

In this case study, the generation and minting of tokens on the blockchain network were facilitated using the Solana Blockchain, which also encompassed various "DeFi" transactions.

3.4.3 Fundraising Details: Compose a detailed whitepaper that elucidates the project's aims were fund allocation, team credentials, and developmental roadmap.

3.4.5 Pre-launch Activities: Establish KYC (Know Your Customer) protocols for potential investors. KYC was a mandatory process for identifying and verifying the identity of clients to prevent identity theft, money laundering, and other illicit financial activities. It typically involved gathering data such as the investor's name, an address of residence, date of birth, and photographic proof of identity.

3.4.6 Launch IDO: Set the inaugural price, overall supply, and mechanisms for token distribution. Launching an Initial DEX Offering (IDO) involved a set of strategic decisions. The inaugural price of the token might be set, which represented its initial value. Furthermore, the total supply of tokens that would ever be minted or made available must

be determined. Additionally, mechanisms for how these tokens would be distributed to investors and users needed to be delineated.

3.4.7 Post-launch Activities: After the IDO was launched, it was imperative to ensure that the returns from the sale of the project house were as anticipated. This requires utilizing the funds exactly as specified in the project's investment details. Such transparency was crucial for establishing trust among investors and maintaining the overall credibility of the project. In this study, the researcher opted for the Annual Percentage Rate (APR) method. The APR on Decentralized Finance (DeFi) platforms generally referred to the annualized rate of interest (or yield) that users could expect to earn or pay. However, it was essential to note that in DeFi, APRs could be fluid, affected by various factors like liquidity, demand, supply, and strategies employed by the protocols.

The general formula for APR is:

$$APR = \left(\left(\frac{Interest\ earned\ or\ paid\ during\ a\ period}{Principal}\right) \times \frac{365}{Days\ in\ period}\right) \quad \text{— (4)}$$

Where (4):

"*Interest earned or paid during a period*" was the actual interest accrued in the specific timeframe.
"*Principal*" was the original sum of money deposited.
"*Days in period*" was the number of days for which interest was calculated.

In addition, there were tools for calculating feasibility. Another method was the Internal Rate of Return (IRR), a metric used in capital budgeting to estimate the profitability of potential investments. The IRR for a series of cash flows was the rate that produces a net present value (NPV) of zero. The general formula for IRR was:

$$NPV = \sum \frac{CFt}{(1+IRR)^t} = 0 \quad \text{— (5)}$$

Where (5):

"CFt" was the cash flow at time *t.*
"IRR" was the internal rate of return.
"t" was the period.

For DeFi applications, the IRR was calculated in the same manner. However, the cash flows would be a factor in specifics of the DeFi environment, such as yields from staking rewards.

3.4.8 Suggestions for Further Study: Share findings with relevant stakeholders, providing insights and recommendations for future IDO initiatives in the real estate sector. The sensitivity analysis [114] for the proposed study examined the feasibility and efficiency of IDO Launchpads in the real estate sector. Sensitivity analysis was a technique used to determine how different values of an independent variable impact a particular dependent variable under a given set of assumptions. However, sensitivity analysis was not strictly a formula; rather, it was a process or method. Within this process, specific formulas might be applied based on the type of sensitivity analysis being conducted.

For instance, in financial modeling, one could be using a formula like:

$$NewOutcome = BaselineOutcome \pm (BaselineOutcome \times SensitivityPercentage) \quad \text{— (6)}$$

From (6) essentially calculated a new outcome by adjusting the baseline outcome by a specified percentage.

This analysis was instrumental in identifying the most influential parameters and understanding their potential impact on the fundraising campaign. The success of the IDO could be assessed using key metrics such as funds raised and return on investment [115].

CHAPTER 4

RESULTS AND DISCUSSION

The chapter shows the results of this research, which was to examine and understand the challenges and difficulties associated with blockchain technology in real estate projects. The aim was to determine how blockchain technology could be used to solve these problems and enhance the real estate industry. Those were in line with purpose of the studies, and the results are divided into three sections according to the research, as follows: 1) Sentiment Analysis, 2) Demonstration of using token in the real estate project, and 3) Guidance on the Benefits and Potential Challenges.

4.1 Sentiment Analysis (Section 1)

The first section of results examines how Reddit users, mostly foreigners, viewed investment via blockchain after COVID-19, particularly focusing on blockchain and token investment, to determine whether their sentiment was positive or negative, which is in accordance with the purpose of the study at (1.2.2).

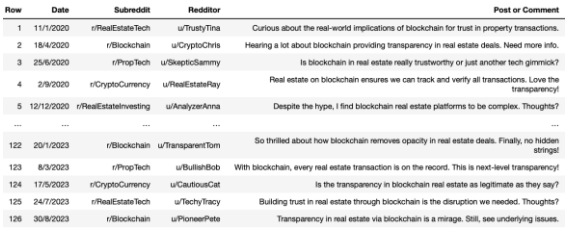
4.1.1 Collection data

Results of using the tools in (3.3.1) to extract data from the Reddit platform website according to the topics of interest: 1. Increased transparency and trust 2. Enhanced Security and Efficiency; 3. Global Investor Connectivity; 4. Tokenization of Real Estate Assets; and 5. Lower Costs and More Efficient Transactions, which used the relationship between key words searched with the Python function program from (Fig. 3. 3). After data extraction, the data was shown in Table 4.1.

Table 4.1 The dataset of the preprocessing

No.	Relevance	Data Before Preprocessing	Data After Preprocessing
1	Increased Transparency and Trust	230	126
2	Enhanced Security and Efficiency	235	222
3	Global Investor Connectivity	250	66
4	Tokenization of Real Estate Assets	233	196
5	Lower Costs and More Efficient Transactions	215	209
	Total	**1,163**	**819**

The total number of posts and associated comments, as presented in (Table 4.1), pertain to blockchain's application in real estate investment. After preprocessing and cleaning data by (3.3.2), out of the initial 1,163 data points, 819 were deemed suitable for sentiment analysis. The results from this dataset were saved in a CSV file which were shown as Figure 4.1.



Row	Date	Subreddit	Redditor	Post or Comment
1	11/1/2020	r/RealEstateTech	u/TrustyTina	Curious about the real-world implications of blockchain for trust in property transactions.
2	18/4/2020	r/Blockchain	u/CryptoChris	Hearing a lot about blockchain providing transparency in real estate deals. Need more info.
3	25/6/2020	r/PropTech	u/SkepticSammy	Is blockchain in real estate really trustworthy or just another tech gimmick?
4	2/9/2020	r/CryptoCurrency	u/RealEstateRay	Real estate on blockchain ensures we can track and verify all transactions. Love the transparency!
5	12/12/2020	r/RealEstateInvesting	u/AnalyzerAnna	Despite the hype, I find blockchain real estate platforms to be complex. Thoughts?
...	...	...	...	...
122	20/1/2023	r/Blockchain	u/TranparentTom	So thrilled about how blockchain removes opacity in real estate deals. Finally, no hidden strings!
123	8/3/2023	r/PropTech	u/BullishBob	With blockchain, every real estate transaction is on the record. This is next-level transparency!
124	17/5/2023	r/CryptoCurrency	u/CautiousCat	Is the transparency in blockchain real estate as legitimate as they say?
125	24/7/2023	r/RealEstateTech	u/TechyTracy	Building trust in real estate through blockchain is the disruption we needed. Thoughts?
126	30/8/2023	r/Blockchain	u/PioneerPete	Transparency in real estate via blockchain is a mirage. Still, see underlying issues.

(a)

	Date	Subreddit	Redditor	Post or Comment
1	18/1/2020	r/RealEstateTech	u/SecureSam	Wondering how blockchain contributes to enhanced security in real estate transactions. Anyone with insights?
2	2/3/2020	r/Blockchain	u/EfficientElla	Utilized blockchain for a property transaction; the efficiency gain was remarkable.
3	6/3/2020	r/PropTech	u/CautiousCal	Are blockchain platforms really as secure as they claim for real estate dealings?
4	24/4/2020	r/CryptoCurrency	u/DebateDan	Some say blockchain boosts efficiency in real estate, but aren't there potential security risks?
5	3/5/2020	r/RealEstateInvesting	u/ProTechPaul	Just completed a deal on a blockchain-based platform. Impressed by the security and speed!
...	...	...	...	...
218	28/5/2023	r/Blockchain	u/SkepticalSue	I've read about increased security with blockchain in real estate, but I'm concerned about potential tech glitches.
219	10/6/2023	r/PropTech	u/QuestionQuinn	What are the tangible security benefits of using blockchain for property transactions?
220	17/6/2023	r/CryptoCurrency	u/CryptoChris	Efficiency is one thing, but is blockchain in real estate truly hack-proof?
221	30/6/2023	r/RealEstateTech	u/AnalyticAnna	Research indicates blockchain offers improved security in real estate. How does this play out in real-world applications?
222	22/7/2023	r/Blockchain	u/RealtorRob	From a realtor's perspective, blockchain has streamlined many processes. Also, feels more secure than traditional means.

(b)

	Date	Subreddit	Redditor	Post or Comment
1	12/11/2019	r/RealEstateTech	u/InvestorX	Stumbled upon a blockchain project aimed at real estate. Global connectivity is the future!
2	07/12/2019	r/Blockchain	u/JaneDoe	Anyone else seeing blockchain's potential in real estate? Connecting global investors seamlessly!
3	15/9/20	r/PropTech	u/traderY	I'm not convinced about blockchain in real estate. How does it improve global connectivity for investors?
4	21/12/2020	r/CryptoCurrency	u/JohnSmith	Imagine a world where blockchain bridges all global investors in the real estate market. We're getting there.
5	18/2/2020	r/RealEstateInvesting	u/propertyGuru	Global investor connectivity via blockchain is making real estate transactions transparent. Thoughts?
...	...	...	...	...
62	23/5/23	r/Blockchain	u/MaryWhite	Struggling to integrate blockchain for real estate global connectivity. Anyone else facing this?
63	14/6/23	r/PropTech	u/InnovatorZ	Blockchain might be the key to unlocking true global real estate investor connectivity. It's revolutionary.
64	4/7/23	r/CryptoCurrency	u/LisaBrown	Anyone concerned about data security with blockchain in global real estate investing?
65	22/07/2023	r/RealEstateTech	u/finance Freak	A report highlighted how blockchain boosts global investor connectivity in real estate. Anyone has more insights?
66	09/08/2023	r/Blockchain	u/RobertGreen	The buzz around blockchain for global investor connectivity in real estate - is it all hype?

(c)

	Date	Subreddit	Redditor	Post or Comment
1	3/1/2020	r/RealEstateTech	u/TokenPro	Diving into the concept of tokenizing real estate assets via blockchain. Game changer?
2	14/3/2020	r/Blockchain	u/AssetAce	Just tokenized my first property! Real estate will never be the same again.
3	19/4/2020	r/PropTech	u/CryptoSkeptic	Tokenization of real estate sounds like a bubble. Thoughts?
4	5/6/2020	r/CryptoCurrency	u/RealTechie	Real estate tokenization on blockchain could solve liquidity issues. Imagine the possibilities.
5	12/7/2020	r/RealEstateInvesting	u/PropertyMogul	Anyone here experienced with tokenizing their properties? Any potential pitfalls?
...	...	...	...	...
192	10/2/2023	r/Blockchain	u/RealtorJane	Attended a seminar on tokenizing real estate. Seems like the future but also feels risky.
193	28/3/23	r/PropTech	u/InvestorMike	Real estate tokenization might just revolutionize asset management and investments.
194	15/4/23	r/CryptoCurrency	u/BlockMaster	Concerned about the regulatory framework around tokenizing real estate. Anyone have insights?
195	23/4/2023	r/RealEstateTech	u/TokenGuru	The benefits of real estate tokenization: more investors, more liquidity, and transparent transactions. Thoughts?
196	30/6/2023	r/Blockchain	u/LandBaron	Why aren't more people talking about the tokenization of real estate? It's the future!

(d)

	Date	Subreddit	Redditor	Post or Comment
1	10/1/2020	r/RealEstateTech	u/EfficiencyGuru	Blockchain could significantly lower transaction costs in real estate. Anyone else notice this?
2	16/3/2020	r/Blockchain	u/CostCutter	Reduced my property transaction costs using blockchain. It's the real deal?
3	24/4/2020	r/PropTech	u/DoubtfulDan	Not convinced that blockchain can make real estate transactions more efficient. Prove me wrong?
4	31/5/2020	r/CryptoCurrency	u/Innovatorlvy	Efficiency gains in real estate are remarkable thanks to blockchain. More people need to adopt this!
5	7/8/2020	r/RealEstateInvesting	u/RealtyRex	How much can you really save on transaction costs using blockchain?
...	...	...	...	...
205	13/10/2022	r/Blockchain	u/ValueVic	Leveraging blockchain for property transactions is the way forward. Lower costs, higher efficiency. Welcome to the new age!
206	9/1/2023	r/PropTech	u/TransactionTim	While blockchain promises efficiency, the adoption rate in real estate seems slow. Why?
207	21/2/2023	r/CryptoCurrency	u/CriticCarl	Worried about hidden costs in blockchain real estate transactions. Need advice.
208	5/4/2023	r/RealEstateTech	u/OptimizerOli	Transaction cost savings through blockchain in real estate are commendable. Check it out!
209	11/7/2023	r/Blockchain	u/FrugalFran	Anyone have real-world data on how much blockchain actually saves in property deals?

(e)

Figure 4.1 CSV dataset file read by Python. (a)– Increased Transparency and Trust. (b)– Enhanced Security and Efficiency. (c)– Global Investor Connectivity. (d)– Tokenization of Real Estate Assets. (e)– Lower Costs and More Efficient Transactions.

The Exploratory Data Analysis (EDA) approach was used to analyze the total number of comments. The primary objective was to summarize their main characteristics through visualizations. The EDA process was considered a crucial step conducted prior to sentiment analysis or model building, as it helped unveil valuable insights that held significance in later stages of the results. As shown in (Fig. 4.2), a graph was plotted to illustrate the dominant discussions among Reddit users, which primarily revolved around the topic of "Enhanced Security and Efficiency." This topic received the highest level of engagement and was the most discussed. On the other hand, "Global Investor Connectivity" was the least discussed topic among Reddit users.

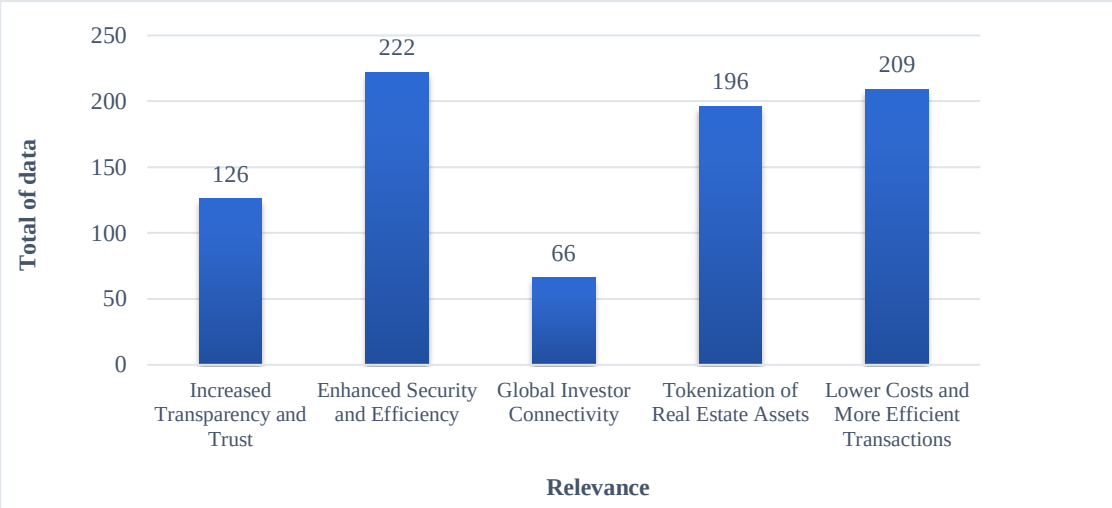


Figure 4.2 A chart depicting the frequency of mentions for type of interest

The study investigated the common words associated with Reddit users. Our "Pandas Data Frame" used a Python function by (Figure 3.4) to help exclude stop words, punctuation, and emojis. Subsequently, a word cloud was generated to depict the most frequent terms. In this context, Figure 4.3 showcases words that frequently co-occurred with "blockchain technology in real estate" within the related category of responses.

(a) (b)

(c) (d)

(e)

Figure 4.3 Words that exhibited the highest frequency of co-occurrence among Reddit users related to blockchain in real estate investment. (a)– Increased Transparency and Trust. (b)– Enhanced Security and Efficiency. (c)– Global Investor Connectivity. (d)– Tokenization of Real Estate Assets. (e)– Lower Costs and More Efficient Transactions.

4.1.2 Classification tools

The results of sentiment analysis using the TextBlob, SentiWordNet and VADER tools were showed in the following results:

4.1.2.1 TextBlob classifier

The category "Tokenization of Real Estate Assets" exhibited the highest positive sentiment regarding real estate investment via blockchain. It accounted for 88.26% of the overall user interest on the Reddit dataset, as detailed in Table 4.2.

Table 4.2 Sentiment analysis used by TextBlob

Relevance	Positive	Neutral	Negative
Increased Transparency and Trust	56 (44.44%)	46 (36.5%)	24 (19.06%)
Enhanced Security and Efficiency	107 (48.2%)	94 (42.34%)	21 (9.46%)
Global Investor Connectivity	52 (78.79%)	9 (13.64%)	5 (7.57%)
Tokenization of Real Estate Assets	173 (88.26%)	15 (7.65%)	8 (4.09%)
Lower Costs and More Efficient Transactions	99 (47.37%)	93 (44.5%)	17 (8.13%)
Total	**487 (59.46%)**	**257 (31.38%)**	**75 (9.16%)**

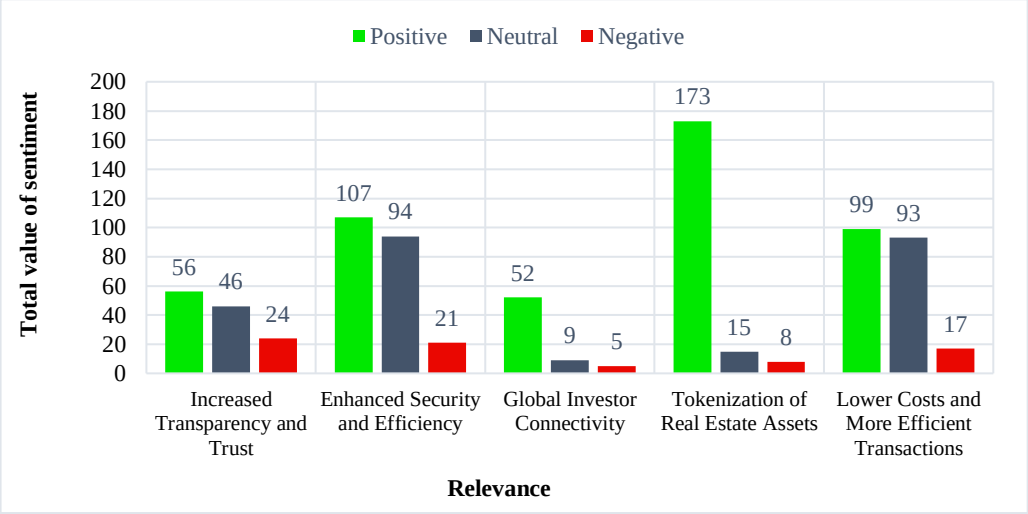


Figure 4.4 Value plot of sentiment analysis used by TextBlob

Data that predominantly indicated a positive sentiment, rather than negative [Fig. 4.4].

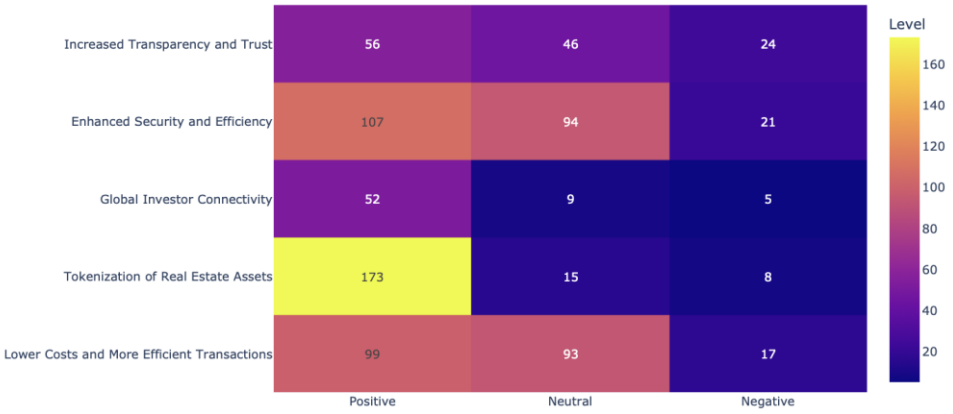


Figure 4.5 Heatmap of sentiment analysis used by TextBlob

A gradient heatmap showed that the category "Tokenization of Real Estate Assets" was the most positively discussed topic [Fig. 4.5].

4.1.2.2 SentiWordNet classifier

The category "Enhanced Security and Efficiency" registered the highest positive sentiment regarding real estate investment via blockchain, accounting for 57.21% of the overall user interest on the Reddit dataset, as detailed in Table 4.3.

Table 4.3 Sentiment analysis used by SentiWordNet

Relevance	Positive	Neutral	Negative
Increased Transparency and Trust	54 (42.86%)	41 (32.54%)	31 (24.60%)
Enhanced Security and Efficiency	127 (57.21%)	60 (27.03%)	35 (15.77%)
Global Investor Connectivity	33 (50.0%)	21 (31.82%)	12 (18.18%)
Tokenization of Real Estate Assets	101 (51.53%)	61 (31.12%)	34 (17.35%)
Lower Costs and More Efficient Transactions	98 (46.89%)	61 (29.19%)	50 (23.92%)
Total	**413 (50.43%)**	**244 (29.79%)**	**162 (19.78%)**

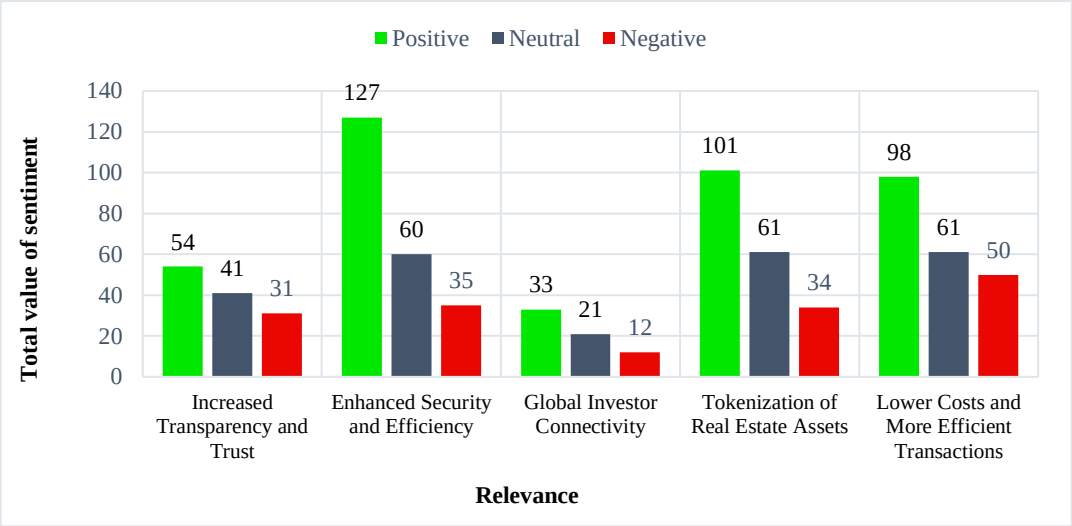
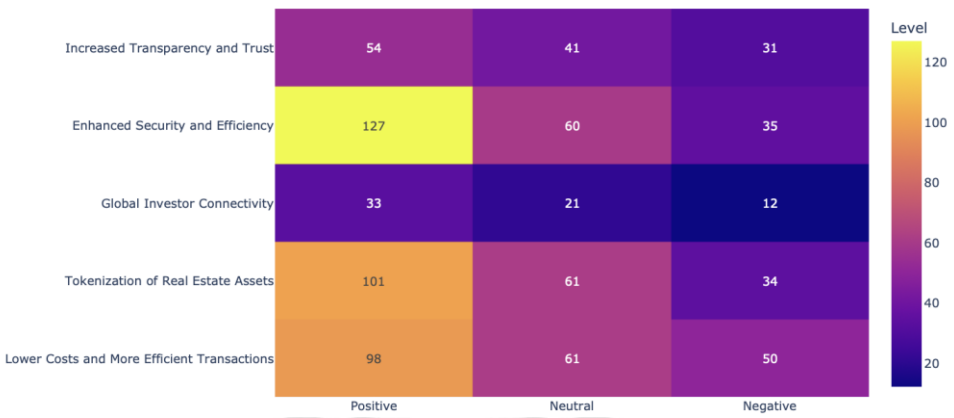


Figure 4.6 Value plot of sentiment analysis used by SentiWordNet

The value plot of sentiment analysis showed that predominantly indicates a positive sentiment, rather than negative [Fig. 4.6].



Figures 4.7 Heatmap of sentiment analysis used by SentiWordNet

A gradient heatmap showed that the category "Enhanced Security and Efficiency" was the most positively discussed topic [Fig. 4.7].

4.1.2.3 VADER classifier

The category "Enhanced Security and Efficiency" registered the highest positive sentiment regarding real estate investment via blockchain, accounting for 54.95% of the overall user interest on the Reddit dataset, as detailed in Table 4.4.

Table 4.4 Sentiment analysis used by VADER

Relevance	Positive	Neutral	Negative
Increased Transparency and Trust	66 (52.38%)	39 (30.95%)	21 (16.66%)
Enhanced Security and Efficiency	122 (54.95%)	85 (38.29%)	15 (6.76%)
Global Investor Connectivity	31 (46.97%)	26 (39.39%)	9 (13.63%)
Tokenization of Real Estate Assets	80 (40.82%)	97 (49.49%)	19 (9.69%)
Lower Costs and More Efficient Transactions	101 (48.32%)	82 (39.24%)	26 (12.44%)
Total	**400 (48.84%)**	**329 (40.17%)**	**90 (10.99%)**

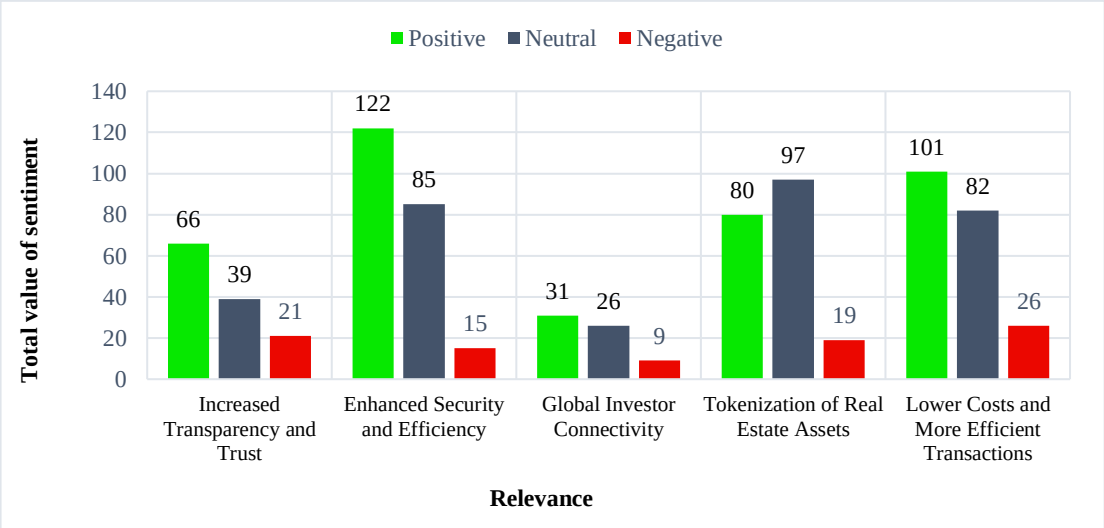


Figure 4.8 Value plot of sentiment analysis used by VADER

The value plot of sentiment analysis showed that predominantly indicates a positive sentiment, rather than negative [Fig. 4.8].

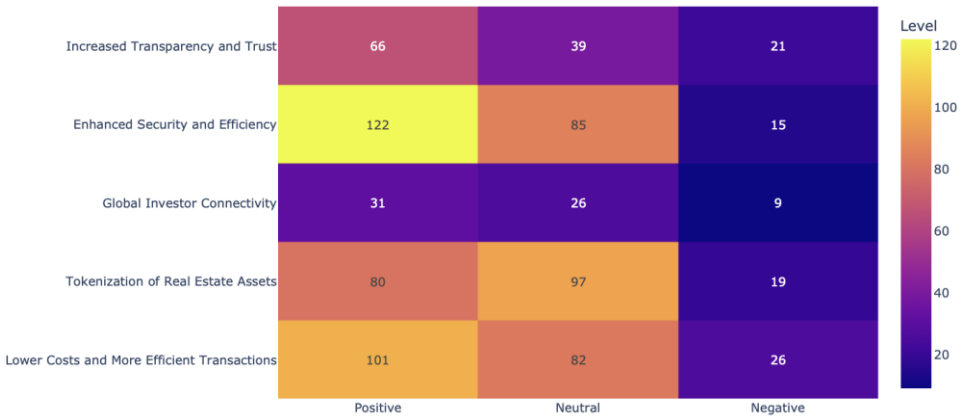


Figure 4.9 Heatmap of sentiment analysis used by VADER

The gradient heatmap illustrating that the category "Enhanced Security and Efficiency" was the most positively discussed topic [Fig. 4.9].

4.1.3 Comparison

Within the dataset at hand, a comprehensive analysis was carried out using three esteemed sentiment analysis methodologies: TextBlob, SentiWordNet, and VADER. These methodologies aim to segregate textual information into three specific sentiment categories: positive, neutral, and negative. The subsequent sections provided a succinct summary of the results obtained from the deployment of each tool, as illustrated in the (Table 4.5) and (Fig. 4.10) that follow.

Table 4.5 Number of polarities from sentiment analysis classifiers

Classifier Name	Positive	Neutral	Negative
TextBlob	487 (59.46%)	257 (31.38%)	75 (9.16%)
SentiWordNet	413 (50.43%)	244 (29.79%)	162 (19.78%)
VADER	400 (48.84%)	329 (40.17%)	90 (10.99%)

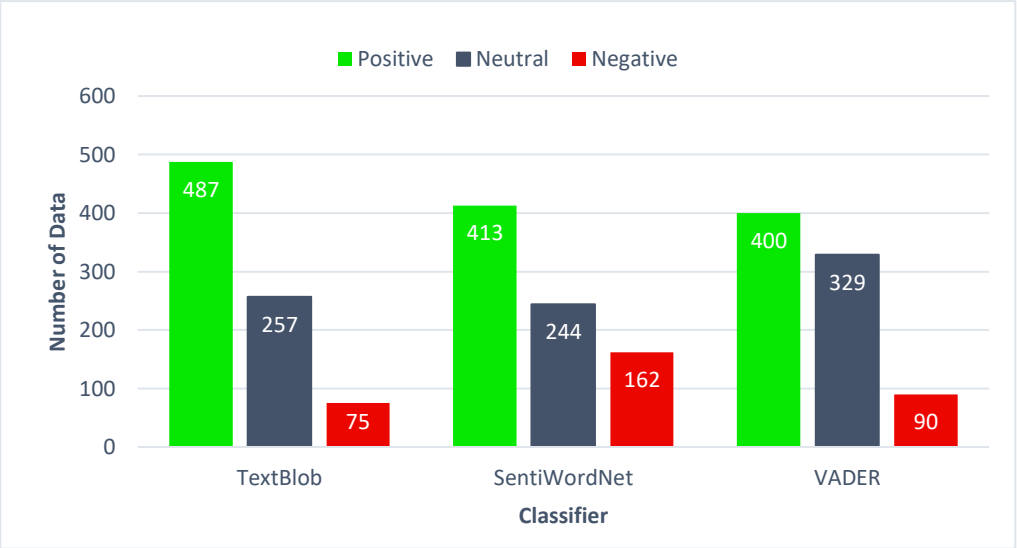


Figure 4.10 Polarity calculation used by each sentiment classifier

An analytical evaluation had been conducted on three sentiment analysis instruments: TextBlob, SentiWordNet, and VADER. These tools endeavored to categorize textual data into three distinct sentiment classifications, namely: positive, neutral, and negative. The ensuing discourse offered a concise overview of the outcomes derived from each tool's application on the dataset and was shown as follows:

Positive Classification: TextBlob appeared to classify a significantly higher portion of data points as positive (59.46%) when compared to both SentiWordNet (50.43%) and VADER (48.84%). This might indicate that TextBlob had a more lenient or broad interpretation of positivity in this dataset.

Neutral Classification: VADER classifies a considerably higher percentage of data points as neutral (40.17%) compared to both TextBlob (31.38%) and SentiWordNet (29.79%). This could suggest that VADER was more conservative, preferring not to strongly classify sentiments unless they clearly lean towards positive or negative.

Negative Classification: SentiWordNet classified the highest percentage of data points as negative (19.78%), noticeably more than TextBlob (9.16%) and VADER (10.99%). This might indicate that SentiWordNet was more sensitive to negative sentiments, or perhaps that it was more prone to classifying neutral sentiments as negative compared to the other tools.

Tool Suitability: The choice of tool might depend on the specific use case. If a user prioritizes detecting positive sentiments, TextBlob might be the best choice. If avoiding false positives and negatives is important and a more balanced or neutral classification is preferred, VADER could be more suitable. If detecting negative sentiments was crucial, SentiWordNet appeared to be the most sensitive.

Dataset Context: The efficacy of these tools also depended on the nature of the dataset. For instance, VADER was tailored for social media texts, and its performance might differ on formal reviews.

In the post-COVID-19 era, sentiment analysis of social media data revealed diverse opinions regarding the use of blockchain technology in real estate. Most opinions were positive, emphasizing the potential advantages of blockchain, such as increased transparency, reduced fraud, and improved transaction efficiency. Users showed enthusiasm for the accessibility and fractional ownership opportunities offered by blockchain. However, concerns raised regarding the viability and scalability of blockchain in the real estate sector. Regulatory frameworks, data privacy, and interoperability were critical factors to consider for widespread adoption. The positive reaction from social media users reflected their interest in the transformative potential of blockchain in real estate. Blockchain enhanced security, transparency, and efficiency by streamlining transactions and reducing costs.

Despite the excitement, challenges related to legislation, standards, and interoperability needed to be addressed to effectively utilize blockchain technology. Collaboration among industry players, legislators, and technology developers was essential in establishing robust frameworks that ensure data privacy, security, and legal compliance. Moreover, the sentiment analysis of social media data post-COVID-19 revealed diverse opinions about blockchain in real estate. The majority expressed enthusiasm, contributing to an overall positive sentiment. Further discussions and results related to the study topics was shown in Table 4.6.

Table 4.6 Interpretation of the obtained data quantitatively

Relevance	Interpretation
Increased Transparency and Trust	Blockchain technology offers a decentralized and immutable ledger, fostering transparency and bolstering investor confidence. In the aftermath of the COVID-19 era, as trust in conventional investment avenues might have waned, the transparency provided by blockchain could lure investors to real estate via social media platforms.
Enhanced Security and Efficiency	By employing cryptographic algorithms, blockchain technology bolsters transaction and record security, thereby mitigating the risk of fraud and unauthorized activities. Using blockchain for real estate investment on social media platforms can enhance trust in transaction security, fostering a positive attitude and promoting increased participation.
Global Investor Connectivity	Social media platforms boast a vast user base and have the potential to connect investors worldwide. Through blockchain technology, there is facilitated access to international real estate investment opportunities. Such enhanced accessibility to global markets could foster industry diversification and expansion, further bolstering blockchain-based real estate investment.
Tokenization of Real Estate Assets	Blockchain facilitates the tokenization and fractional ownership of real estate assets. By eliminating traditional barriers, such as high capital requirements, it allows investors to engage in real estate investment with smaller sums. These digital tokens can be traded and exchanged via social media channels, rendering real estate investment more accessible and attractive to a wider audience.

Table 4.6 Interpretation of the obtained data quantitatively (Cont.)

Relevance	Interpretation
Lower Costs and More Efficient Transactions	Blockchain technology facilitates peer-to-peer transactions, thus eliminating the need for intermediaries and the associated fees. By circumventing middlemen like brokers or banks, real estate transactions on social media platforms can become faster, more efficient, and cost-effective. The efficiency and potential cost savings of blockchain-based real estate investments may appeal to investors.

4.2 Demonstration of using token in the real estate project (Section 2)

This second part presented the results obtained from demonstrate environment tests of a real estate investment project working with blockchain. This part focused on testing digital token fundraising using the IDO Launchpad method (refer to 3.4) through the decentralized platform on the Solana blockchain, which is in accordance with the purpose of the study at (1.2.3), with the following results:

4.2.1 Project plan

Land allocation for the case study of fundraising had been established. In the project's initial phase, an area spanning 4,800 square meters would be utilized. Of this, 3,000 square meters would be allocated for the construction of 10 houses, while the remaining 1,800 square meters would be designated as a common area.

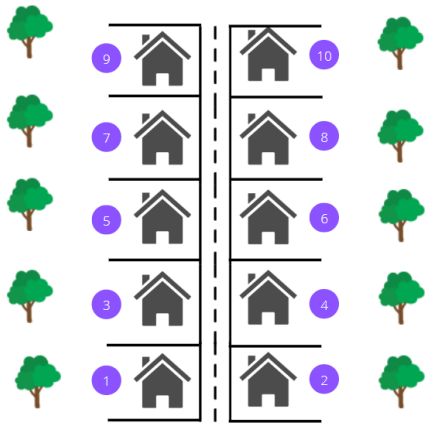


Figure 4.11 Housing project plan

The number of houses [Fig. 4.11] slated for construction in the fundraising project. Details about these houses, including their construction costs, were provided in Table 4.7.

Table 4.7 Details of land and house

No.	Details	Amount	Unit
1	Size of Land	300	m^2
2	Size of One Story House	180	m^2
3	Available Area	120	m^2

In this simulation environment, we utilized medium-quality materials with a cost of 13,800 baht per 1 m^2, as shown in the cost of building construction appraisal [116]. Constructing a single-story house [117] with a size of 180 m2 cost 2,484,000 baht, with an additional 10% allocated for central area project management services. Therefore, the total construction cost amounted to 2,732,400 baht, or approximately 80,365 USD per house.

Figure 4.12 Single-story house plan [117]

An example of a single-story house [Fig. 4.12] represented in this study was approximately 180 square meters in size.

The details regarding the design, including the number of tokens, token price, funding period, and the return to investors after the house sale, were shown in Table 4.8.

Table 4.8 Token for sale

No.	Details	Amount	Unit
1	Total Token Sale	8,036,471	Tokens
2	Token Price	0.1	USD

Table 4.8 showed 8,036,471 tokens for sale, equivalent to the price of a total of 10 houses sold, 803,647 USD, with a price per token of 0.1 USD. There was also a period of Year 1 for investors of all levels to invest in the project fund. After the fundraising was complete in Year 2, we would go through the process of building a total of 10 houses within 1 year. After the construction process was completed from the Year 3 onwards, there would be sales of housing from the real estate project.

4.2.2 Tokenization

The description for token generation in the Solana Blockchain Environment encompassed several terms. "Address" refered to the specific number assigned to the token on the blockchain network. "Current Supply" conveyed the total amount of tokens that had been generated. "Mint Authority" identified the address associated with the token creator. Lastly, "Decimals" represented the decimal value of the token. In this study, all decimal values were converted into integer values, as illustrated in Figure 4.13.

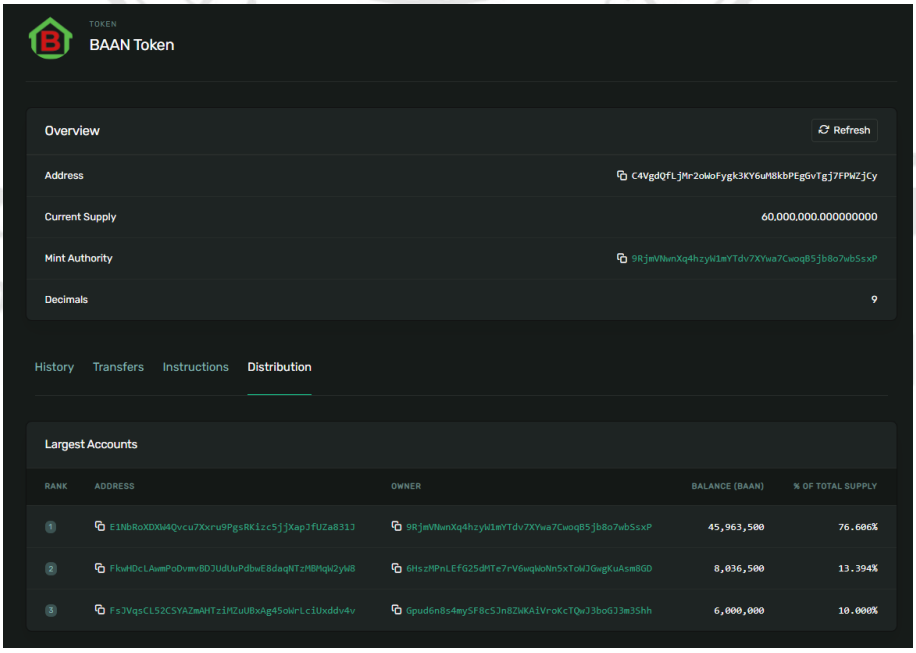


Figure 4.13 Results of the creation of the BAAN Token

4.2.3 Fund Management

The allocation of capital management was structured as follows: Upon receiving funds from investors, the distribution of project expenses was designated as 65% for construction materials, 25% for construction labor costs, and the remaining 10% to cover project management and team development costs.

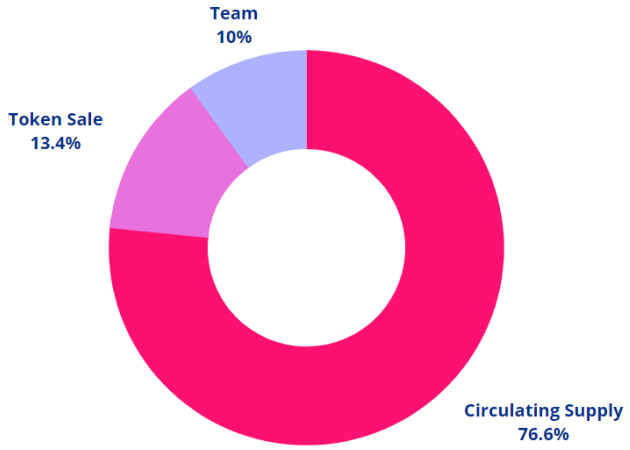


Figure 4.14 Proportion of Total Tokens

The project's total token allocation was detailed as follows:

a) 13.4% of the total, equivalent to 8,036,470 BAAN, represented an actual conversion amount of 803,647.1 USD. This sum was the price of one house, set at 80,365 USD. This allocation targeted individuals keen on investing and those wanting to collaborate with the company by holding tokens instead of traditional stock.

b) 76.6% was earmarked for circulation within the system, including token allocations designed to yield returns for investors. These tokens remained locked in the platform's system until a house was purchased via the project. Following such a purchase, tokens were unlocked and distributed according to the number of actual house buyers. This structure guaranteed that real asset-backed tokens-maintained parity with the physical assets.

c) 10% of the house sales profits were allocated to create tokens. These tokens were then distributed to the project management team and support staff in charge of platform management and the development of smart contracts via blockchain technology, effectively treating them as partners.

4.2.3 Demonstration of Investor Joining the Project Fund

Before investment, the service provider would first check the user's basic personal information. The process involved using KYC methods to verify the investor's identity. By connecting a DeFi wallet to the platform to request the investor's wallet address, this address was called the public key. Used for registering as an investor on the platform. As shown in Figure 4.15.

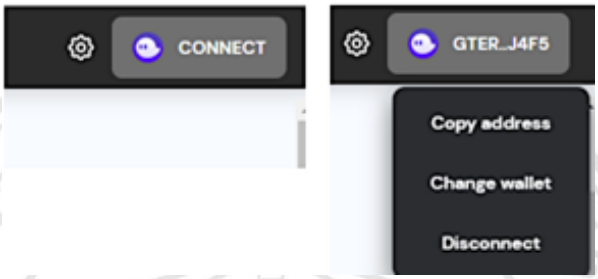


Figure 4.15 Connected with the Phantom wallet to the dApp

Figure 4.15 shows the connection to a digital wallet. This study used the Phantom wallet as specified in 3.4.1 (c), which was the designated wallet for transactions on the platform. Because registering as an investor on the platform required a public key.

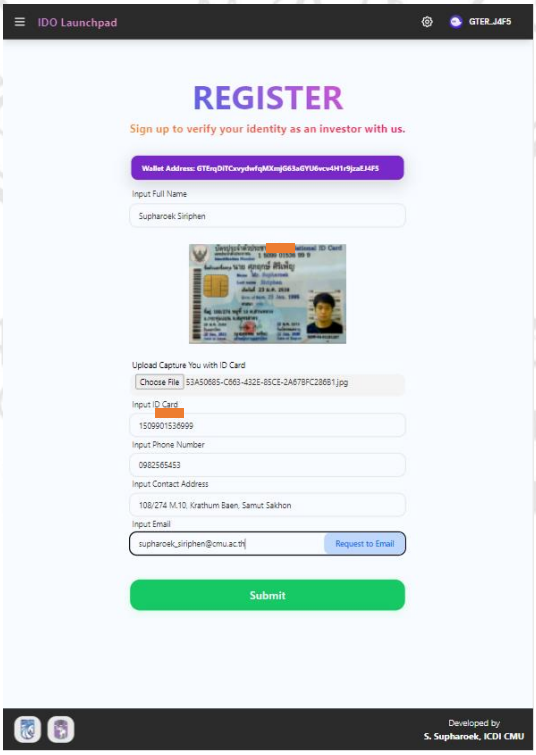


Figure 4.16 Register as an Investor

The demonstration results of user registration and identity verification on the platform was showed in Figure 4.16. Specifically, the wallet address or public key was required for the verification and processing of all blockchain transactions. For this KYC process, basic information was required as follows: first name, last name, photo, ID card number, telephone number contacts and emails, including an additional layer of security with a one-time password (OTP), were shown in Figure 4.17.

Figure 4.17 OTP password

The system's process of sending a verified password to the user's email address [Fig. 4.17], which was ensured the email's validity for those intending to invest in the project fund.

A platform for selling BAAN tokens to raise funds, and the window displays the BAAN token address for users checked the token details on the blockchain network. The page also indicated the number of BAAN tokens available (ready for sale). The number of tokens sold and the price of the BAAN token relative to USDT, which was set at 0.1 USD, were shown in Figure 4.18.

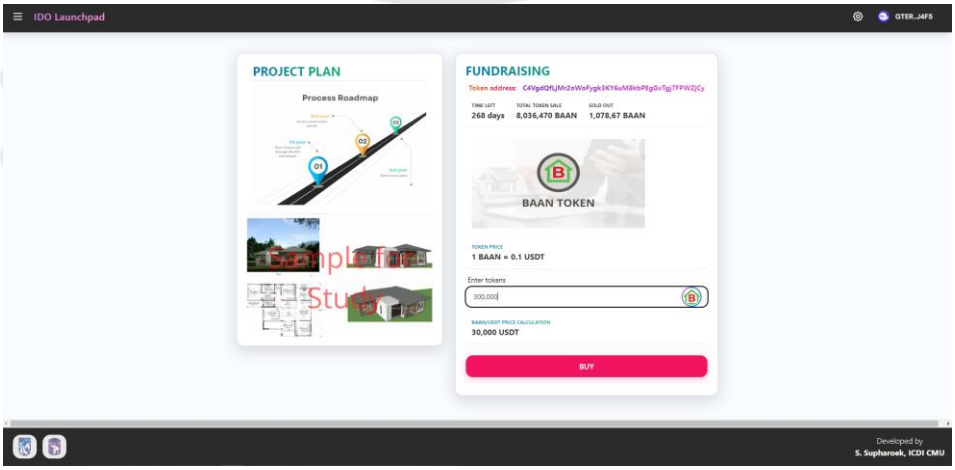


Figure 4.18 Token sale page

Figure 4.18 also showed an example of purchasing 300,000 BAAN tokens, equivalent to 30,000 USDT. To buy BAAN tokens, we might use USDT to buy them, which could be traded on digital asset exchange platforms such as Binance or Bitkub after the exchange. Users could move these coins to their Phantom wallet to proceed with the purchase of BAAN tokens on the platform.

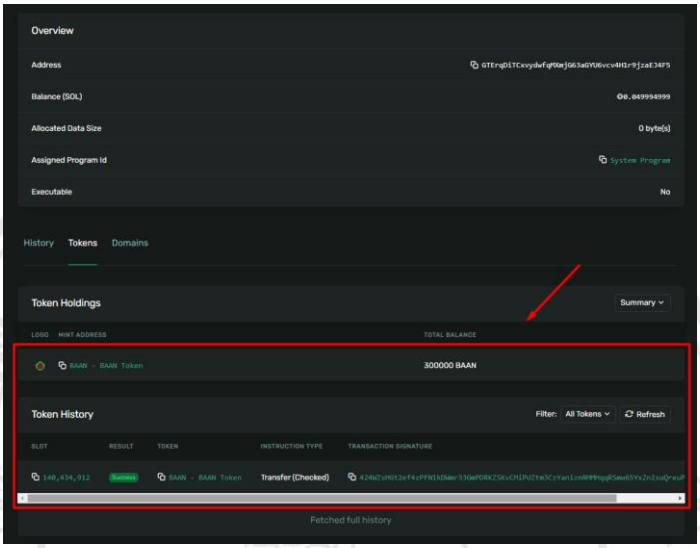


Figure 4.19 Transaction history after the buy token

The transaction history logged on the blockchain was presented in Figure 4.19. This history comprised various details: "SLOT," denoting the transaction's block sequence; "RESULT," which indicated the status of the transaction; "TOKEN," specifying which token was involved in the transaction; "INSTRUCTION TYPE," which characterizes the display type; and "TRANSACTION SIGNATURE," a unique identifier for each transaction. This signature stems from transaction data encrypted using the SHA-256 algorithm, leading to a 64-character alphanumeric output. The SHA-256 algorithm is renowned for its robust security [118]. As a one-way hash function, it prevented decryption of the original data, thereby maintaining the blockchain's security.

This section showed how a BAAN token deposit page serves as a platform for users to accrue rewards throughout the project's lifespan. Here, users could indicate the amount of BAAN tokens they wish to invest. The system also forecasted the potential returns at the project's conclusion, where the returns from tokens were equivalent to ten houses sold.

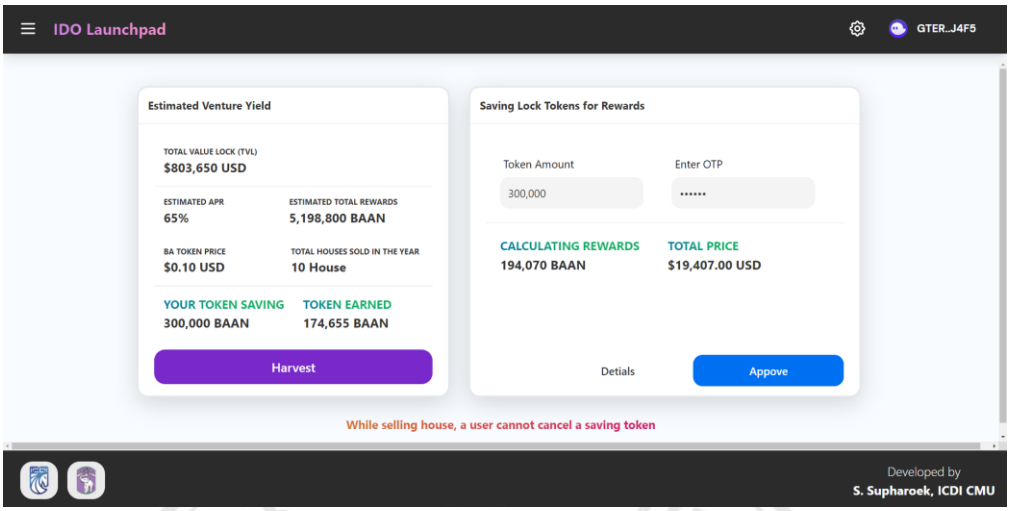


Figure 4.20 Token deposit page

The steps for depositing BAAN tokens to receive expected returns was showed in Figure 4.20. Once the user specified the number of tokens they wished to purchase, the smart contract on the decentralized platform would be signed using the public key to record the agreement between the investor and the platform, as shown in Figure 4.21.

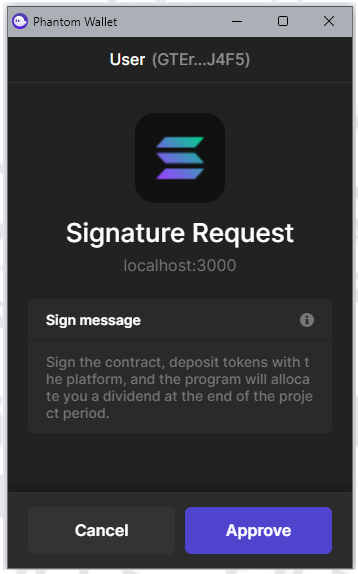


Figure 4.21 Sign message

Figure 4.21 illustrated an authentication between an investor and a project. The data was encrypted and stored on the blockchain network, as shown in Figure 4.22.

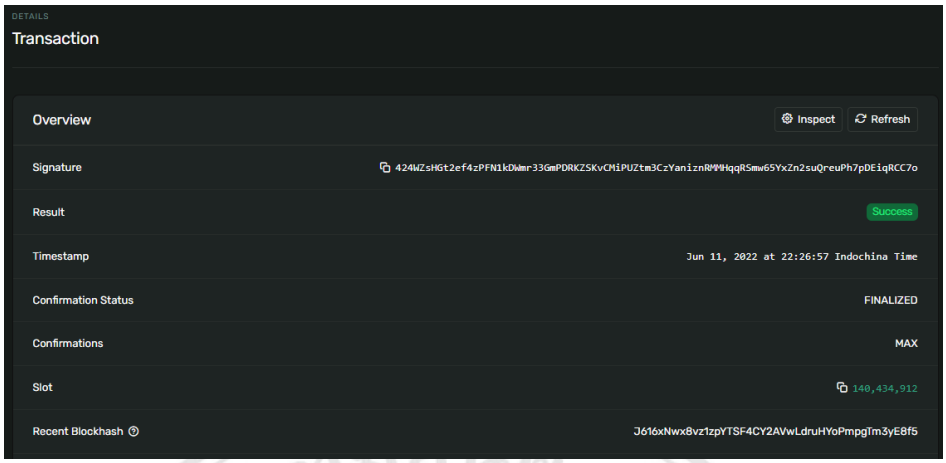


Figure 4.22 Record contract on Blockchain

4.2.4 Demonstration received of the return on investment

This section showed the results of estimating the return on investment. The return was calculated using the APR method from equation — (4). The result of the calculation from the above equation gave a return of 65%, and an investor would receive 194,070 BAAN tokens. However, the platform asked for a share of 10% from returns for development and project management, which, after deducting shares, resulted in a net investment profit of 174,665 BAAN tokens, resulting in a total net profit of 474,655 BAAN tokens, as shown in Figure 4.23.

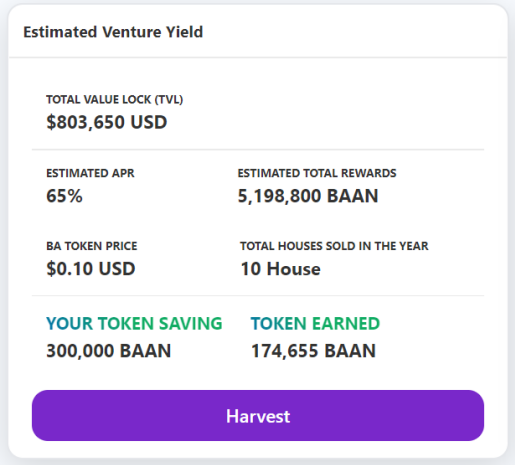


Figure 4.23 Demonstrate rewards for depositing tokens

After earning token rewards, users could exchange them for US dollars on the platform. The platform offered a token trading feature. This facilitated the conversion of BAAN token value into USDT of stable coin currency, as shown in Figure 4.24.

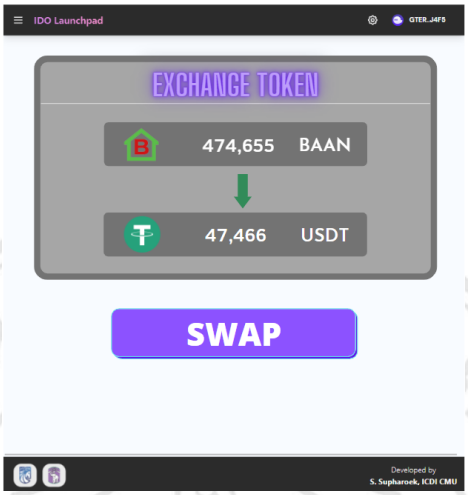


Figure 4.24 Exchange token

The exchange or 'SWAP' of BAAN tokens page [Fig. 4.24] to a stable coin named 'USDT', which holded a value equivalent to the US dollar. The projected return on investment stood at 474,655 BAAN, equivalent to 47,466 USDT. Moreover, this USDT could be moved to renowned exchanges such as Binance or Bitkub to be converted into Thai baht.

4.2.5 Estimated Shareholders' Reward

This section provided estimates for calculating the returns allocated to investors from the sale of houses in this project.

Table 4.9 Data estimated of house sales from 3 years

Period	House	Price	Liquidity	Allocate
1	5	$661,765	$401,825	$259,940
2	2	$264,706	$160,730	$103,976
3	3	$397,059	$241,095	$155,964
Total	**10**	**$1,323,530**	**$803,650**	**$519,880**

The allocation of tokens as returns was presented in Table 4.9. The reward goal would be reached once all 10 houses in the project had been sold. Totaling a total of $1,323,530, the house was sold over a three-year period, with each house being priced at $132,353. The profit from the sale was split in two. The first section deals with liquid funds. This referred to the funds raised by investors for the construction of houses in this project. The second part represented the benefit allocation fund used to create tokens to reward investors.

Table 4.10 Estimated results for APR calculation

Period	TVL	APR	Token	Team	Shares
1	$401,825	32%	97,035	$970	$8,733
2	$160,730	13%	38,814	$338	$3,493
3	$241,095	19%	58,221	$582	$5,240
Total	**$803,650**		**194,070**	**$1,941**	**$17,466**

A simulation of the APR investment return for an investment of 300,000 BAAN tokens was presented in Table 4.10. The annual returns were as follows:

In the first year, if the project sells 5 houses and yields a return of 32%, equivalent to 97,035 BAAN tokens or 9,704 USD. This amount was allocated as follows: investors receive 8,733 USD, and an additional 10% was distributed to the project team.

In the second year, if the project sells 2 houses and yields a return of 13%, equivalent to 38,814 BAAN tokens or 3,881 USD. This amount was allocated as follows: investors receive 3,543 USD, and an additional 10% was distributed to the project team.

In the final year, the sale of the remaining 3 houses brought in a 19% return, amounting to 58,221 BAAN tokens or 5,822 USD. Of this, investors received 5,240 USD, and an additional 10% was earmarked for the project team.

However, this was merely simulated data. The rewards produced by this APR mechanism were disbursed to investors in a tokenized form. The number of tokens issued correlates with the value of annual home sales. This implied that the returns from digital tokens were pegged to prices that align with real-world home values, essentially making them asset-backed tokens.

4.2.6 Feasibility Evaluation of the Token Investment

Within this section, the APR return estimation data prepared from (4.2.5) would be used to measure the performance and financial trajectory of the project over the specified period. This would facilitate an efficient assessment of profitability.

The results of the utilization of internal rate of return by equation — (5) computations to assess investment ventures, when viewed through the lens of an investor, were meticulously elucidated in Table 4.11.

Table 4.11 IRR calculation results

	CF0	**CF1**	**CF2**	**CF3**	**CF4**
Value	-30,000	0	8,733	3,493	35,240
			IRR = 14%		

Table 4.11 showed the IRR computation, wherein the variable CF denoted the annual net cash inflows. The series begins with the project's initial funding amounting to $30,000 USD, leading to a negative CF0. In the construction's first year, CF1 was set at 0. For the subsequent years, CF2, CF3, and CF4 represent year-end revenues of $8,733 USD, $3,493 USD, and a combined total of $5,240 USD plus the original $30,000 USD, respectively. This pattern suggested that a yield span of 3 years, ranging from CF2 through CF4. By applying IRR, or discount rate, was deduced to be 14%.

Furthermore, the sensitivity analysis evaluated how different outcomes vary when pivotal parameters undergo changes [119]. In essence, it gauged the shifts in model results when input variables experience alterations. Given its pivotal insights, investors and corporate decision-makers regarded this analysis with keen interest, especially when assessing business projects. This facilitates and scrutiny, making it was approachable even for those with basic financial acumen. The outcomes derived from the sensitivity analysis tool are detailed in Table 4.12.

Table 4.12 Estimated sensitivity analysis of the investor

A	B	C	D	E	F	G	H	I
№ Period	Cash inflow	Cash outflow	Cash flow	PP	№ after the payback period	Discount coefficient	Discount (reduced) cost	PI
1	$ -	$ (30,000.00)	$ (30,000.00)	$ (30,000.00)		0.91	$ (27,272.73)	
2	$ -	$ -	$ -	$ (30,000.00)		0.83	$ -	0.00
3	$ 8,733.00	$ -	$ 8,733.00	$ (21,267.00)		0.75	$ 6,561.23	0.22
4	$ 3,493.00	$ -	$ 3,493.00	$ (17,774.00)		0.68	$ 2,385.77	0.08
5	$ 35,240.00	$ -	$ 35,240.00	$ 17,466.00	5	0.62	$ 21,881.27	0.73
Totals:	**$ 47,466.00**		$ 17,466.00				**$ 3,555.54**	**1.03**

n	5
PP	4
IRR	14%
PN	$ 3,493.20

Table 4.12 showed the investment projection through digital tokens in the real estate project, highlighting the following key financial metrics:

a) Payback Period (PP)

The 'PP' was essentially the duration required for an investor to recover their initial investment. In this instance, the 'PP' was set at 4 years in a project that spans 5 years. This implied that for almost the entirety of the project's lifespan, the investor was recouping their initial outlay. Given that profitability started in the fourth year, investors should be prepared for a wait before they see any returns. This could be a concern for those looking for quicker liquidity or faster returns on their investment.

b) Internal Rate of Return (IRR)

At 14%, the 'IRR' was a measure of the project's potential return over its duration. This percentage meant that the project's expected annual return was 14%, which was robust, especially when compared to traditional, low-risk investments. The consistency of this IRR value with previous results (from Table 4.14) lended credibility and indicated that the projected returns were not anomalous but based on a solid financial model.

c) Return on Investment (ROI)

With a potential 'ROI' of 58% by the end of the period, or an average ROI/year of 21%, an investment of $30,000 could yield a profit of $17,466 over the project's lifespan. This represented a significant return, suggesting that the project offered strong profit potential. However, while the 'ROI' was substantial, investors should also consider the time value of money. Although the returns were impressive, they were

realized over the entire duration of the project. Investors needed to consider the opportunity cost of committing their capital for this period.

d) Profitability Index (PI)

The PI was an indicator of a project's attractiveness in terms of the present value of future cash flows versus the initial investment. A 'PI' greater than 1.0 typically signals a worthy investment, it suggested that the present value of the project's future cash flows exceeded the initial outlay. With a 'PI' of 1.03, the project appeared to be marginally above the threshold for viability. While this was positive, it was a modest ratio.

In this project simulation environment presented as a viable investment methodology with a decent rate of return and profitability. However, potential investors should be comfortable with the prospect of waiting until the fourth year to start realizing profits. The moderate PI value suggested that while the project was financially sound.

4.2.7 Comparison of Related project

To provide a comparative analysis of four distinct blockchain projects in the real estate sector: "BAAN," "SiriHub," "RealX," and "Empowa," in terms of their structure, potential returns, regulatory oversight, and unique selling propositions. This would enable investors to make informed decisions based on their individual preferences, as it was shown in Table 4.13.

Table 4.13 Comparison of blockchain usage in the real estate sector among BAAN, SiriHub, RealX, and Empowa

Criteria	BAAN	SiriHub	RealX	Empowa
Structuring cost and complexity	Easy	Difficult	Easy	Difficult
Company Type	Startup scale	Public company	Public company	Startup scale
Categories	IDO	ICO	ICO	ISPO
Token sale	8,036,470 BAAN	SiriHubA: 160,000,000 SiriHubB: 80,000,000	1,000,000,000 RELAX	6,042,439 EMP
Project's period	5 years	4 years	5 years	10 years
Provider	DeFi Application Solana Blockchain	XSpring	1. TokenX 2. Bitkub	DeFi Application Cardano Blockchain
Dividend distribution	Avg. 21% / Year	Avg. 4.5% / Year (Token A) Avg. 8.0% / Year (Token B)	Avg 5.0% / Year	The project will pay back to investors as EMP tokens which is 420 EMP tokens
Asset-backed token	Yes	Yes	Yes	No
Nature of underlying asset	The project will return the profit to investors annually	The project will return the profit to investors, and the percentage of return depends on the type of tokens	Digital tokens allow investors to virtually own real estate or condominiums in micro-square inches.	The project will return EMP tokens or Impact Cards (NFT) to investors within 10 years or 120 months
Regulator	No	Thai SEC	Thai SEC	No
Platform	Decentralized	Centralized	Centralized	Decentralized

In the blockchain domain of the real estate sector, the projects "BAAN," "SiriHub," "RealX," and "Empowa" each delineate a distinct niche, offering attributes specifically designed to cater to diverse investor predilections as follows:

BAAN: This platform stood out primarily due to its potential high returns. Its decentralized nature might resonate with investors who favor direct investments with fewer intermediaries. Typically, decentralized platforms aimed for streamlined transactions, which often translated to higher returns. However, the lack of centralized oversight meant investors should be vigilant about associated risks.

SiriHub: Falling under the Thai SEC's jurisdiction, SiriHub offered investors the comfort of regulatory oversight, which often brought a semblance of security. The introduction of a dual-token system added a layer of flexibility, allowing investors a choice between two distinct ROI prospects.

RealX: Sharing regulatory oversight from Thai SEC like SiriHub, and with the backing of a public company, RealX might instill additional confidence in investors. Its unique approach allowed investors to hold virtual pieces of real estate or condominiums on a micro-scale. This approach had the potential to revolutionize real estate investment, broadening accessibility.

Empowa: With a distinctive 10-year project span, Empowa's proposition set it apart. Rather than traditional returns, it provided EMP tokens or Impact Cards (NFTs). This long-term vision might be enticing for investors looking for extended engagements, and the token-based returns might pique the interest of those intrigued by the broader applications of blockchain.

In summation, while BAAN's model offered potentially high returns on a decentralized platform, platforms like SiriHub and RealX might cater to those with a preference for regulatory oversight and the assurance of public company backing. Empowa, with its extended project scope and distinctive return approach, presents a unique investment avenue. It was crucial for investors to evaluate the benefits and potential pitfalls of each platform against their individual investment goals and strategies.

4.3 Benefits and Potential Challenges (Section 3)

This section presents a guide to the results obtained from the social media sentiment analysis tool and the outcomes of a blockchain token deployment demonstration in an initial project. It outlines both the potential and challenges for industry projects that are beginning to adopt blockchain in the future, which is consistent with the purpose of study at (1.2.4), as follows:

4.3.1 Sentiment Analysis Model

The application of blockchain technology in real estate investment on social media platforms could lead to positive sentiment and contribute to the industry's growth in the post-COVID-19 era. Blockchain's ability to provide increased trust, transparency, security, efficiency, global accessibility, fractional ownership, and cost-effectiveness had the potential to revolutionize real estate investment and attract a broader range of investors. The results of the sentiment analysis were interpreted to identify patterns, common themes, and significant shifts in sentiment. Positive and negative sentiments were analyzed separately, with a focus on the key aspects driving each sentiment as follows:

4.3.1.1 Positive Sentiment:

a) Transparency and Security: Users noted that blockchain offered enhanced transparency, which increased confidence among investors in the real estate investment industry. The immutability and decentralized structure of blockchain were viewed as viable solutions to reduce fraud and improve transaction security.

b) Improving Efficiency and Reducing Costs: Blockchain technology was seen to automate procedures and eliminate middlemen in real estate transactions, leading to enhanced efficiency and cost reduction for investors, developers, and buyers.

c) Users observed that blockchain technology had the potential to democratize real estate investment by allowing fractional ownership and enabling greater market participation. This feature was enthusiastically embraced and viewed as an opportunity to promote more diversity in the industry and enhance transaction security.

4.3.1.2 Negative Sentiment:

a) Regulation and Compliance: Users expressed concerns regarding the regulatory frameworks governing the use of blockchain technology in the real estate sector. There were worries about ensuring compliance with the law and the need for appropriate regulations to manage potential risks and ensure ethical behavior.

b) Standardization and Interoperability: Several users emphasized the importance of standardization and interoperability across blockchain platforms to facilitate seamless integration and data sharing within the real estate industry. The lack of standardization was identified as a potential barrier to widespread acceptance.

4.3.2 Initial Decentralized Offering Model

In this part of the considerations of the IDO model, it has two sections, which are Potentials and Benefits and Challenges and Concerns, as follows:

4.3.2.1 Potentials and Benefits:

a) Tokenization: The real estate sector could tokenize private assets on the blockchain, streamlining transactions and asset exchanges.

b) Access to a Broad Investor Base: IDOs appealed to both retail and crypto investors interested in the real estate sector via tokens.

c) Reduced Capital Raising Costs: Token sales via IDOs could minimize the costs of capital collection and associated fees.

d) Transparent and Secure Transactions: Leveraging blockchain and cryptography, IDOs ensured secure transactions and indelible data records.

e) Investment Flexibility: Investors had the option to trade tokens for a fraction of an asset, eliminating the need to buy the entire property.

f) Future Application Support: As blockchain technology and 'DeFi' (Decentralized Finance) evolve, understanding IDOs became essential for future real estate applications.

4.3.2.2 Challenges and Concerns:

a) Technical Comprehension: Grasping the nuances of blockchain and the mechanics of IDOs remained challenging for many, complicating promotional efforts and potentially undermining investor confidence.

b) Regulatory Stability: Not all countries' regulations had adapted to the rise of IDOs or tokenized real estate investments.

c) Investment Risks: Not all projects launching through IDOs would thrive, presenting potential capital loss risks for investors.

d) Management and Operations: Launching a real estate IDO demands a skilled team proficient in project management, as well as expertise in finance and technology.

e) Market Acceptance: Traditional markets might be slow to embrace new investment or asset management paradigms.

f) Building Trust: The novelty of this technology and investment approach necessitates cultivated market trust.

4.4 Discussion

This research presented potential innovations in the real estate industry that are hindering business progress. Used by social media sentiment analysis tools. The results of the analysis were mostly positive, indicating online users' opinions towards the potential of blockchain innovation in the real estate sector. After getting the results of the sentiment analysis, the study found that most people are very interested in the tokenization of assets and the security enhancement, which is the reason to create a decentralized blockchain-based digital token demonstration model to study how tokens can be used for funding small real estate startup projects. When collecting and analyzing these results, it can be interpreted that after the COVID-19 pandemic, society was rapidly changed into the digitalization era that most traditional financial transactions have adapted to digital financial, which is already shown in the result of sentiment analysis. Furthermore, the demonstration crowdfunding model is a described the way to do IDO real estate crowdfunding via blockchain, which this model can be an initial model for other people to use or develop to make it become a real crowdfund in the near future.

Therefore, the research concludes that blockchain technology harbors transformative potential for the real estate sector, notwithstanding its technical and regulatory challenges. The favorable sentiment observed on social media emphasizes blockchain's potential to significantly impact the industry. There is a clear need for further

exploration into the technological hurdles, economic ramifications, and broader integration of blockchain within the sector. Such an inquiry lays the groundwork for a comprehensive understanding of the disruption blockchain is bringing to traditional real estate practices and the intricate challenges involved. This study highlights blockchain's promising future in real estate and also calls for continued research and adaptation to harness its full potential.

The research results of this study achieved the following purposes:

In purpose 1.2.1, the study has achieved its purpose because the results of the comprehensive literature review conducted as part of this research revealed numerous barriers and significant shifts in various sectors, particularly emphasizing the period before and after the COVID-19 pandemic. This era has been identified as a critical turning point, marked by the rapid global adoption of digital technologies and methods. The advancements have brought to light various challenges and pain points specific to real estate projects. In response to these findings, the study embarked on a series of studies and experiments, aiming to delve deeper into these identified issues. The outcomes of these investigative efforts are documented in the study results, result 4.1 (Section 1), result 4.2 (Section 2), and result 4.3 (Section 3) of Chapter 4. These sections collectively provide a detailed analysis of the impact on the real estate sector, offering insights into the potential of digital solutions in addressing the industry's emerging challenges.

In purpose 1.2.2, the study has achieved its purpose, as evidenced by findings that demonstrate the effectiveness of machine learning tools in categorizing social media comments about blockchain-based real estate investments. These tools skillfully dissect sentiments across positive, neutral, and negative ranges, delivering consistent and insightful outcomes. The results underline the interesting relevance of blockchain in real estate and the public's perception of it. For an in-depth examination of these results, detailed analyses can be found in result 4.1 (Section 1) and specifically in subsection 4.1.3, which indicates that all sentiment analysis tools, when applied to the same dataset, consistently demonstrate a positive impact of blockchain on real estate projects.

In purpose 1.2.3, the study has achieved its purpose. It provides an in-depth experimental of the mechanisms employed to showcase the use of blockchain-based digital tokens in real estate projects. A focal point of this analysis is the deployment of

Initial DEX Offerings (IDOs) on decentralized platforms. This innovative approach highlights a new frontier in real estate financing and investment. Furthermore, the study conducts a comparative analysis, juxtaposing various blockchain-utilizing real estate projects within the same sector. This comparative perspective offers a broader understanding of blockchain's application and potential in the industry, refer to result 4.2 in (Section 2).

In purpose 1.2.4, the study has achieved its purpose. As detailed in Result 4.2 (Section 2), it demonstrates the utilization of tokens in real estate projects. This includes a comprehensive look at blockchain fundraising, the creation and management of tokens, engaging investors, evaluating returns on investments, and benchmarking against similar projects. These facets provide crucial insights for informed decision-making in real estate investments. Moreover, the sentiment analysis results are interpreted to identify patterns, general issues, and significant shifts in sentiments. Positive and negative emotions are analyzed separately, with a focus on the key factors driving each sentiment. This analysis is based on the findings presented in result 4.3.1. Additionally, result 4.3.2 (Section 3) delves into the benefits and challenges of employing the Initial DEX Offering (IDO) model in real estate. It covers critical areas such as the requisite technical knowledge, navigating regulatory frameworks, managing investment risks, operational strategies, gaining market acceptance, and fostering trust. This dual focus offers a well-rounded perspective on the innovative application of blockchain in real estate.

CHAPTER 5

CONCLUSSION

This research document delved into potential innovations for the real estate sector, which had struggled to progress in its business operations following the COVID-19 crisis. This stagnation was attributed to several pivotal factors. Upon reviewing the literature, it became evident that certain technological approaches, especially blockchain, hold significant promise to rejuvenate the real estate industry. Numerous projects had leveraged blockchain to facilitate their objectives. Examples, they had included the use of blockchain to enhance the transparency of financial transactions, the elimination of traditional investment intermediaries, and the adoption of digital tokens for fundraising by startups. Blockchain presented immense potential advantages for the real estate sector. However, blockchain also confronted a multitude of challenges and limitations. Some projects fail to achieve success, potentially due to a lack of thorough insight or feedback from users and investors at the outset. This often resulted in directionless project development, highlighting a critical area of concern. Furthermore, the perspectives and sentiments expressed in the media and online communities played a pivotal role in shaping the trajectory of many blockchain-centric projects. These sentiments could be distilled and analyzed through various programming techniques.

This study specifically aimed to analyze sentiments expressed on social media about real estate investments powered by blockchain. The underlying hypothesis was that social media sentiment was largely positive regarding such investments. The research particularly emphasized sentiment analysis derived from Reddit data spanning the post-COVID-19 era from 2020 to 2023. The sentiment analysis executed using three tools: TextBlob, SentiWordNet, and VADER, yielded intriguing findings. While TextBlob tended to classify a larger proportion of the data as positive, suggesting a general positive bias, VADER leaned towards a more conservative stance, designating most data as neutral. SentiWordNet, on the other hand, appeared particularly attuned to negative sentiments, marking the highest percentage of data points in that category. The optimal

tool might vary based on the specific use case and dataset characteristics, as each tool possesses unique strengths tailored for different scenarios and needs. Additionally, post-COVID-19 outbreak, sentiment analysis revealed a predominantly positive inclination towards integrating blockchain in the real estate sector on social media platforms. Users predominantly extoled its virtues, like heightened transparency and cost reductions. However, issues like scalability, data privacy, and regulatory challenges remained prevalent. Developers might recognize and address these concerned to ensure the effective implementation of blockchain projects in the real estate domain. Notwithstanding these challenged, the overarching sentiment on social media underscores blockchain's transformative potential within the real estate sector.

Additionally, this research had one more aim: to elucidate the role of IDOs in the capital accumulation process within the real estate sector. The findings might have indicated a paradigm shift in real estate financing approaches. Such an exploration underscored the potential of decentralized mechanisms to enhance transactional efficiency and mitigate the impediments inherent to conventional real estate intermediaries. The implementation of token offering within the real estate sector offered transformative potential in the landscape of asset investment and management. The advantages of tokenization, which included streamlining transactions and the potential for cost reductions, introduced a revolutionary approach to real estate funding mechanisms. Access to a broad investor base and the transparent, secure nature of blockchain transactions further amplified the potential benefits. However, the effectiveness of "IDO" was not without its challenges. Technical complexities and the need for a nuanced understanding of blockchain mechanics presented barriers for some stakeholders. Regulatory uncertainties, investment risks, and the demand for skilled management teams emphasized the necessity for meticulous planning and expertise in both finance and technology. While market hesitancy and trust-building remained integral issues to address, the study underscored the undeniable influence of "IDO" in reshaping capital accumulation processes in the real estate sector. Conclusively, during the study, we found the importance of token offerings and blockchain's transformative prowess to be palpable. The journey was mired with technical intricacies, regulatory ambiguities, and the ever-present needed for expertise in both technology and finance. The study, thus,

stands as a testament to both the revolutionary prospects of blockchain in real estate and the intricate challenges that lie in its path.

Following the comprehensive insights unveiled in this study, there was an evident pathway for extending research into various domains. One primary direction was to expand the range of data sources. While our research predominantly centered on Reddit for sentiment analysis, subsequent investigations could branch out to other platforms. Engaging with sources like Twitter, LinkedIn, and specific real estate forums might yield different sentiment dynamics, providing a holistic perspective on market sentiment. Another significant direction could be a meticulous exploration of projects that did not find success. Analyzing these failures could offer crucial insights, uncovering shared pitfalls and strategies that might be more conducive to success in the future. A significant area of concern, especially given the evolving technological landscape, was the realm of regulations. A focused exploration into the changing regulatory paradigms for blockchain in real estate, including a comparative analysis across countries and emergent best practices, could provide a clearer picture of the future trajectory. The technological challenges, especially those surrounding scalability and data privacy, deserved a detailed investigation. By diving deeper into these challenges, the industry could be better equipped for expansive implementations in the future. Furthermore, the economic implications of integrating blockchain into real estate, from a cost-benefit analysis to the long-term financial prospects, warranted a thorough analysis. This extended to understanding the economic disruptions the technology might trigger in the sector. Moving forward, these studies could help in elucidating the strategies that worked, the challenges encountered, and the unique solutions devised. Additionally, it would be fascinating to discern how blockchain intersects with other burgeoning technologies, such as artificial intelligence, the Internet of Things, and big data analytics, within the real estate framework. Finally, this research had made the way in elucidating the myriad potentials of blockchain in the real estate arena. As we find ourselves at the cusp of a technological renaissance in real estate, an ongoing commitment to research and knowledge-building remained essential to navigate the future.

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APPENDICE

CURRICULUM VITAE

Author's Name	Mr. Supharoek Siriphen	
Place of Birth	Chiang Mai Province, Thailand	
Education	2019	Bachelor of Engineering, Computer Engineering at Rajamangala University of Technology and Science University, Chiang Mai, Thailand
	2016	Higher Vocational Certificate in Technical Computer from Chiang Mai Technical College, Chiang Mai, Thailand
Internship	2019	In the position of Software Engineer at the Northern Meteorological Department in Chiang Mai, Thailand, my development responsibilities included developing a heat index forecasting program, managing satellite servers, and engaging in web development
Publications	2023	Supharoek Siriphen (First author) et al., "Social Media Sentiments of Real Estate Investment on Blockchain Technology in Post-COVID-19," International Journal of Intelligent Systems and Applications in Engineering, (ISSN: 2147-6799), Novemver 2023, 12(5s), Page No. 347–359.
	2022	Supharoek Siriphen (First author) et al., "Real Estate Fundraising Using the IDO Process Based on Blockchain Technology," The 3rd International and National Conference, International Conference on Proactive Management of Cooperative and Social Enterprises Reacting to the Challenges of New Social Dynamics, Kasetsart University, July 2022, Page No. 42-52.

	2022	Supharoek Siriphen (Co-author), "Visualizing Electrical Energy Consumption with Virtual Augmented Technology and the Internet of Things," the 4th International Conference on Environment, Resources, and Energy Engineering (EREE), Volume 1094 Issue 1, Article No. 012010, 2022, DOI: 10.1088/1755-1315/1094/1/012010.
	2022	Supharoek Siriphen (Co-author), "Semi-automated IoT based Cabinet for Rearing Black Soldier Fly Larvae (BSFL)," 2022 7th International Conference on Information and Network Technologies (ICINT), Okinawa, Japan, 2022, Page No. 80-84, DOI: 10.1109/ICINT55083.2022.00020.
	2021	Supharoek Siriphen (Co-author), "Designing Trustworthy Microfinance Blockchain System Based on PoA Consensus Mechanism," the 16th International Conference on Humanities and Social Sciences, Khon Kaen University, Page No. 176-190.
Experience	2022 - 2023	In the position of Laboratory Manager for Research and Development of Herbs for Medical Use in the Biological Laboratory at the RPAH project in collaboration with APA Industries and Payap University, Chiang Mai
	2019 - 2022	In the Position of Research Assistant at Fabrication Laboratory (FabLab) within the International Research and Service Center, ICDI at Chiang Mai University, Thailand
Other:	2021 - 2022	Teaching Assistant and Mentor for the Nondegree New Generation of Graduates, ICDI at Chiang Mai University

- Smart Digital courses at Chamber of Commerce (First and Second sections) and Montfort College, Chiang Mai
- Smart Digital course at Meta Chinese of the Confucius Institute, Chiang Mai
- Smart Electronic courses at Rajamangala University of Technology Lanna, Chamber of Commerce (Sakon Nakhon), Phanomsarakham Technical College, Chachoengsao Technical College, Rajabhat Rajanagarindra University, Banglamung Inter-Tech College, and Aeronautical Radio of Thailand, Bangkok

2020 - 2021

- Smart Digital courses at the Chamber of Commerce and Sri Suphan Temple, Chiang Mai
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- Smart Electronic and Digital courses at Sahapat industrial, Bangkok
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