MARMARA UNIVERSITY
INSTITUTE FOR GRADUATE STUDIES
IN PURE AND APPLIED SCIENCES

ANALYSIS OF CRYPTO ASSET INVESTMENT PROCESSES USING FUZZY BASED MULTI CRITERIA DECISION MAKING METHODS

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MASTER THESIS

Department of Industrial Engineering

Thesis Supervisor
Asst. Prof. Dr. Semih ÖZEL

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ÖZET

KRİPTO VARLIK YATIRIM SÜREÇLERİNİN BULANIK TABANLI ÇOK KRİTERLİ KARAR VERME YÖNTEMLERİ İLE ANALİZİ

Günümüzde, internet uygulamalarının gelişmesiyle birlikte kripto para olarak yaygınlaşan, fiziksel bir varlığı olmayan ve tamamen internet üzerinden alınıp satılabilen finansal varlıklar popüler hale gelmiştir. Çeşitli ticari işlemlerin yapılmasına olanak sağlamasının yanında gelecekte daha da değerli hale gelebileceğinin düşünülmesi sebebiyle kripto paralara yatırım yapan kişi sayısı da gün geçtikçe artmaktadır.
Literatür araştırmasına göre özellikle son yıllarda bu konuda yapılan araştırmaların arttığı gözlenmiştir. Bu çalışmaların çoğunluğunda kripto paraların geçmiş fiyatlarına bakarak gelecek fiyatlarının tahmin edilmeye çalışıldığı görülmüştür. Fakat kripto paralardaki bu yüksek dalgalanma ve değişkenlik, fiyatların tahmin edilmesini zorlaştırmaktadır. Dolayısı ile bir blok zincir teknolojisi kullanılarak oluşturulan kripto varlıkların, sadece geçmiş fiyatlarına bakılarak değil birçok kriter göz önünde bulundurularak değerlendirilmesi gerekmektedir.
Bu çalışmada, öncelikle blok zincir teknolojisi anlatılmış ve kripto varlıkların daha iyi anlaşılması için genel bilgiler sunulmuştur. Bununla birlikte kripto paralara yatırım süreci için bir karar verme modeli oluşturulmuştur. Bu amaçla öncelikle kriterler belirlenmiş ve bu kriterler kullanılarak Bulanık Çok Kriterli Karar Verme yöntemleri ile belirli kripto paraların değerlendirilmesi sağlanmıştır.
Bu amaçla Teknik Faktörler, Ekonomik Faktörler ve Sosyal & Çevresel Faktör olmak üzere 3 ana kriter ve 13 alt kriter literatür araştırması ile belirlenmiştir.
Kriter ağırlıkları, uzman değerlendirmelerinin Bulanık SWARA ve Bulanık DEMATEL yöntemleri kullanılarak hesaplanması ile elde edilmiştir. Alternatiflerin değerlendirilmesi içinse bulanık TOPSIS yöntemi kullanılmıştır.

Bu çalışma ile kripto varlıkları teknik bakımdan incelenerek karar verme konusunda bilimsel bir çalışma ortaya konmuş, bu alanla ilgili çalışmalar yapan araştırmacılara yol göstermesi hedeflenmiştir. Çalışma kesinlikle finansal bir yatırım tavsiyesi niteliği taşımamaktadır.

Anahtar kelimeler; Blockzincir, Kripto varlıklar, Kripto para, Bulanık SWARA, Bulanık DEMATEL, Bulanık TOPSIS, Bulanık Tabanlı Çok Kriterli Karar Verme

ABSTRACT

ANALYSIS OF CRYPTO ASSET INVESTMENT PROCESSES USING FUZZY BASED MULTI CRITERIA DECISION MAKING METHODS

Nowadays, with the development of internet applications, financial assets that have become widespread as crypto money, which do not have a physical existence and can be bought and sold completely over the internet, have become popular. In addition to allowing various commercial transactions, the number of people investing in cryptocurrencies is increasing day by day, as it is thought that they may become more valuable in the future.

According to the literature research, it has been observed that research on this subject has increased especially in recent years. It has been observed that most of these studies attempt to predict the future prices of cryptocurrencies by looking at their past prices. However, this high fluctuation and variability in cryptocurrencies makes it difficult to predict prices. Therefore, crypto assets created using blockchain technology should be evaluated not only by looking at their past prices, but also by taking into account many criteria.

In this study, blockchain technology is first explained and general information is presented for a better understanding of crypto assets. In addition, a decision-making model has been created for the investment process in cryptocurrencies. For this purpose, first of all, criteria were determined and using these criteria, certain cryptocurrencies were evaluated with Fuzzy Multi-Criteria Decision Making methods.

For this purpose, 3 main criteria and 13 sub-criteria, namely Technical Factors, Economic Factors and Social & Environmental Factors, were determined through literature research. Criterion weights were obtained by calculating expert evaluations using Fuzzy SWARA and Fuzzy DEMATEL methods. The fuzzy TOPSIS method was used to evaluate the alternatives.

With this study, a scientific study on decision-making was presented by examining crypto assets from a technical perspective, and it was aimed to guide researchers working on this field. The study certainly does not constitute a financial investment recommendation.

Keywords; Blockchain, Crypto assets, Cryptocurrency, Fuzzy SWARA, Fuzzy DEMATEL, Fuzzy TOPSIS, Fuzzy Based Multi-Criteria Decision Making

SYMBOLS

Sj **:** Comparative significance of mean value

K_j **:** Comparative importance coefficient

Qj **:** Significance vector value

Wj **:** Criteria weights found by SWARA method

X **:** Defuzzified number

di **:** Distance from the fuzzy negative ideal solution

***A* *** : Negative ideal solution

A^- **:** Positive ideal solution

CCi **:** Closeness coefficients for the alternatives

ABBREVIATIONS

BTC **:** Bitcoin

ETH **:** Ethereum

CFCS **:** Converting Fuzzy data into Crisp Scores

DEMATEL: Decision Making Trial and Evaluation Laboratory

DLT : Distributed Ledger Technology

SWARA **:** Step-Wise Weight Assessment Ratio Analysis

TOPSIS **:** Technique for Order Preference By Similarity to an Ideal Solution

MCDM **:** Multiple Criteria Decision Making

ICO : Initial Coin Offering

PBFT : Practical Byzantine Fault Tolerance

PoS ; Proof of Stake

PoW : Proof of Work

NFTs : Non-fungible tokens

PoA : Proof of Authority

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1. INTRODUCTION

Blockchain technology serves as the foundational infrastructure for a significant portion of cryptocurrencies. Essentially, it functions as an encrypted and decentralized electronic ledger. In the context of blockchain technology, it is important to note that data is not held within a singular system, such as a server computer. In contrast, the process involves the replication and retention of data across all nodes inside the system through the utilization of the Distributed Ledger Technology (DLT) architecture. The blockchain architecture possesses the capability to be utilized in several domains, eliminating the requirement for an intermediary. However, its primary purpose is to maintain an enduring and unmodifiable ledger of all authorized transactions pertaining to cryptocurrencies. The blockchain technology functions as a decentralized method for approval. The records inside the system are validated by a large number of users, referred to as nodes, rather than relying on a central server. Registries are centralized institutions that are under the jurisdiction of a singular entity and rely on a singular database. The blockchain is a sequential series of interconnected blocks containing information that is arranged in chronological order and protected by cryptographic proofs (Binance Academy, 2020). Within the framework of blockchain architecture, one encounters Bitcoin and its various variants, which serve as a kind of digital currency.

The concept of a crypto asset lacks a universally agreed consensus, as stated by HM Treasury in 2018. The below explanations present many definitions of crypto assets as documented in scholarly literature, all of which share fundamental similarities.

Crypto assets refer to digital representations of value that may be electronically transferred, stored, or traded. This encompasses non-fungible tokens (NFTs) as well. Crypto assets are a distinct category of digital assets that employ cryptographic techniques to safeguard digital information and distributed ledger technology to document and authenticate transactions.Cryptoassets refer to digital representations of value or contract rights that are cryptographically secure and utilize distributed ledger technology. These assets may be electronically transferred, stored, and exchanged (HM Treasury, 2018). In scholarly discourse, the examination of crypto assets is commonly categorized into two primary groups: cryptocurrencies and tokens (Ernst et al.,2018).

Bitcoin was the pioneering cryptocurrency, but, a multitude of cryptographic currencies

and cryptographic assets, sometimes referred to as "tokens," have emerged since. Hence, it may be inferred that cryptocurrencies, along with other assets distinct from traditional fiat currencies, are classified as crypto assets. Cryptology, sometimes referred to as the discipline of encryption, pertains to the utilization of encryption techniques in the context of virtual currencies that operate online and are decentralized, without any central governing authority.Cryptocurrencies are a type of digital asset that is encrypted and safeguarded, offering a novel and alternative medium of Exchange (Kesebir et al.,2019).

The field of encryption encompasses the study and use of cryptographic technology. The system provides data encryption functionality. In contrast, Bitcoin is classified as a digital asset primarily utilized for the purpose of facilitating commerce. Cryptocurrencies are transferred in the digital arena through the utilization of cryptographic methods, which involve the creation and subsequent decryption of passwords (Aksoy et al., 2020).

Cryptocurrency and blockchain technologies are being utilized across several industries. The growing preference for cryptocurrency as an alternative form of currency has led to a significant surge in its usage over the years. This trend is seen in the substantial growth in the number of listed crypto assets on CoinMarketCap, a prominent platform in the cryptocurrency industry, which currently boasts over 1600 types of crypto assets (Yılmaz et al., 2022).

It is crucial for nations and individuals to conduct a comprehensive analysis of the growth and potential ramifications of cryptocurrencies within the evolutionary trajectory of these digital assets. As of November 2017, the daily transaction volume of cryptocurrencies surpassed $3 billion. This analysis should primarily focus on the financial advancement that cryptocurrencies can offer to both nations and individuals. The impact of cryptocurrencies on investor portfolios, mostly utilized for financial objectives, has significant importance owing to their pronounced volatility and exemption from legal regulations (Öncü et al.,2021).

In recent years, there has been a significant amount of study conducted on the subject of crypto assets. However, the majority of these research primarily focusses on the technical features of cryptocurrency assets or are centered around price prediction. Insufficient study has resulted in a dearth of information about the factors influencing user preferences for crypto assets.

It has been established that a significant proportion of individual investors in crypto assets tend to take into account only a few key elements when making investment decisions in this particular asset class. With this study, a decision support system that can help those who want to invest in cryptocurrency will be developed. The system aims to identify the key factors that should be taken into account throughout the investment process and aid in selecting the most optimal solution from the available possibilities. Therefore, it will aid investors in formulating trading strategies. Initially, the establishment of criteria will be undertaken, followed by the assignment of appropriate weights to each criterion. During the process of determining criteria, a thorough review of relevant literature will be undertaken, with past studies serving as a point of reference.

Cryptocurrencies have substantial prospects in terms of their revenue generation and adaptable manufacturing capacities. Nevertheless, the environmental impact and potential future consequences of the crypto mining process are substantial due to high levels of energy usage, carbon emissions, and technological trash. Due to their virtual nature, cryptocurrencies possess inherent resistance against cyber assaults originating from the internet. This attribute assumes significance in the assessment of cryptocurrencies' dependability.

This study aims to comprehensively investigate and evaluate cryptocurrencies, considering several elements like the Impact of Crypto Mining on Air Pollution and Climate Change, the trustworthiness of cryptocurrencies, and the potential benefits offer. Additionally, this research seeks to establish standards for assessing cryptocurrencies. The utilization of fuzzy logic is anticipated in the process of criterion selection. Fuzzy logic is favored because to its capacity to address the inherent uncertainty in human cognition by converting imprecise verbal phrases into numerical values.

1.1 Aim and Scope

In this thesis study, Fuzzy SWARA and Fuzzy DEMATEL methods, which are multi-criteria decision-making methods that have not been applied before in the evaluation of cryptocurrency investment criteria in the literature, have been tried to be explained in detail, and the original criteria and altcoin alternatives are explained. Compared using Fuzzy TOPSIS. In general, the criteria determined by expert decision makers were weighted with the Fuzzy SWARA method and Fuzzy DEMATEL using linguistic

expressions, and then the most ideal solution and the ranking of alternative solutions were found with the Fuzzy TOPSIS method. This is not investment advice, but a scientific study. The aim of this study is to;

To examine crypto projects that have become very popular all over the world in recent years, to determine which criteria are important when investing in these projects, and using these criteria to invest in the right projects among alternatives with the multi-criteria decision-making method.

2. LITERATURE REVIEW

In this section, it is explained what has been researched by researching the previous studies of the researchers about the choice and methods of cryptocurrency. There is not much research in determining the criteria for the selection of cryptocurrencies and in the selection of alternatives. The methods and combinations used will be described. These studies are a reference to the study and these studies are included in different articles, publications, and books. It is examined in detail and the conclusions of the study are discussed in the parts that follow.

2.1. Crcyptocurrency Investment

Studies on this subject are limited.In Table 1, a literature review has been made for the criteria discussed in crypto money investment. Information on the methods and criteria used in similar studies is given. In the literature, 5 studies on a similar subject have been identified. Information such as how to measure the criteria specified in these studies or where they can be reached is not mentioned. Generally, economic evaluations were made, and economic criteria were used extensively. In the past studies, issues such as the environmental damage of Cryptocurrency transactions, social media impact, the concept of tokenomics and the effects of consensus mechanisms have never been addressed. These criteria will also be discussed in this study.

In general, the use of Fuzzy Topsis-Fuzzy Swara,Fuzzy Topsis-Fuzzy Dematel in the selection of crypto money alternatives and in the weighting of the selection criteria was not found in the literature review.

Table 1. Criteria and methods considered in cryptocurrency investment

	Studies					
Criteria	Çilek A. (2022)	Katrancı A. et al (2020)	Bulduk S.et al (2023)	Genç U. C. et al. (2018)	Arıkan Kargı S. (2022)	This study
Supporting Organizations	√	√	×	×	√	√
Total Market Value	√	√	√	√	√	√
Security	√	√	×	×	√	√
Number of Exchanges Traded in	√	√	√	√	√	×
Transaction Speed	√	√	√	√	√	√
Coin Team	×	√	×	×	×	√
Change from Peak Value	√	√	√	√	√	evaluated differently
Total Market Value	√	√	√	√	√	√
Roadmap	×	√	×	×	×	√
white paper	×	√	×	×	×	evaluated differently
Social media Activity	×	×	×	×	×	√
Competition	×	×	×	×	×	√
Environmental impact	×	×	×	×	×	√
Token economy	×	×	×	×	×	√
Transaction fee	×	×	×	×	×	√
Decentralization	×	×	×	×	×	√
Annual Average Return	√	√	√	√	√	×
Methods	LBWA	F-CODAS	ENTROPY-ARAS	AHP	F-TOPSIS	Fuzzy TOPSIS, Fuzzy SWARA, Fuzzy DEMATEL

When it comes to investing, Bitcoin is frequently the first port of call for individuals who are new to cryptocurrencies. It is one of the biggest cryptocurrencies by market cap and the most well-known blockchain project.

However, there are several other cryptocurrencies. While some alternative coins leverage pre-existing networks (like Ethereum or BNB Smart Chain), others use their own blockchain. Every project has a unique idea, and each offers potential advantages and hazards of its own. The criteria that can be used while making the selection for this subject will be mentioned.

2.2. Fuzzy Step-Wise Weight Assessment Ratio Analysis (Fuzzy Swara)

Fuzzy SWARA is a method in which fuzzy expressions are used during comparisons in the SWARA method. The Fuzzy SWARA method, which is built on fuzzy logic, allows the evaluation process to be more effective and close to reality, despite the difficulties experienced while making a decision. Taking into account the uncertainty, the SWARA method is the preferred method for weighting the criteria in a fuzzy environment.

The SWARA method was first used by Keršuliene et al. (2010) revealed by when a literature review is made for the SWARA method; Aghdaie et al. (2014) is used for the sales branch selection problem. Considering the studies carried out in recent years; Peker B. (2023) Facility Location Selection was made with Fuzzy SWARA and Fuzzy CODAS Methods in the Manufacturing Industry, by using fuzzy SWARA approach to calculate the priority weights and final ranking of lean enablers, Sharma H. (2023) identified criteria weights for enhancing supply chain agility., Fuzzy SWARA and Fuzzy COPRAS are used in Green Lean Supplier Selection by Şahin Y. and Arc (2023) , Puška, A (2022) eve et al. Fuzzy SWARA and Fuzzy CRADIS approaches were used in the selection of locations in the establishment of distribution centers. A Comparison of the Financial Performance of Turkish Cement Firms with the subjective Fuzzy SWARA method-COPRAS MAUT Methods was made by Demir G. (2021). It is seen that Şengül et al. (2021) used the Fuzzy swara method to determine the importance and salary of a job compared to other jobs and to place the job description in the most correct place in the wage scale according to the importance level, Virmani N. et al. (2023) The importance of each obstacle was determined by using the fuzzy progressive weight evaluation ratio analysis (fuzzy-SWARA) method of the criteria that create obstacles in the adoption of electric vehicles.

As can be seen, the Fuzzy SWARA method is mostly used on a selection problem. Fuzzy SWARA is performed by calculating the steps of the SWARA method with fuzzy numbers, although the studies carried out in this way are much less than normal studies, it is seen in the literature review that the use of Fuzzy SWARA has increased in recent years. In the criterion weighting problem of many different subjects, fuzzy swara application has been encountered. For complicated cases, it employs straightforward relative comparisons, and it makes it simple to include expert perspectives. The approach

also has the benefit of allowing evaluation through the use of questions that are equal to one minus the number of criteria. In comparison to other approaches, the SWARA method requires a lot less comparisons. As a result, consistency is improved and ambiguity is avoided (Hashemkhani Zolfani et al., 2015). However, comparing the criteria only with the previous criterion after ranking may not be an appropriate method for detailed comparison of the criteria and we cannot obtain an evaluation in terms of the interactions of the criteria with each other.

2.3. Fuzzy Decision Making Trial and Evaluation Laboratory (Fuzzy Dematel)

When the literature is examined, it is seen that the Fuzzy DEMATEL technique is used to weight criteria in many different research problems. There are studies in the literature on subjects such as the determination of supplier selection criteria and the examination of the factors affecting the investment process.

Chang et al. (2011) evaluates the factors affecting the selection of suppliers by using the DEMATEL method. And this study proposes that the use of fuzzy DEMATEL method in fuzzy environment can be extended and applied to many businesses that need to deal with complex criteria problems.

Dincer H. Vd. (2019) used the Fuzzy Dematel to determine the factors affecting the investments made by local governments. As a result, it has been determined that population growth and regional GDP per capita are the most important criteria affecting the investment choices of local governments.

In the study conducted by T. and Candan G. (2019), Fuzzy DEMATEL was preferred in weighting the criteria that affect individual investors in the process of choosing investment alternatives in the uncertain environment in financial markets. Opinions of 10 experts were taken. As a result of the study, it has been seen that investors pay attention to the past price movements of investment instruments in the market in the decision-making process.

Lin, A.J (2021) et al. determined the criteria affecting the performance of asset management banks in Taiwan during the COVID-19 pandemic using fuzzy logic and the Decision Making Trial and Evaluation Laboratory (DEMATEL) method.

The aim of the study by Kamalov, F (2023) is to determine the causal relationship factors for the security problem based on blockchain technology using the Fuzzy Decision

Making Experiment and Evaluation Laboratory (FDEMATEL) approach. As a result of the current study, it shows the effectiveness of the proposed approach and Authentication, intrusion detection and usability were calculated as the most effective criteria, respectively.

In summary, DEMATEL can suggest the most important criteria that influence other criteria. Important advantages of the method are that it simplifies the problem by examining the cause and effect relationship in complex problems and allows understanding the relationship between the criteria with its graphical structure. However, the criteria are evaluated according to the decision maker's knowledge. Since it is a subjective method, it is a method that depends on the knowledge of the expert.

2.4. Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy Topsis)

The TOPSIS method is a multi-criteria decision-making technique developed by Hwang and Yoon in 1981 in order to choose the best alternative based on the consensus solution concept (Perçin and Çakır, 2013). TOPSIS method supplier selection, economics and management problems, accounting and finance, capital investment, decision support, production, marketing, product design, planning, portfolio selection, risk analysis, application evaluations, group decision making, facility location selection, resource allocation, policy It can be used in many similar areas such as strategy, transportation, education, environmental decisions, health, public sector, market selection, portfolio selection, computer and information selection. The most important reason why the TOPSIS method is preferred is that it can help the decision maker in multi-criteria decision problems in many different fields. The main advantages of the method are; It is a method that is easy to apply and simple to understand, it can show the change in the ranking of alternatives in case of an unsuitable alternative, it is based on logical thinking and it can be used in many areas. Its disadvantages are that it may create an uncertainty effect on the criteria. If the weights of the criteria are too small, the distance between the criteria and negative ideal solutions may increase.

Initially, Chen (2000) stated that decision makers should use linguistic variables in order to reflect more reality in decision making problems where there is uncertainty and there are many decision makers. By expanding these linguistic variables within the scope of fuzzy set theory, the Fuzzy TOPSIS method was revealed by creating the solution in a

fuzzy environment. The studies on various subjects using the fuzzy topsis method are briefly mentioned below;

Cenk Z. et al. (2023) used the Fuzzy TOPSIS method in the Pythagorean Fuzzy TOPSIS Method for Green Supplier Selection in the Food Industry study for green supplier selection. The results were compared with the F-TOPSIS and classical TOPSIS approach. The results were found to be close, showing that the proposed method and set of criteria are consistent. By using the PF-TOPSIS methodology, decision makers were able to make the supplier selection process more accurate and reliable by taking into account the uncertainty and uncertainty in the evaluation criteria. In Anvar S. et al. (2023) An Integrated Fuzzy DEMATEL and Fuzzy TOPSIS Method for Analyzing Smart Manufacturing Technologies study, FDEMATEL was used to determine interrelationships and to determine the weights of the criterion, while the fuzzy TOPSIS approach was used to rank I4.0 technologies.

The goal of Toker's study from 2023 is to make it easier for SMEs in poor nations to select the best circular economy business models by applying the global fuzzy TOPSIS technique, which is a brand-new approach to problem-solving.

Praneeth B. et al. (2023) Demonstrated the working of the proposed framework, which includes a hybrid methodology of BWM and Fuzzy TOPSIS, to measure the performance of e-commerce supply chains by identifying critical key performance criteria and a study was conducted on a real e-commerce situation. The fuzzy weights of the criteria were determined with BWM and then the alternatives were ranked with Fuzzy TOPSIS using the weights obtained from Fuzzy BWM. Perçin and Aldalou (2018) made an evaluation of financial performance among Turkish airline companies. The study's criterion weights were calculated using the Fuzzy AHP technique, and the alternatives were ranked using the Fuzzy TOPSIS approach. They found that Pegasus had better financial performance than Turkish Airlines. Boran et al. (2009) used the TOPSIS method with fuzzy set theory for appropriate supplier selection. In the study, 5 different alternatives were analyzed with the Fuzzy TOPSIS method under 4 criteria. They said that when the decision maker is faced with uncertainty beacuse of the analysis, the Fuzzy TOPSIS method gives very successful results.

As a result, it is seen that it is a reliable and preferred method used in different subjects

in many important studies in the literature. As a result of many studies, it has been stated that the Fuzzy TOPSIS method gives successful results.

3. BLOCKCHAIN AND CRYPTO ASSETS

In this section, the concepts that are important for us to understand the world of cryptocurrency will be explained. Concepts such as cryptocurrencies, Blockchain, consensus mechanisms and token economy should be known in the investment process. There is detailed information for each topic.

3.1. Blockchain Technology

The importance of Blockchain technology, whose roots go back to the 1990s, was not well understood until Bitcoin emerged. Bitcoin became known for its virtual currency. A public digital ledger known as a blockchain is essentially a chain-like data structure where groups of transactions or occurrences are recorded, saved, and shared (Ducas et al., 2017; Simoyama et al., 2017). This technology is described as a distributed ledger. In a broader sense, Blockchain is a distributed, shared, encrypted, irretrievable and indestructible repository of information.

Blockchain verifies and stores all transactions between users using the system with the help of the network. Transactions are stored in blocks that are linked together to build chains in the blockchain system. Blocks are created within the framework of certain rules and written to the system. The block is then propagated. Once propagated, it is added to all distributed ledgers. When creating a new block, the summary of the previous block is taken and the next block is produced and added to the chain structure. This structure continues with a structure that connects all the blocks and continues with the summary of the previous block. When a transaction occurs, it is broadcast over the existing network and a block is created by verifying this transaction with encryption algorithms. Each node included in the system keeps its record by confirming this transaction made by any two people in the system. In this way, the block is verified and this information can never be changed, tampered with or deleted from now on. Each new block continues to be added by being chained together. So that someone else cannot change them. Each user in the system represents a node. Each node participating in the system has its own copy of the blockchain, namely the registry and therefore the database. This ledger is synchronized

with other nodes using an end-to-end protocol. In this way, the intermediary is eliminated and the necessity of having a central authority is eliminated. Blockchain functionality is illustrated in the figure below (Zheng et al. 2016) .

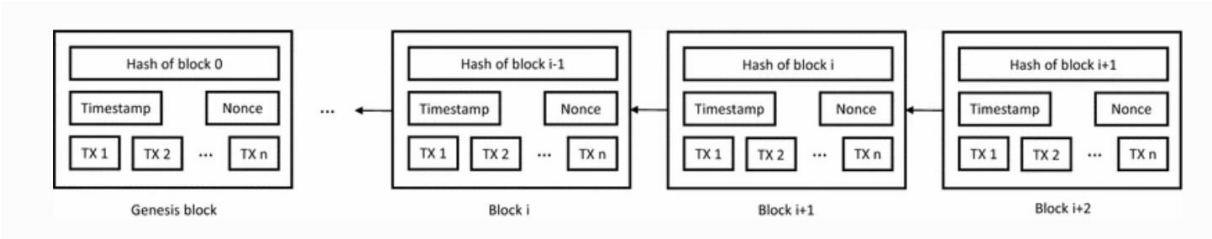

Figure 1. Blockchain Example

Every time a block is added, the blockchain grows. The transaction history is a comprehensive ledger as a result. Blocks employ encryption techniques so that the network can validate them. Each block also includes a timestamp, the hash of the block before it (the "parent"), and a nonce, a random integer used to confirm the hash. The integrity of the blockchain up to the first block (also known as the "genesis block"), is guaranteed by this idea. The same hash value is not allowed. Fraud may be avoided if a block in the chain is changed since this also affects the related hash value. By deciding on a consensus process on the legitimacy of transactions in a block and the validity of the block itself, the majority of nodes in the network can be added to the blockchain. This consensus method, according to Swanson (2015), "is the procedure by which the majority (or in some cases all) of network validators agree on the state of a ledger." A consistent set of facts may be maintained across all participating nodes thanks to this collection of rules and processes. new transactions are not immediately reflected in the ledger due to its structure. Instead, before these transactions are added to the ledger, the consensus mechanism first keeps them in a block for a certain amount of time (for instance, 10 minutes on the Bitcoin blockchain). After then, the data on the blockchain can no longer be modified. It is added to the chain through the mining procedure. For instance, so-called miners in Bitcoin construct blocks and are compensated with Bitcoin for validating blocks. The Bitcoin example demonstrates that the blockchain concept may transform more than just the way in which money is transacted.

The distributed ledger technology also has a lot of benefits. In contrast to centralized systems, the network may continue to run even if some nodes are down. As there is no

requirement for users to investigate the legitimacy of the agent or other network participants, this fosters more trust. People merely need to increase their level of systemic trust. Data security is further increased by the lack of middlemen. According to Zyskind et al. (2015), the practice of third parties collecting personal data now poses a security concern. The security of the user can be increased as a result of third parties who utilize the blockchain becoming outdated.

In addition to the positives, there are drawbacks and potential hazards described in the literature. Theft or loss of Bitcoins (malware assaults, unintentional loss), scalability problems (such as delayed transaction confirmation, data storage and communication faults), and structural problems (such as a deflationary spiral) are highlighted by Berber et al. (2012). Blockchain is an open source project. With this system, which increases reliability, records can be kept in more than one place. If even one of the save locations is lost, the other records in the network continue to be stored in their place. If information comes out of the blockchain, the information becomes inaccessible until it reaches the other party, and the codes match and the information is revealed. This system is used not only in cryptocurrencies, but also in many areas, including banking, as a high-security system. Blockchain technology and distributed ledgers have received a lot of attention lately and are used for multiple projects in different industries. Among them, the financial sector mostly uses the blockchain concept (Nofer M., 2017).

3.1.1. Blockchain Trilemma

Blockchain is a distributed ledger technology for a peer-to-peer (P2P) network. The term Blockchain Trilemma was popularized by Ethereum co-founder Vitalik Buterin (D. Parashar & M. Sharma ,2022). According to Vitalik Buterin's “Scalability Trilemma”, there are three characteristics that every distributed system should strive to achieve: scalability, security and decentralization. For a distributed system to be scalable, it must expand easily as the network grows without requiring excessive storage, even as the number of active nodes and transactions increases (A. Altarawneh, T. Herschberg, 2020). To understand the term Blockchain Trilemma, it is necessary to know the connection of these three elements well. The blockchain deadlock states that it is difficult for blockchains to achieve optimum levels in all three properties simultaneously. Given the link between desirable decentralization and security features, the basic design of how

blockchain works makes it difficult to scale. Strengthening one of these factors weakens the other. There are various efforts and proposals to improve the scalability of the blockchain. However, scalability issues of blockchain are difficult to solve without compromising the security, decentralization or trust of the blockchain.

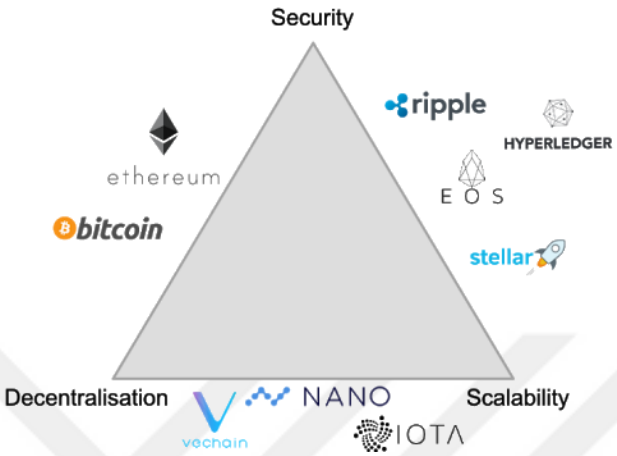

Figure 2. Blockchain Trilemma

Reference ; Fingo,2023

Security

It doesn't matter how decentralized an insecure exchange is. A good blockchain should be resistant to attacks from malicious people. The security of a blockchain can be measured by the network's ability to protect itself from attacks. Blockchain provides its security with consensus mechanisms. The security of the data, that is, its protection against attacks, is ensured by consensus mechanisms.

Scalability

Scalability represents a blockchain development goal that can support more and more transactions per second. Scaling is necessary if blockchain is to serve a wider audience and potentially billions of users. However, many blockchains still struggle with this. This is because decentralization and security are of paramount importance to blockchain, so it is primarily focused on these issues. For example, Bitcoin failed to process more than seven transactions per second, and the second network, Ethereum, was limited to around 15 transactions per second. This is quite a big difference compared to traditional exchanges.

Decentralization

To be considered decentralized, a cryptocurrency must meet two criteria: first, it must be immune to interference and manipulation by the founders, and second, it must not be centrally controlled by the founders (Sedgwick, 2018). Bitcoin and similar blockchains, for example, are decentralized by design. The whole structure is based on the absence of a person or organization in control. A decentralized structure is used. The network layer is open to anyone who wishes to participate. As a result, control is distributed rather than in the hands of a single unit. Everyone has access to the same data. If someone tries to trick the system into changing the records in their own interest, other participants will reject the erroneous data. If we give a simpler example, the information of the product purchased while shopping can be changed as desired only if it is on the other side. Debt information can fall into the hands of malicious people. But if it was not central and this information was in many places, the accuracy of the information could be checked by confirming it with other information. And this structure will not be centralized, that is, it will not be dependent on a single person.. Thus Manipulations can be avoided. It would ensure the accuracy of the information, the correct data would be accessible, and the correct actions would be taken. The data would have been preserved. However, the fact that there is a lot of decentralization has its disadvantages. Because it brings a large number of approval structures for transactions and negatively affects scalability. These three constraints of the blockchain affect each other in this way.

Examples are decentralized cryptocurrencies Bitcoin (BTC), Ethereum (ETH), Litecoin (LTC) and Chainlink (LINK); and centralized cryptocurrencies Ripple (XRP), EOS (EOS), NEO (NEO) and IOTA (MIOTA) (Audil Khaki,2023).

Multiple consensus mechanisms with minor modifications have been proposed to overcome such difficulties. For example, the Approaching Solutions to Blockchain Security Trilemma and Consensus Mechanisms study examined the consensus mechanisms that can be used for this problem. The consensus mechanisms used in the blockchain structure in this study are evaluated in terms of three critical elements of the blockchain.

Table 2. Trilemma Properties of Different Consensus Algorithms

Approach	Scalability	Decentralization	Security
Proof of Work	No	Yes	Yes
Proof of Stake	No	Yes	Yes
Proof of Capacity	No	Yes	Yes
Proof of Authority	Yes	No	Yes
Proof of Benefit	Yes	Yes	No
Proof of Burn	No	Yes	Yes
Proof of weight	Yes	Yes	No
Proof of Activity	No	Yes	Yes
Proof of Importance	Yes	Yes	No
Directed Acyclic Graphs	Yes	No	Yes

Reference : Parashar et al., 2022

3.1.2. Protocols and Consensus Mechanisms of Blockchain

Blockchain transactions are grouped into blocks, complying with a certain block size limit, and any number of transactions can occur per block. Nodes in a blockchain network group these transactions and send them across the network. Eventually the peers synchronize to an exact copy of the blockchain throughout the network. The blockchain update procedure needs a consensus, i.e. an agreement, between the network peers(Belotti,2019). Network consensus refers to the process of reaching agreement among network participants on the correct state of data in the system. Consensus results in all nodes sharing exactly the same data. Therefore, a consensus algorithm ensures that the data in the ledger is the same for all network nodes and prevents malicious actors from manipulating the data.

Consensus mechanisms and blockchain protocols for cryptocurrency are two different concepts, but they are closely related. A consensus mechanism is a set of rules or protocols that allow nodes in a blockchain network to agree on the state of the blockchain.

Consensus mechanisms ensure that all nodes in the network have the same copy of the blockchain and that new transactions are added to the blockchain in a secure and transparent manner. Some common consensus mechanisms include Proof of Work, Proof of Stake, and Practical Byzantine Fault Tolerance.

On the other hand, a blockchain protocol is the directive that specifies how a blockchain network works. Blockchain protocols define how transactions are validated, how blocks are added to the blockchain, how consensus is reached, and how the network is secured. Examples of blockchain protocols include Bitcoin, Ethereum, and Ripple.

In other words, consensus mechanisms are a critical component of blockchain protocols, as they enable nodes to agree on the state of the blockchain. Without a consensus mechanism, there would be no way to ensure that all nodes have the same copy of the blockchain. However, a blockchain protocol also includes other components, such as the network architecture, the transaction structure, and the smart contract language, among others. Therefore, while consensus mechanisms and blockchain protocols are related, they are not the same thing. Consensus mechanisms are a key part of blockchain protocols, but they are just one of several components that make up a blockchain network.

Currently, Bitcoin, Ethereum, and Binance Smart Chain are the most often utilized blockchain technologies for cryptocurrency ventures. The original and best-known cryptocurrency and blockchain protocol is called Bitcoin. Its main use are as a store of value and a payment method. The building of decentralized apps and smart contracts is possible with Ethereum, a more flexible blockchain platform. It is the second-largest cryptocurrency by market capitalization and has served as the foundational technology for several non-fungible tokens (NFTs) and decentralized finance (DeFi) applications. A more recent blockchain system called Binance Smart Chain has been popular because of its low transaction fees and quick transaction speeds. It can also execute apps based on Ethereum since it is compatible with the Ethereum Virtual Machine. Cardano, Polkadot, and Solana are other blockchain technologies that are utilized by cryptocurrency projects. The blockchain protocol used will rely on the particular needs of the project and the objectives of the creators. various blockchain implementations may have various reconciliation processes. Blockchain relies on consensus methods to make sure that every node in the network agrees on the blockchain's current state. The consensus process must

be resilient to malicious assaults in order to protect the network's integrity while confirming transactions and adding them to the blockchain.

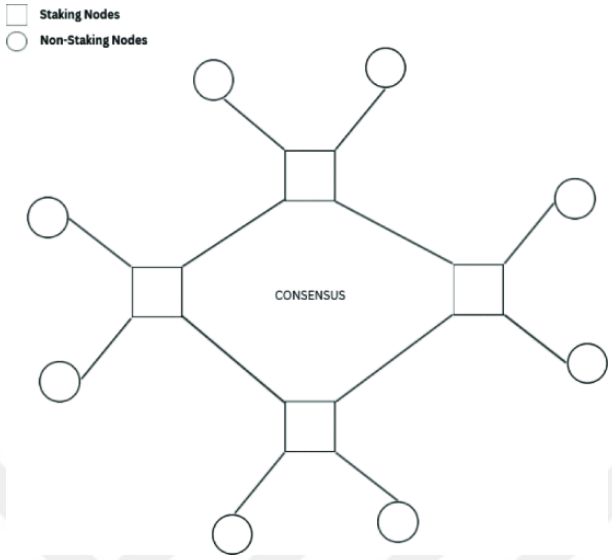

Figure 3. Consensus

Reference ; Parashar et al., 2022

Blockchain uses a variety of consensus processes, each with unique benefits and constraints. Here are a few of the most commen ones:

Proof of Stake (PoS) ; Some blockchain networks utilize the consensus mechanism known as Proof of Stake (PoS) to verify transactions and protect the network. In a Proof-of-Stake (PoS) network, validators (sometimes called "forgers" or "stakers") are selected to add new blocks and approve transactions depending on the amount of bitcoin they "stake" (invest) in the network.

A PoS system selects validators based on their stake, or the quantity of cryptocurrency they own. Transactions must be approved by validators before they can be added to the blockchain as new blocks. To guarantee that they act honestly and do not attempt to manipulate the system, validators are obliged to retain a set quantity of the cryptocurrency utilized by the network. This cryptocurrency serves as collateral. Then, at random, new block creators and validators are selected, and as payment for their efforts, they are rewarded with transaction fees and fresh bitcoin. PoS does not need a lot of computer power, in contrast to the Proof of Work (PoW) method, which necessitates validators to solve challenging mathematical puzzles in order to validate transactions. As a result, PoS

is more economical and energy-efficient than PoW.

PoS is an overall strategy for encouraging network activity and ensuring the safety and reliability of the blockchain network. Numerous blockchain initiatives, including Ethereum 2.0, Cardano, and Binance Smart Chain, employ it. PoS is thought to be more energy-efficient than PoW but may occasionally be less secure.,

Proof of work (PoW) is a consensus mechanism used in blockchain networks to validate transactions and add new blocks to the chain. This is the original consensus mechanism preferred by Bitcoin and many other cryptocurrencies. Although this system is renowned for its great level of security, it also uses a lot of energy. Miners compete in a PoW system to find solutions to challenging mathematical puzzles in order to add new blocks to the blockchain. In a PoW system, miners use powerful computers to solve complex mathematical problems, which requires a significant amount of computational power and energy consumption. The first miner to solve the problem and verify the transaction is rewarded with a certain amount of cryptocurrency.

This mathematical issue is solved through a process known as "mining," and the miners are effectively competing with one another to find a solution and add the next block to the blockchain. The blockchain is immutable and impervious to hacking efforts because once a block is added, it cannot be changed.

To maintain a constant pace of block production and prevent the system from becoming overloaded with transactions, the mathematical problem's complexity is continuously changed. Bitcoin, the first and best-known cryptocurrency, and many other cryptocurrencies employ PoW as its consensus algorithm. Alternative consensus techniques like Proof of Stake (PoS) are being investigated as more environmentally friendly alternatives to PoW since it has less of an influence on the environment and consumes less energy.

Practical Byzantine Fault Tolerance (PBFT); A consensus process used in distributed systems, including certain blockchain networks, is called Practical Byzantine Fault Tolerance (PBFT). It is intended to make it possible for a network of nodes to agree on a transaction or block even when there are unreliable or malicious nodes present.It can put up with as many as one-third of the nodes having errors or malicious intent. The consensus is said to have been attained when a predetermined number of clones concur

on the outcome.

PBFT is meant to be robust to a specific number of defective nodes, which can be brought on by malicious attacks or hardware malfunctions. In particular, PBFT allows up to one-third of the network's nodes to be broken or malicious without endangering the integrity of the consensus. Rather than in public blockchains where any node may join, PBFT is frequently utilized in permissioned blockchain networks where the nodes are known and trusted.

Even though PBFT offers great performance and fault tolerance, it is complicated and necessitates a substantial amount of processing power. As a result, not all distributed systems are ideal for PBFT, and in certain circumstances, Proof of Stake or Proof of Work may be preferable.

Delegated Proof-of-Stake (DPOS) is a PoS variant in which participants elect delegates who are in charge of approving transactions and putting new blocks on the blockchain. The superior speed and scalability of DPoS are well known, although it is that this consensus method is more centralized than others.

A novel mechanism for protecting the bitcoin network is called Delegated Proof-of-Stake (DPOS) (Yang et al., 2019). It offers a solution to the issues with both PoS and PoW coins. It employs witnesses (officially known as delegates) and a layer of technical democracy to counteract any possible negative effects of centralization.

The member stakeholders contract with these witnesses to sign the transactions and commit them to the blockchain. DPOS has a decentralized voting process, making it inherently more democratic than other systems. DPOS-based cryptocurrencies contain systems to make sure that individuals with the authority to sign blocks and validate them do so correctly and impartially, as opposed to completely eliminating the need for trust. The speed of transactions is increased with DPOS-based cryptocurrencies since there is no requirement that a sufficient number of untrusted nodes verify and validate a transaction before confirming it. No artificial impediment has to be put in place to impede the process of block signing because confidence is deliberately placed on more reliable nodes.

Compared to PoW- or PoS-based coins, more transactions may be included in a block with these ones. Unlike previous methods, which tend to concentrate all of the

confidence among the nodes with the most resources, each and every node is able to select who is to be trusted. DPOS enables the network to retain some degree of decentralization while utilizing some of the key benefits of centralization approach. These cryptocurrencies' core characteristic is that shareholders have adequate influence over the whole process. However, DPoS-based systems also have some disadvantages. In accordance with the working philosophy of DPoS, it is difficult to maintain confidentiality in these systems as it cannot protect information if transactions, sending addresses and receiving addresses are hidden. Only if token holders have the means to assess, manage, and ultimately penalize their representatives will DPoS function as intended.

As a result, it is impossible to ensure total anonymity with DPoS-based coins. However, DPoS-based systems give their share holders the largest amount of dividends. Users also have less to worry about with these systems in terms of network security.

Proof of Authority (PoA) ; In a PoA system, validators are chosen based on their identity or reputation, rather than their stake. PoA is considered to be highly efficient and suitable for private or enterprise blockchain networks.

Hybrid Consensus Mechanisms ; Some blockchain networks use a combination of consensus mechanisms to balance performance, security, and decentralization. The choice of consensus mechanism depends on the specific requirements of the blockchain network and the goals of its developers.

3.1.3. Security of Blockchain

Consensus mechanisms are one of the most important points in ensuring security in the network. In this section, possible attacks and the resilience of consensus mechanisms against these attacks will be discussed. Some other potential attacks on cryptocurrencies that affect the complexity of executing them included as:

The balancing attack: Attacker only acts against one subgroup after initiating a delay between the appropriate subgroups with equal mining strength. After that, the attacker removes enough blocks from another subgroup to greatly increase the likelihood that its subtree surpasses that of the transaction subgroup. Even if the transactions are committed, the attacker has a high likelihood of rewriting the blocks that include these transactions,

outweighing the subtree that contains that transaction (Natoli, 2016).

Selfish mining attack: By using honest miners to mine blocks that won't be included in the Blockchain, the miner pool attempts to squander their computer resources. Selfish miners do this by exposing some of the blocks they have selected to mine, so undoing the effort done by ethical miners. In particular, while ethical miners continue to work on the longer public branch, the pool of miners employing a selfish mining method keeps their mined blocks secret and establishes a private branch of the Blockchain. When selfish miners openly disclose their secret blocks after a given amount of time, honest miners begin to work on the newly revealed blocks They would eventually abandon the shorter public branch they were working on in the process. As a result, their prior efforts are wasted, and avaricious miners seek greater rewards by adding more of their blocks to the Blockchain. Selfish miners frequently disclose their blocks with several IP addresses and other cryptocurrency addresses at very low cost to conceal their selfish mining approach (Eyal et al., 2014).

51% attack: A possible assault is more likely to be launched in a 51% attack if the mining power of a hostile node—typically the miner—exceeds 50% of the Blockchain's hash power. This poses a number of risks, including the ability of an attacker to:

reverse transactions (e.g., alter records), alter the order of transactions, obstruct the honest nodes' routine mining activities and halt the approval process.

Double-spending and Finey attack: This assault is predicated on the idea that it is possible to duplicate and reissue digital currency. Because of this, rogue nodes could try to utilize the same asset as input for a number of transactions at once. Malicious nodes may also try to get around the cryptocurrency verification system by disabling the blockchain security features or employing a double-spend technique that involves sending one fraudulent transaction log to one vendor and the other to the remaining cryptocurrency network. 2019 (Nicolas et al.). The Finey assault is one of these unique double-spend attacks (Kaushik et al., 2017). The basic stages to perform this attack are as follows:

1) The attacker must accept this before carrying out the attack,

2) Since the attacker cannot use the first transaction, they must start mining on the second block without using the first block. for second block mining,

3) The first stored transaction is used to execute the purchase after the mining procedure of the second block is completed,

4) The attacker broadcasts the mined block.

Table 3 below provides a summary of security attacks that different consensus mechanisms are vulnerable to. [✓- Possible, × - Not possible] (Quamara et al.,2022).

Table 3. Comparison of different consensus mechanisms based on their vulnerability towards security attacks

Type of Security Attack	Proof-Of-Stake(PoS)	Delegated Proof-Of-Stake (DPoS)	Proof-Of-Work (PoW)
Balance attack	×	√	√
BGP hijacking attack	×	×	√
Coin age accumulation	may be possible	×	×
DoS	√	√	√
Long range	√	√	×
Pre-computing	√	×	×
P+Epsilon attack	×	√	√
Sybil	√	√	√
Selfish mining	×	×	may be possible
Short range	√	×	×
%51 attack	√	√	√

When the Table 3 above is examined, it is understood that Pos and Pow mechanisms have an equal number of attack risks. Dpos, on the other hand, is the mechanism with the most attack probability among them. Based on this information, cryptocurrencies using Pos and Pow mechanisms can be preferred. In order to choose between the two mechanisms, the information in Figure 2 can be taken into account. Accordingly, in terms of transfer speed, Pos is faster than Pow. In addition, PoW theory may be good in terms of security, but requires high energy consumption in nonce calculation (Nakamoto, 2008). Therefore, something equally effective and less energy consuming has been invented and Proof-of-Stake (PoS) has been proposed as a viable alternative (Wood et al., 2014). As a result, it can be considered as the most reliable and fast choice among Proof-of-Stake mechanisms. Table 4 compares these consensus mechanisms and shows their major differences (Lee, 2019).

Table 4. Comparison of PoW, PoS, DPoS and PBFT

	PoW	**PoS**	**Dpos**	**PBFT**
Block generation speed	Anyone	Anyone	Elective Representative	Authorized member
Transaction processing speed	Slow	Slow (Faster than PoW)	Fast	Fast
Security level	High	High	Relatively low	Relatively low
Rule change	Difficult	Difficult	Normal	Easy
Examples	Bitcoin, Etherium	QTUM	EOS , Steem	Hyperledger, R3

3.2. Cryptocurrency

Cryptocurrency is one of the most common currency terms nowadays. With the abolition of the trade border between countries, crypto money, which is an alternative currency to national currencies, can be used in the trade of goods and services, and in other cases, its use has been increasing over the years. Crypto literally is the word that is formed by combining the words cyripto and currency, the main theme of which is password.

Today's commerce movements are not restricted by anything thanks to the Internet. The most successful technology advancement that may be used to illustrate how this barrier can be removed is cryptocurrency. With the use of cryptocurrencies, these technical advancements alter the financial system (Alar, 2007: 178). People's faith in technology has declined as its use has grown. This is the point where cryptography really shines (Yılmaz, 2007). The study of cryptography is known as cryptology, in which data is encrypted via a system, transferred from a trustworthy environment to the recipient, and then decrypted. Cryptography and crypto are the two basic components of cryptology. The use of cryptography makes sure that data is secure and unchangeable. The individual installs the feature of not acting on behalf of others and securely authenticates with this program (Yılmaz, 2007).

Today, bitcoin is the cryptocurrency that is most often used. Decrypting the above-mentioned encryption mechanism results in the creation of new bitcoins. Those who couldn't figure out the password can purchase bitcoin for cash. Like other currencies, bitcoin also has an exchange rate mechanism. Before utilizing bitcoin, a wallet must be given A bitcoin wallet is required before using bitcoin. Inside this wallet is a virtual ledger, called a blockchain, that keeps track of how much a person owns.

3.2.1. Tokenomic Structure

The phrases "token" and "economics" are combined to generate the term "tokenomics," which refers to a cryptocurrency's economic framework. This phrase is used to describe how a cryptocurrency ecosystem is structured and operates.

Blockchain technology is frequently used to construct cryptocurrencies, and as a result, the tokenomics of a cryptocurrency entails the application of economic theory to blockchain technology. These theories cover ideas like demand and supply, incentive systems, mining, and token distribution. Tokenomics seeks to balance the supply and demand of a cryptocurrency's tokens, maintain price stability, foster more community involvement, and assure the long-term viability of the cryptocurrency ecosystem.

The planning and administration of a cryptocurrency's economic structure is referred to as tokenomics. This plan takes into account token distribution, financial incentives, price stability, and the long-term viability of the blockchain ecosystem. Tokenomics is therefore essential to a cryptocurrency's success. Through the incentive systems employed in cryptocurrencies, tokenomics supports the longevity of the cryptocurrency ecosystem. As an illustration, several cryptocurrencies compensate miners for their contributions to the blockchain network. The network's sustainability is ensured via these incentives. The price of cryptocurrencies is also stabilized through tokenomics. Tokenomics' use of incentives and distribution strategies can aid in lowering the market's volatility. In turn, this makes the ecosystem safer for bitcoin users and investors to invest in. To enhance community involvement in cryptocurrency ecosystems, tokenomics is also employed. By piqueing the attention of token holders and cryptocurrency users, Tokenomics' design may aid in the expansion and development of the ecosystem. Overall, a cryptocurrency's success depends on tokenomics. By assuring the sustainability, price stability, and community participation of the cryptocurrency ecosystem, tokenomics can aid in the acceptance and use of cryptocurrencies.

For instance, a straightforward supply curve covering around 140 years was used to construct Bitcoin.

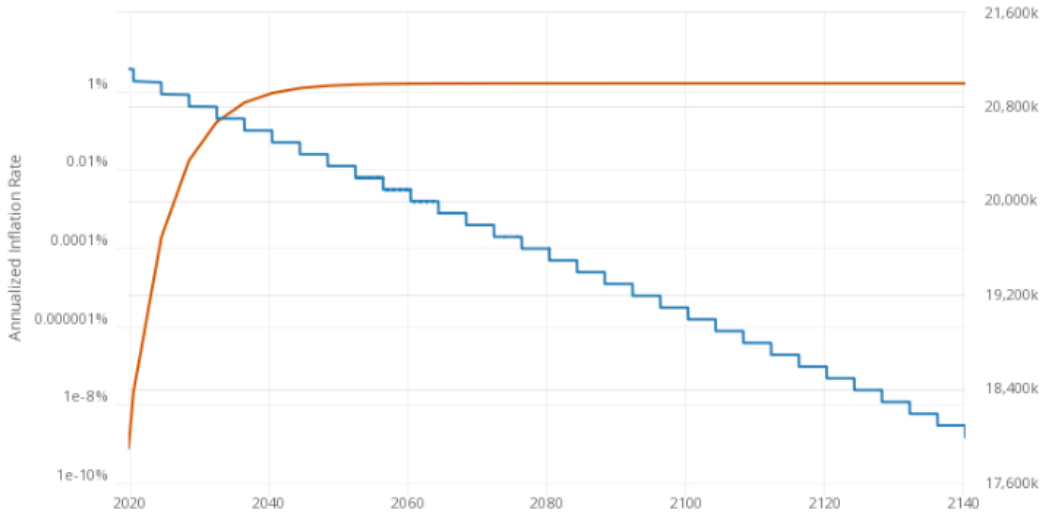

Figure 4. Bitcoin supply curve

Reference: Almanack tokenomics,2023

Only 21,000,000 bitcoins have ever been created, and they are distributed at a pace that is cut in half every four years. There are only 2,000,000 left to be released in the following 120 years because there are now about 19,000,000 in current circulation.

With just 10.5% additional bitcoins present in 100 years and 90% of the supply currently in use, there is little chance that inflation will significantly affect the value of the coin.

There is no cap on the number of Ethers that may exist; the circulating supply for Ethereum is about 118,000,000. However, Ethereum's net emissions have recently been modified via a burn mechanism, with the goal of achieving a constant supply that may even be deflationary. This will result in a total of between 100 and 120 million tokens. Given this, one should not expect Ether to experience a lot of inflation pressure. Probably even deflationary. Dogecoin has no supply limit, currently growing at around 5% annually and is still being released. Among the three, it can be predicted that Doge will depreciate faster than Bitcoin or Ethereum due to inflationary tokens.

3.2.2. Crypto Mining

The process of creating bitcoin is referred to as "crypto mining". Crypto mining is crucial for tracking who performs this labor and for validating procedures. Diggers, in a sense, guarantee the blockchain system's security and the accuracy of the transactions' recording

in distributed ledgers. All users may control their transactions using the blockchain system because it is a public system. While there were fewer people involved in crypto mining during the early days of Bitcoin and a significant amount of the currency could be created quickly, today there are more people involved in the activity, crypto production has become more challenging due to the algorithm that raises the hashing difficulty level, the system requires more transactions, and excavation activity is more expensive.

One million individuals are thought to work in the mining industry. Purchase Bitcoin Worldwide in 2021. Despite the fact that this is true in terms of how the system works, mining and distributing cryptocurrencies requires a significant amount of electrical energy. On the one hand, this condition drives up expenses, while on the other, it has a detrimental impact on traders' results. The main cause of this is that daily investments in increasingly powerful but more expensive specialist gear are required by cryptocurrency miners (Vigna et al., 2016). The cost of building the infrastructure and buying the hardware account for the largest portion of these cost categories, each accounting for 45% of the overall cost (Blandin et al., 2020).

Data from Cambridge University shows that the amount of electricity used for cryptocurrency mining went from 9.5 Terawatt-hours (TWh) in 2017 to 73.1 TWh at the beginning of 2019, with a subsequent partial decline in consumption but a spike in price in 2021. As a result of the rise in energy use, as of May 2021, it had reached a record high of 121.13 TWh, up more than ten times from the previous year (Bitcoinenergyconsumption, 2021). The energy used for Bitcoin mining alone is greater than the energy used in several African nations. In a same vein, a research by the UK-based Power Compare Company in 2018 claims that while BTC utilized more energy than 159 nations in 2017, including numerous African nations, the number of these nations rose to 181 by the end of 2018 (powercompare, 2021). Currently, only 38 nations' power use exceeds the energy required for Bitcoin mining.

3.2.2.1. Amount of Carbon Emission and Electronic Waste

The results are striking when looking at the carbon footprint of cryptocurrency mining (Stoll, Klaaßen, & Gallersdörfer, 2019). In his book titled “Attack of the 50 Foot Blockchain: Bitcoin”, Gerard (2017) says that electricity consumption in BTC mining leads to a high increase in carbon emissions. While the amount of carbon emissions per

transaction in BTC was 162 kg CO2 as of the end of 2017, this figure increased to 545.03 kg CO2 in the middle of 2021, increasing 3.5 times. This amount corresponds to 1,207,971 VISA transactions or 90,838 hours of Youtube video viewing (digiconomist.net, 2021). The electricity consumption per transaction for BTC production is 1,147.43 kWh, which corresponds to the average daily electricity consumption of an American family of 39.33 days. For Ethereum, the amount of electrical energy and carbon emissions per transaction in 2021 are 77.7 kWh and 36.91 kg CO2, respectively. This amount corresponds to the average two-day electricity consumption of an American family. The amount of carbon emission is equal to 81,805 VISA transactions or 6,152 hours of video watching on Youtube. On an annual basis, the amount of carbon emissions released for BTC production is 52.66 Mt CO2. This amount is equal to the total amount of carbon emissions produced by Sweden. Likewise, the annual electrical energy consumption for BTC is 110.86 TWh, almost equal to the energy consumption of the Netherlands (117.10 TWh). The amount of electronic waste generated as a result of BTC scraping is 103.90 grams. This amount is equivalent to a 1.64 1C battery, or the weight of 2.26 golf balls. For example, the carbon footprint of producing the amount of gold equivalent to mining one BTC is 23 tons of CO2, while this figure is 139 tons of CO2, including commissions for one BTC. In other words, the carbon footprint of BTC production is 6 times more than the carbon footprint of gold production (digiconomist.net). However, while making this comparison, it should not be forgotten that there are steps such as processing, transporting, changing hands and storing gold, and each of these steps increases energy consumption and carbon footprint (Aydemir, 2020).

3.3. Popular Cryptocurrencies

The cryptocurrencies to be considered in the selection of the most suitable crypto money investment alternative will be explained below.

3.3.1. Bitcoin Project

Bitcoin is a digital currency that is neither created by or guaranteed by any organization (Sönmez, 2014). Its symbol is and its acronym is BTC. The fundamental components of the ecosystem for digital currencies are combined in bitcoin. Additionally, known as bitcoin, this kind of money is utilized for transactions between users of the system

(Antonopoulos, 2014). According to some economists, bitcoin possesses the qualities of a currency, such as being a medium of exchange, divisible, inimitable, transferrable, storing value, and homogeneity (Bitcoin markette, 2014). Since it is not managed by a central bank and is not issued, it cannot be used as a tool for monetary policy. Therefore, bitcoin is a money that, like traditional currencies, may be used for transactions, savings, and investments, but, unlike them, it is created and maintained electronically. The following is a list of how Bitcoin differs from other currencies (how-bitcoinworks, 2015);

1. P2P3 technology is used by Bitcoin, which is independent of a centralized authority. Peer to Peer Connection (P2P): This network protocol enables data exchange and communication between two or more "peer" clients.

2. Bitcoin is entirely electronic.

3. The maximum number of bitcoins is 21 million.

4. Bitcoin is a sophisticated item.

5. Uses of bitcoin is restricted.Bitcoin is not insured, note

6. In a message posted to a private mailing list in November 2008, Satoshi Nakamoto first described Bitcoin.

The first bitcoin program was released in 2009. There is no verified information concerning Satoshi Nakamoto's identity. According to reports, Nakamoto quit the system he created before the end of 2010, made a significant amount of bitcoin, and has been working on other projects since 2011. Although it is known that Satoshi Nakamoto's email originated in Japan, it is unknown with certainty if Nakamoto is Japanese. Many presumptions regarding who or what Nakamoto is have been made and continue to be made.

Bitcoin technology operates on a network that enables simple payments to anybody worldwide without the need for a centralized authority (economy that favors digital money to gold, 2015). In other words, the system simply has the internet, with no middlemen like a government, organization, or bank. It is therefore nearly difficult for the seller to impose unforeseen expenses or fees (account maintenance fee, card membership fee, etc.) (what is litecoin, 2013). This is true just as with other payment methods. The bitcoin software system increases speed while lowering cost in this instance

when compared to its alternatives (bitcoin frenzy, 2013). Additionally, Bitcoin owners may transfer money freely across borders while paying miners extremely modest commissions4. Additionally, the system's encryption mechanism guarantees the privacy of all transactions (virtual currency, 2014). All of these raise the popularity of bitcoin. According to well-defined criteria, the process of increasing the money supply is carried out in public view (What is Litecoin, 2013). The technology issues a digital signature to each electronic transaction and stores it in a centralized database (actual money bitcoin, 2015). Users that are a member of a computer network system can transfer bitcoin amongst each other in a virtual setting.

The public and private keys are kept in a file called a bitcoin wallet. A application that is downloaded to the computer can be used to construct the wallet, or web-based services like Blockchain, Flexcoin, and My Wallet can be used instead. As a consequence, a unique address is produced, and this address is used to send bitcoins. These addresses may be kept on the internet, computers, or paper. The ideal method for storing a Bitcoin wallet, according to some, is paper. A type of digital ledger known as "blockchain" is used while Bitcoin is being bought and sold. It maintains track of how much Bitcoin each party has in their possession and preserves records based on the Bitcoin addresses of the parties involved before each transaction. The blockchain keeps track of every transaction and every stage of every transaction. After a 10-minute confirmation procedure, the automated registration of a Bitcoin sale culminates in the input of the same amount to the buyer's address and the departure from the former owner's wallet's encrypted address. After the transfer, the seller loses ownership of the topic Bitcoin. Everyone can simultaneously observe how much bitcoin was transmitted from which address to which address with this transaction. The following steps are involved in the Bitcoin transfer process: The person receiving the bitcoin sends the person sending it his address. After approving it with his personal password, the sender adds this address to the recipient field during the transfer procedure, makes it public for all Bitcoin users to view, and then sends money to the recipient. This publication serves to both record all transactions made by users and to guard against transaction modifications. The fact that every Bitcoin user has a copy of the transaction stops one Bitcoin from being used concurrently in several places. The computational power required to reuse a single Bitcoin is larger than the combined processing power of all Bitcoin users. A transaction that has already been completed in

Bitcoin is thought to be difficult to alter. because Bitcoin is created from each Bitcoin transaction. Since the identities of the users are kept confidential, it is difficult for the person who intends to manipulate the data to make changes to the data by entering the account of the previous transaction owner. The user's responsibility is to safeguard their unique password (Acar, 2013). Bitcoin verifies transactions via point-to-point networking, public-key encryption (asymmetric encryption), and digital signatures. Multiple addresses are permitted for each user. Each transaction is recorded in the blockchain and broadcast to the network. Each transaction is promptly locked by the enormous processing power that continues to strain the blockchain within one hour or two. By utilizing these technologies, Bitcoin offers a user-friendly, quick, and highly trustworthy payment network. By utilizing the free bitcoin miner program, users create bitcoins as a consequence of certain algorithms running over the bitcoin network (Yalçin et al., 2015). Because it connects the process of making money with the mining of gold, the procedure is known as mining. Bitcoin mining is possible at a reducing and predictable rate. Over time, less Bitcoin is placed into circulation. 21 million is the maximum number of Bitcoins that may ever be issued. According to bitcoin software, there is a cap of 21 million on the total amount of bitcoins that may be created. An algorithm, which serves as the brain of the Bitcoin program, determines the quantity of Bitcoin that will be created by resolving several mathematical conundrums of varying degrees of complexity. Due to the process' high level of complexity, a lot of processing power is needed to do computations. With only a few standard computers, this demand cannot be satisfied. The processing power needed for computations must be connected to a computer network (a Peer-to-Peer-Network, or P2P for short), as Bitcoin is an open source code movement and its base cannot yet afford high-capacity supercomputers. It is cooperatively developed by linked highly powerful computers.

3.3.2. Other Cryptocurrencies

Following the advent of Bitcoin, other cryptocurrencies were designated as "Altcoins," denoting their status as alternative coins, owing to their emergence as alternatives to Bitcoin and being inspired by it. Litecoin, Namecoin, Anoncoin, Darkcoin, Counterparty, Nextcoin, Dogecoin, Bitshares, Ripple, and Ethereum are just a few of the many altcoins that are now in use. Furthermore, new cryptocurrencies continue to emerge on a daily

basis. Due to their lack of differentiation from existing cryptocurrency systems, the majority of altcoins fail to garner adoption within the crypto money ecosystem, ultimately leading them to be relegated to the altcoin cemetery. Only a limited number of these alternative digital currencies offer novel answers to the underlying issues of the cryptocurrency system, introducing fresh perspectives and expanding the range of applications for cryptocurrencies. Transactions involving open source cryptocurrencies, like as bitcoin, take place globally, where profits and losses are determined by real-time fluctuations in supply and demand. There are certain exchanges exclusively dedicated to facilitating the conversion between Bitcoin and Altcoins, as opposed to exchanges that enable the conversion of Bitcoin into conventional currencies. The market value of Altcoins is intrinsically linked to Bitcoin, so that fluctuations in Bitcoin's market value have a direct impact on the market value of Altcoins.

Bitcoin has gained significant popularity due to its status as the pioneering cryptocurrency. Nevertheless, the emergence of several crypto currencies and blockchain initiatives might be attributed to the limitations and sluggishness of the Bitcoin blockchain. Altcoins, which are frequently mentioned, generally possess a more sophisticated framework or propose a solution within a certain domain.

During the initial stages of the emergence of the Bitcoin blockchain, the user base was quite limited in size. Nevertheless, the use of blockchain technology has witnessed a significant surge due to the influx of numerous users and investors in this domain over a period of time. Numerous novel blockchains and cryptocurrencies have surfaced as alternatives to Bitcoin, which has exhibited a persistent sluggishness in terms of transaction velocity inside the blockchain ecosystem. These recently launched digital currencies provide enhanced efficiency and cost-effectiveness in the transmission of transactions.

The terminology surrounding cryptocurrencies sometimes leads to the interchangeable usage of the phrases "coin" and "token"; nonetheless, it is important to note that these terms carry distinct meanings. The native currency of a blockchain is commonly referred to as a coin. An illustration of this concept may be seen in the fact that Ether serves as the primary cryptocurrency within the Ethereum network. Cryptocurrencies encompass a range of digital assets, such as Bitcoin, Ripple, Ethereum, Dogecoin, NEO, and Litecoin.

Tokens are digital assets that are generated and operate on a separate blockchain network. Numerous tokens have been generated on the Ethereum blockchain, such as Enjin Coin, SAND, Radix, and Lotto. This article aims to provide an overview of several cryptocurrency initiatives, elucidating their respective purposes and highlighting key distinctions between them.

3.3.2.1. Ethereum Project

Ethereum, a blockchain project launched by Vitalik Buterin at the 2013 North American Bitcoin Conference, is a decentralized and open source platform that facilitates the execution of smart applications on the blockchain. Ethereum's robust infrastructure has facilitated its integration into many token specifications, including ERC-20 and ERC-721. The indigenous digital currency of the Ethereum blockchain is known as Ethereum (ETH). Ethereum is a blockchain-based initiative that originated subsequent to Bitcoin, enabling the development and execution of programmable contracts on the network. The Ethereum project, introduced in 2014, has experienced significant growth and has facilitated the emergence of many industries and novel tokens inside the realm of cryptocurrency.

The Ethereum project has faced several challenges throughout its development, which have subsequently given rise to other emerging domains. The advent of smart contract functionality on the Ethereum blockchain has catalyzed the emergence of decentralized finance (DeFi) as a prominent business. The Ethereum project first implemented the Proof of Work method before transitioning to the Proof of Stake algorithm in September 2022. The initial phase, known as Ethereum Merge, marks the commencement of measures undertaken to enhance the scalability, speed, affordability, and decentralization of the Ethereum project.

The primary objective of Ethereum is to enhance user experience by implementing a more efficient and cost-effective framework that is also highly scalable. In addition to the aforementioned objectives, Ethereum distinguishes itself from other initiatives by its aspiration to establish a decentralized framework. Ethereum may be characterized as a decentralized computing platform. Ethereum may be conceptualized as a computing system akin to a desktop or laptop computer, although one that operates across several devices rather than being confined to a single device. In contrast, Ethereum operates

concurrently on a multitude of machines distributed globally, therefore establishing a decentralized ownership structure.

Similar to Bitcoin and other cryptocurrencies, Ethereum enables the transmission of digital currency. However, it possesses the potential to do well beyond its current capabilities. One possible illustration is the ability to generate personalized code and engage with programs developed by fellow users. The Ethereum platform offers a high degree of flexibility, enabling the deployment of a wide range of complex programs.

The fundamental concept underlying Ethereum is that developers possess the ability to generate and provide access to code that operates on a decentralized network as opposed to a centralized server. In a theoretical context, it might be argued that these applications possess inherent resistance to shutdown or censorship. Hence, the programs remain impervious to external manipulation. The aforementioned codes are included into Ethereum's database, often referred to as the blockchain, and possess the capability to be coded in a manner that renders them unalterable. Furthermore, the database is accessible to the public, allowing people to examine the code prior to engaging with it.

The blockchain serves as the fundamental infrastructure for Ethereum, functioning as the centralized repository that stores the data utilized by the protocol. The Ethereum blockchain exhibits similarities to the Bitcoin blockchain, although with distinctions in terms of the nature and storage mechanisms of the data it encompasses.

Blockchain technology, renowned for its applications in several domains such decentralized finance (DeFi), non-fungible tokens (NFTs), and the Metaverse, provides a distinctive and unparalleled user experience. The utilization of the Ethereum blockchain and its native cryptocurrency, ETH, is prevalent in the development of games and apps. The Ethereum 2.0 transition aims to establish a more expedient, cost-effective, and decentralized framework. The objective is to establish a blockchain system that incorporates many interlocking layers, including a second layer (Layer-2) and maybe a third layer (Layer-3), as outlined in Ethereum's roadmap. The varied structure of Ethereum renders it appealing to a wide range of user levels. The Ethereum project is experiencing a surge in popularity because to the increased investment and corporate interest from various firms, particularly in sectors such as Non-Fungible Tokens (NFTs) and the Metaverse. The ETH cryptocurrency possesses significant significance owing to

its extensive utilization inside the network and its role as a local currency.

There are altcoins built on the Ethereum blockchain.The Ethereum network accommodates several tokens under the ERC-20 standard. Several Ethereum-based alternative cryptocurrencies have gained popularity in recent years. These altcoins include: Uniswap (UNI), Compound (COMP), Apecoin (APE), Aave (Aave), Axie Infinity (AXS), Ethereum Name Service (ENS), Curve (CRV)

3.3.2.2. XRP Project

The XRP coin serves as the inherent digital currency within the XRP Ledger, which is a decentralized blockchain-based platform. The XRP Ledger operates without the need for mining and using several validation processes. The utilization of XRP Ledger results in enhanced processing speed and efficiency compared to Bitcoin and several other cryptocurrencies. The Ripple network experiences an average of 1,500 transactions every second. The rate of transactions in Bitcoin is 7 per second, but in Ethereum it is 15.

In contrast to Bitcoin and other cryptocurrencies, XRP operates without employing a Proof of Work (PoW) or Proof of Stake (PoS) process. In the Ripple network, users predominantly employ a consensus process that relies on reputation, as they possess established trust and familiarity with one another. The consensus process employed by XRP distinguishes it as a notable characteristic.

Conventional international payment methods often need a duration of 1 to 4 business days for completion, however utilizing XRP facilitates near-instantaneous transactions, taking less than 5 seconds. Ripple adopts a unique perspective while examining the bitcoin ecosystem. In contrast to Bitcoin (BTC) and Ethereum (ETH), as well as several other cryptocurrencies, Ripple places its emphasis on enhancing the current banking system, which is deemed insufficient. Ripple endeavors to realize its goal by integrating a global network of autonomous banks and payment providers, employing a cost-effective and standardized protocol to facilitate immediate transmission and transfer of payments. One distinguishing characteristic of Ripple, in contrast to other cryptocurrency initiatives, is its centralized nature rather than being decentralized.

Ripple is distinguished from several other cryptocurrencies due to its centralized nature. Although the books sold on the blockchain system undergo processing, their management

remains under the purview of the corporation. The objective of Ripple is to facilitate the efficient, secure, and cost-effective movement of substantial quantities of assets and funds by leveraging blockchain technology. The initiative titled "Best digital asset for global payments" by the Ripple firm might be considered as qualifying.

3.3.2.3. Tether

Tether (USDT) is widely recognized as the inaugural stablecoin, representing a form of cryptocurrency designed to maintain a consistent value relative to traditional fiat currencies. The initial launch of Realcoin took place in 2014, spearheaded by prominent Bitcoin investor Brock Pierce, entrepreneur Reeve Collins, and software developer Craig Sellers.

The Tether (USDT) cryptocurrency operates on a blockchain network that is integrated with the ERC-20 standard. The cryptocurrency known as Tether (USDT) was introduced to the market in 2015 by Tether Limited.

Tether (USDT) is a digital currency designed to maintain a steady value, mirroring that of the United States dollar. The value of USDT remains constant at a set rate of 1 USDT to $1. According to the company's assertion, there exists a monetary reserve of $1 in its vault for each unit of Tether (USDT) cryptocurrency currently in circulation. The Tether (USDT) cryptocurrency is pegged to the value of the US dollar, ensuring a one-to-one correspondence between the two. The price of the product is predetermined, and as a result, there exists a corresponding monetary value stored in the company's secure storage facility.

One of the most significant benefits of real cash is its capacity to be transferred at little expenses. The utilization of the Omni Layer, a component that facilitates the segregation inside the Bitcoin blockchain framework, initially supported the aforementioned system. However, due to the inability of the Omni Layer blockchain network to adequately address the prevailing requirements, a shift towards the ERC-20 system was initiated. Cryptocurrency exchanges provide individuals with the ability to engage in trading activities using the United States dollar as a medium of exchange.

3.3.2.4. BNB Project

The project under consideration is NB coin, previously known as Binance Coin, which falls under the realm of cryptocurrency initiatives associated with the BNB chain. The BNB token was introduced via an initial coin offering (ICO) in 2017, precisely 11 days prior to the commencement of online operations by the Binance platform. The first issuance of the BNB currency as an ERC-20 token took place on the Ethereum network. The BNB currency acquired an independent chain structure with the introduction of the BNB Beacon Chain, and subsequently, the BNB Smart Chain with Ethereum virtual machine compatibility in April 2019. The BNB currency is notably recognized as the native utility token of the Binance platform. BNBs possess the capability to serve as payment instruments, facilitate reservations, and facilitate credit card payments.

The Binance Smart Chain (BSC) is a blockchain network that operates on the Ethereum Virtual Machine (EVM) technology. The BNB Smart Chain offers efficient and cost-effective infrastructure services for decentralized finance, non-fungible tokens (NFTs), and Metaverse applications. The BNB Coin possesses a significant scope of use, primarily serving as the service token inside the Binance platform and functioning as the native token of the BSC network. The BNB Coin serves as a means of accessing other cryptocurrencies inside the Binance Smart Chain (BSC) network, and it also functions as the network's native coin. The BNB Coin provides users with benefits such as reduced commissions and the opportunity to engage in exclusive events on the Binance platform.

The BNB Coin is a form of cryptocurrency that operates on the Ethereum network and was introduced in 2017. It is classified as a non-mining cryptocurrency and adheres to the ERC-20 protocol. The establishment of the BNB Beacon Chain and BNB Smart Chain in 2019 and 2020, respectively, facilitated the development of an independent ecosystem for the BNB coin. The whole quantity of BNB Coin, which holds significant utility within the ecosystem, amounts to 200,000,000.

The Binance platform engages in the practice of burning BNB Coins, wherein it eliminates a portion of these coins equivalent to 20% of its yearly revenues. The aforementioned combustion procedure will persist till the aggregate quantity reaches 100,000,000. The objective of this transaction is to decrease the circulating supply of BNB Coin (BNB) inside the market.

Binance engages in an annual practice of burning and redeeming a specific quantity of BNB tokens in accordance with their predetermined strategies. Binance allocates 20% of its revenues towards the acquisition of BNB tokens, and meticulously documents the process of burning and receiving these tokens on the blockchain. This transparent approach enables users to access transaction records at their convenience, until the total supply of BNB reaches 100 million. BNB burning refers to the practice of enhancing value by diminishing the quantity of circulating BNBs inside the market. Binance, the globally leading cryptocurrency exchange, endeavors to enhance its market capitalization and bolster the value of BNB (Binance Coin) by a strategic approach including the repurchase of BNB from users and the subsequent removal of BNB from circulation through a process known as burning.

3.3.2.5. USD Coin (USDC)

The project under consideration is USD Coin (USDC), which is a stable cryptocurrency that maintains a fixed exchange rate of 1:1 with the US dollar. The company's accounts maintain an equal value of $1 in cash or cash equivalents for every USDC present on the supported blockchains. The United States Dollar Coin (USDC) is generated by the Centre, an entity headquartered in the United States. The Centre ensures that its reserves undergo regular audits to maintain transparency and accountability.

The USDC is a stable cryptocurrency that undergoes independent audits and is pegged to the US dollar at a fixed exchange rate of 1:1. The increasing tokenization of products and services inside the bitcoin realm has led to the growing prominence of smart contract platforms as the foundational elements for facilitating value exchange. USDC, an open-source and transparent stablecoin, facilitates the integration of fiat currencies with smart contracts, providing developers with a practical means to incorporate real-world currencies into blockchain applications. The issuance of the USDC stablecoin is conducted by the Center, an entity that maintains complete reserves of fiat money in a 1:1 ratio and is subject to periodic audits. Issuers have an obligation to regularly disclose their holdings of USD reserves, and Grant Thornton LLP releases monthly reports pertaining to these holdings.

The USDC cryptocurrency is a stablecoin that is produced by the Center organization, which is situated in the United States. It is designed to maintain a stable value by being

linked to the US dollar. Center is a corporate entity established in the year 2018 through a collaborative effort by Coinbase and Circle. The United States Dollar Coin (USDC) issued by the Center undergoes monthly audits conducted by Grant Thornton LLP, an accounting and consulting firm headquartered in Chicago, United States of America. A monthly report is generated at the conclusion of each month, which discloses the reserves of the Center company from the previous month as well as the quantity of USDC present on the blockchain.

3.3.2.6. Binance USD Project

Binance USD (BUSD) is a stablecoin issued by Binance, one of the largest cryptocurrency exchanges in the world. Binance is a cryptocurrency exchange platform that facilitates the trading of various digital currencies. The cryptocurrency known as USD, or BUSD in abbreviated form, is well recognized as one of the leading stablecoins on the market. The BUSD coin, which has been developed in collaboration with Paxos and Binance, aims to offer investors a stable pricing environment. BUSD is a stablecoin that is pegged to the value of the United States dollar, as indicated by its name.

Paxos is a renowned company recognized for its stablecoins within the realm of cryptocurrency. One notable example of a stablecoin project that merits attention is PAX Gold (PAXG), which is specifically designed to be pegged to the value of gold. The BUSD currency was developed by Paxos, the same entity responsible for the introduction of PAXG. It was subsequently introduced in collaboration with Binance. This is the reason why it is perceived as a safe stablecoin. The BUSD stablecoin initiative, which is issued by Paxos, operates under regulatory oversight and is backed by the US dollar. Similar to other stablecoins, the primary objective of this particular stablecoin is to provide stability to its investors amongst the unpredictable nature of cryptocurrency markets.

The supply of BUSD is directly proportional to the supply of the US dollar, maintaining a 1:1 parity. In this context, it can be seen that the issuance of each BUSD token results in the addition of one US dollar to the reserves held by Paxos. To clarify, the BUSD token supply is backed by US cash that are housed in Paxos' US bank accounts. When an individual seeks to exchange their BUSD tokens for fiat currency, the corresponding token is subjected to a process of burning, resulting in the individual receiving fiat

currency from the reserves of Paxos. Hence, the maintenance of a constant 1:1 ratio between the supply of BUSD and the reserve of US dollars is ensured.

Given that BUSD is pegged to the United States dollar, the value of BUSD experiences an increase in tandem with the appreciation of the Dollar/TL exchange rate, and conversely, undergoes a decrease when the dollar depreciates. Similar to other stablecoins, it is not uncommon for the value of BUSD to occasionally fall below that of the US dollar. As an illustration, the price of BUSD exhibits a decline, reaching a value of $0.98. This phenomenon presents an arbitrage opportunity for traders. The upward trajectory of BUSD demand results in a corresponding appreciation in its value, ultimately aligning it with the US dollar.

The BUSD cryptocurrency operates on many blockchain networks, including Ethereum (ETH) and BNB Chain (BNB). Individuals have the ability to transfer their BUSD across various networks and execute asset transfers with ease. The dynamic structure of the circulating token supply of BUSD, which is influenced by the total circulating supply, determines its market value. The BUSD is created in proportion to the amount of US Dollars added to the reserves, and its conversion to US Dollars is readily facilitated based on the level of demand shown by investors. At now, BUSD has the position of the third most significant stablecoin inside the cryptocurrency industry. The BUSD stablecoin, which is pegged to the US dollar, does not have a predetermined maximum supply. BUSD is a stablecoin that has been constructed based on three fundamental ideas, namely accessibility, flexibility, and speed. BUSD may be readily exchanged on the official website of Paxos or several cryptocurrency exchanges. The process of converting BUSD to fiat currency is straightforward and convenient. These characteristics render it accessible to a wide range of users.

The BUSD token possesses a versatile framework that enables seamless interoperability across many blockchain networks, with a particular emphasis on Ethereum and BNB Chain. The availability of BUSD enables customers to conveniently convert their money into a secure asset without the need for frequent physical transfers. The flexible framework of the BUSD project encompasses an additional dimension. The availability of BUSD enables consumers to efficiently acquire cryptocurrencies or convert their assets into stable assets across several blockchains. The BUSD cryptocurrency facilitates

expedited transactions involving US dollars on the blockchain.

3.3.2.7. Cardano Project

Cardano is a blockchain platform that aims to provide a secure and scalable infrastructure for the development The project at hand

Cardano is incorporates the ADA cryptocurrency system, enabling users to engage in the transmission and reception of digital currencies. This digital currency embodies the forthcoming trajectory of monetary systems, facilitating expeditious and unmediated transactions that are inherently safeguarded through the implementation of cryptographic techniques.

Cardano is a multifaceted technical platform that extends beyond its cryptocurrency functionality, serving as a robust infrastructure for the execution of financial applications utilized by people, corporations, and governments on a global scale in their daily operations. The platform has been designed with modular components, allowing for seamless system updates and enhancements through the implementation of soft forks. Following the development of the foundational layer responsible for governing ADA, a distinct computational layer will be established to facilitate the execution of smart contracts. These digital legal agreements are designed to facilitate and uphold future trade and commercial activities. Cardano has the capability to support decentralized applications (dapps), which are services that provide direct connections between consumers and suppliers, operating on a blockchain infrastructure.

The prevailing optimism surrounding the potential growth in Cardano pricing mostly stems from the technological advantages it presents. One of the key components is to the algorithm employed for generating blocks in the realm of cryptocurrencies.

The "Alternative Proof of Stake" method is increasingly being recognized as a viable solution for mitigating the energy consumption associated with bitcoin mining. The Ouroboros protocol developed by Cardano represents an early example of a Stake of Proof system, demonstrating a robust security mechanism that has been empirically validated. The development of the Daedalus Wallet started with a focus on enhancing user security through the formulation and implementation of their desired features. In addition to the customary privacy issues associated with a cryptocurrency wallet,

Daedalus additionally offers the capability to customize specific spending passwords and track transactions.

Cardano, being the leading platform in the field of blockchain technology, employs the Proof of Stake (PoS) model as opposed to the conventional Proof of Work (PoW) approach. This particular methodology is recognized as a more ecologically sustainable alternative to Proof of Work (PoW) due to its mitigation of excessive energy use. Cryptocurrency's effects on the environment have received a lot of attention. In this regard, Cardano appears to possess a more favorable position when compared to Bitcoin and Ethereum, both of which rely on Proof of Work (PoW) mechanisms.

3.3.2.8. Dogecoin

Dogecoin (DOGE), a cryptocurrency that has gained significant attention in recent times, had its debut in December 2013. Currently, there is a significant focus on Dogecoin (DOGE) and other digital currencies derived from it, as cryptocurrencies have gained popularity as preferred options for both investment and transactional purposes.

The cryptocurrency known as Dogecoin (DOGE) was developed by Jackson Palmer and Billy Markus with the intention of establishing a lighthearted payment system that operates outside the realm of conventional banking and its associated transaction costs. As of January 2014, this particular currency has exceeded the entire transaction volume of other cryptocurrencies, including Bitcoin. The Dogecoin (DOGE) had a sustained increase, culminating in a pinnacle of $0.017 on January 7, 2018. The Dogecoin (DOGE) cryptocurrency does not prioritize technological innovation within the blockchain domain. Consequently, its transactions are conducted utilizing the blockchain network that has been built by the Litecoin cryptocurrency. The modifications made to the Litecoin network are equally applicable to the Dogecoin (DOGE) network.

In the first stages of its introduction, Dogecoin (DOGE) implemented a system whereby users were provided with a randomized reward for each block mined, with the intention of facilitating investment activities. However, this reward structure was subsequently modified to a fixed amount. Dogecoin (DOGE), derived after a prominent online persona, was developed with the intention of being a cryptocurrency that is more easily attainable and amicable in nature. It was hypothesized that by adopting this approach, it would be feasible to engage with individuals who had evaded the intricacies associated with

Bitcoin. The Dogecoin (DOGE) market is renowned for its highly engaged and expansive community. Cryptocurrency, a widely utilized kind of digital currency, is commonly employed for the purpose of providing gratuities, and is also favored as a means of funding diverse initiatives. Users engage in a practice known as tipping, when they offer monetary compensation or other forms of recognition to fellow users for their valuable contributions or noteworthy senders. According to existing literature, it is widely acknowledged as being efficacious. One notable characteristic that sets Dogecoin (DOGE) apart from other cryptocurrencies is its inflationary nature, as opposed to being deflationary. There exists no restriction on the circulation of Dogecoin (DOGE). Once Bitcoin and other comparable cryptocurrencies reach their maximum capacity, the act of mining will cease to be financially advantageous over time. Due to this rationale, Dogecoin (DOGE) also exhibits advantages in the context of long-term transactions.

3.3.2.9. Polygon Project

Polygon (MATIC), previously known as Matic Network, endeavors to address the issue of scalability by introducing a secondary layer as opposed to modifying the foundational blockchain network layer. Polygon is a Layer-2 solution designed to enhance the functionality and scalability of the Ethereum (ETH) network. Undoubtedly, since its beginning, it has demonstrated efficacy in augmenting the velocity and user-friendliness of Ethereum.

One of the primary objectives of Polygon is to mitigate the intricacy associated with transactions occurring and interacting inside the network. Polygon (MATIC) has been developed with the primary objective of enabling seamless engagement among users, decentralized financial (DeFi) apps, and ecosystems. Polygon utilizes the Proof-of-Stake Commit Chain mechanism in conjunction with its scaling solution known as Plasma to achieve this objective. Plasma is a method that facilitates substantial scalability for the Ethereum network. The solution provided by Polygon (MATIC) facilitates the development of worldwide decentralized financial apps on the underlying blockchain. In conjunction with the established architecture, Polygon (MATIC) has implemented supplementary side chains and Proof-of-Work validators as a means to enhance the overall security measures.

Despite the significant advancements achieved by decentralized apps, the majority of

present blockchain systems are unable to effectively scale to meet the expectations of current users. Polygon (MATIC) stands as one of the pioneering endeavors aimed at effectively addressing this issue by enhancing transaction speed and diminishing expenses. The objective of Polygon is to construct a decentralized platform utilizing the Plasma framework, which offers enhanced speed and reduced costs. Additionally, it expedites the process by utilizing Proof of Stake checkpoints that are accessible on the Ethereum (ETH) network. By utilizing this approach, a total of 65,536 transactions can be executed on a solitary Polygon chain. The cryptocurrency known as MATIC serves as the inherent digital asset of the Polygon network.

According to the whitepaper of Polygon (MATIC) authored by Jaynti Kanani, Sandeep Nailwal, and Anurag Arjun in 2019, the primary objective of the Polygon network is to address challenges related to scalability and usability while maintaining decentralization. This is achieved through the utilization of the current developer community and ecosystem. The MATIC token whitepaper outlines Polygon as a supplementary chain or off-chain scaling solution designed to enhance scalability and improve user experience for decentralized apps and user services on existing platforms.

3.3.2.10. Polkadot Project

Polkadot is an example of a blockchain protocol that implements a hybrid multi-chain blockchain design that aims to address the scalability issues that plague other popular blockchain protocols such as Ethereum (Wood, 2016).

A cryptocurrency and blockchain platform are called Polkadot. The DOT token is the native cryptocurrency of the Polkadot network. The Web3 Foundation, a Swiss organization managed by Polkadot, Gavin Wood, Robert Habermeier, and Peter Czaban, published it in 2020. It is intended to let blockchains communicate and conduct transactions without the need for a reliable intermediary. Decentralized apps (DApps) may now be created utilizing the Polkadot Network, enabling cross-chain data or asset transfers across several blockchains. Wikipedia, year 2023 It paves the path for the formation of new decentralized marketplaces and improves access to services through a range of apps and providers by integrating the finest characteristics of several private blockchains.

The Polkadot network consists of a main blockchain termed the "relay chain" and a large

number of user-created parallel chains known as "parachains". The network's governance layer is provided by the relay chain, and independent projects can build and run their own blockchains that are integrated into the Polkadot infrastructure by bidding on parachains. A relay chain is in charge of data verification, consensus building, and transaction execution. The network's projected transaction throughput is 1,000 per second. The consensus algorithm used by the network is proof-of-stake. The protocol that is employed is based on Aggelos Kiayias' Ouroboros protocol. The state machine for Polkadot was built in the incredibly fast virtual environment known as WebAssembly (Wasm). Wasm has been developed by large companies such as Google, Apple, Microsoft, and Mozilla, which have built up a large support ecosystem for the standard.

Polkadot is designed to work with public, private and enterprise chains. It collaborates with companies such as PLASM, Laminar, Nodle, Chainlink, Edgeware, Cler to develop the first common use cases. (Polkadot whitepaper, 2023)

3.6.2. Advantages and Disadvantages of Cryptocurrencies

Cryptocurrencies have many advantages and disadvantages. The advantages of cryptocurrencies can be listed as follows (Tüfek, 2017, p. 78):

- States cannot impose any tax deductions on the aforementioned cryptocurrencies.
- It is free from legal repercussions such as tax, declaration, or registration.
- Cryptocurrencies are digital money that rely on cryptographic principles, and their secrecy is crucial.
- Unless a person specifically requests it, third parties cannot access their funds or transfers.
- Since it doesn't really exist in the physical world, moving it is not conceivable.
- Transfer costs are quite inexpensive.
- Due to its scarcity in number, it does not contribute to inflation.

Various procedures cannot be carried out on it since it cannot be controlled by a central organization. Both advantages and downsides apply to cryptocurrencies. The following is a list of these drawbacks (Tüfek, 2017, p. 79):

- It does not formally support any institution.

- Since cryptocurrencies are virtual currencies, it is impossible to undo the transactions done since it is not utilized in the real world, it is only used by a small number of people, and it cannot be formally used for various payments.
- Because cryptocurrencies are entirely speculative, their value is subject to rapid drops and increases.
- As a result of crypto mining, energy use and carbon emissions are rising daily and endangering world sustainability.
- It can create deflation even while it doesn't produce inflation. Since the supply of the aforementioned cryptocurrency will eventually run out, its value can rise dramatically.
- The Bitcoin system is a frequent target of cyberattacks despite its extensive security features. Due to a fault in the system, 184 billion false Bitcoins were created in 2010; upon realizing this, all bogus Bitcoins were erased, and substantial actions were taken in this respect. There may be instances where the Bitcoins just vanish on their own since the wallet where they are stored does not exist. Additionally, if a safe encryption is not built, virtual attackers who can access the phone or computer can take these monies.

It is impossible to apply to courts or other comparable organizations that would impose fines in such circumstances since it is not associated with a central authority. It was shut down because it was allegedly selling unlawful goods. In general, the vulnerability of the bitcoin system and even its usage in illicit activities cannot stop it from being more widely used, but investors who wish to invest in cryptocurrencies should take these benefits and drawbacks into account.

4. MATERIAL AND METHODS

In this section, the concept of Fuzzy logic, Fuzzy TOPSIS, Fuzzy Dematel, Fuzzy Swara process and application steps will be explained. Fuzzy Swara and Fuzzy Dematel methods will be compared in weighting the criteria. A choice will be made between the fuzzy TOPSIS method and the cryptocurrency alternatives. Although it is used in subjects such as investment and in various ranking problems, fuzzy swara and fuzzy dematel methods have not been used before in evaluating the criteria in cryptocurrency investment. In this respect, it is thought that the study will bring innovation to the literature.

4.1. Multi-Criteria Decision Making Methods

People always want to make the most advantageous choice for themselves. Criteria play an important role in the decision-making process. The criteria may vary depending on the situation. For example, educational background may be a criterion in the recruitment process of human resources, while one of the criteria may be the lowest cost in choosing a factory location. Multi-criteria decision-making problems can be defined as the problems in which the best alternative is selected from the possible solution sets in which more than one criterion is optimized (Turan, 2018).

Multi-criteria decision problems are encountered when a set of alternatives or candidates must be selected on the basis of a set of criteria or attributes. Comparing alternatives is key to decision making in such situations. However, in case of conflicting alternatives, a decision maker must also consider imprecise or uncertain data in such decision problems. Fuzzy set theory is suitable for overcoming this uncertainty in solving multi-criteria decision making problems (Aouam et al., 2003). While classical multi-criteria decision-making methods are used if the available information is complete and clear, fuzzy multi-criteria decision-making methods have been developed to make choices with incomplete and unclear information.

In addition, in MCDM methods, it is the first step to finalize the preferences of the decision makers of the criterion weights. There are many weighting methods performed for this step (Malczewski, 1999; Zardari et al., 2014). In addition, criterion weighting methods can be divided into classes. For example, the most recent of these ideas is Wang et al. (2009) and Ahn (2011) are known to have developed it. It is divided into three groups as subjective, objective and mixed. In this step; Their enclosures, in which the

criterion weights are determined by the decision maker, and the objective, subjective and objective methods, in which the models or formulas they have are determined by their use, are also named as mixed criteria weighting methods. The SWARA and Dematel methods method used for this purpose are accepted as subjective criteria weighting methods since the criteria weights are determined by the decision makers due to their structure. In my study, since the weights will be determined by the expert, the SWARA method, which is subjective, was chosen.

4.2. Fuzzy Logic

Classical logic includes acceptable decision outputs that can be formed from propositions that include traditional concepts and terminology. However, the world we live in is full of uncertainty and uncertainty. There is no way of thinking that expresses certainties. It is defined as a numerically related function of aggregated values or real numbers of 0.1, containing infinite data between the absolute true or falsehood of an assumption or option, and is based on fuzzy logic. The person who made the first research on this subject was Zadeh. Zadeh chose to use binary membership functions to express concepts such as "long, red, stationary" and to define terms such as "long, red, stationary" with fuzzy sets described using cascading membership.

Engages in the solution while modeling and calculating the ambiguous expressions used in the daily flow in the blur. Decision makers involved in the decision-making process often remain in uncertainty and problems. And, in everyday language, expressing judgments to the other side often involves vague and subjective statements. In order to eliminate these human judgments and ambiguities, fuzzy decision theory (Zadeh, 1965), which can express linguistic terms, was created. The most important advantage of fuzzy logic is that it includes the complexity and uncertainty inherent in human nature and living conditions and expresses them numerically. When other advantages are examined; These are situations such as being compatible with the human mindset, being solved simply, easily understood, being able to reach a solution without requiring high costs, and not requiring complex mathematical operations and models. The disadvantages of fuzzy logic are; The rules of the method require expertise, stability analysis is not performed, and the result is difficult to predict in advance (Sanca et al., 2022). Logic that fits with fuzzy logic and people's ability to use ambiguous expressions system can be defined. In other words,

fuzzy logic adapts to the human way of thinking by showing flexibility such as high-low speed-slow, less high-low low, less fast-less slow, etc. For example, Individuals may not be sure of their choices in daily life. As a result, using linguistic expressions while modeling people's decisions may yield more accurate results. The use of values in verbal expressions is the main reason for successful results in other ways. Examples of important issues where fuzzy logic is preferred and methods and techniques are widely used; image monitoring, signal processing, control systems, artificial intelligence, expert systems, databases and data mining.

In fuzzy MCDM problems, performance rating values and relative weights are usually characterized by fuzzy numbers. A fuzzy number is a convex fuzzy set defined by a specific range of real numbers, each of which has a membership value between 0 and 1. It may be the membership value, given the fact that in some cases this value is difficult to pinpoint. expressed as a range of real numbers. In this study, besides criterion values, criterion weights are also considered as linguistic variables. The linguistic concept of variable is very useful in dealing with situations that are too complex or ill-defined that cannot be reasonably described in conventional quantitative expressions.

4.2.1. Fuzzy Numbers

Triangular fuzzy numbers consisting of three components (l, m, u) are expressed as follows. The first value 'l' indicates the lowest value in the range; If 'm' is the optimum value; The 2u' value is the highest value in the range. Triangular fuzzy numbers also express the neighborhood of real numbers. For fuzzy numbers, the optimum values do not have to be equal to the upper and lower values. In the literature, triangular fuzzy numbers are the most preferred type of fuzzy numbers due to their convenience (Öztürk, 2018). It is also possible to use different fuzzy numbers depending on the method and purpose of the evaluation. When trapezoidal fuzzy numbers and triangular fuzzy numbers are used, it has been found that both types of fuzzy numbers lead to the same result, but triangular fuzzy numbers are an advantageous method because they provide ease and speed of operation.There are various types of fuzzy numbers, but mostly triangular fuzzy numbers are widely used in theoretical and practical applications. Triangular numbers are easy to use and provide time advantages (Fatih, 2007). Due to these advantages, fuzzy triangular numbers have been preferred.

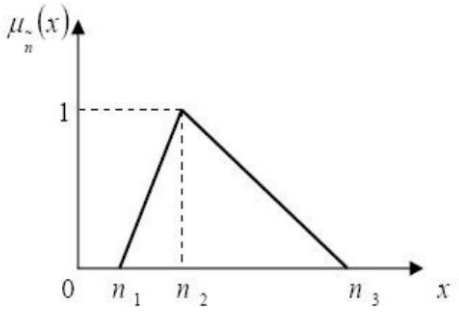

Figure 5. Triangular fuzzy numbers

Reference: Yaman,2019

Some of arithmetic operators for triangular hesitant fuzzy numbers are given as follows (Kayapınar ,2020):

A1=(l1,m1,u1) ; A2=(l2,m2,u2)

Addition : A1 + A2=(l1 +l2 – l1.l2 , m1 +m2 – m1.m2 , u1+u2 – u1.u2 (4.1)

Average of two fuzzy numbers: (A1,A2) =((l1 +l2)/2 , (m1 +m2) /2 , (u1+u2) /2) (4.2)

Division: A1/A2 = (l1/u2 , m1/m2 , u1/l2) (4.3)

Multiplication: A1 * A2 =(l1.l2 , m1.m2 , u1.u2) (4.4)

The process of converting the outputs created after fuzzy logic operations into numbers similar to the inputs is called defuzzification (Guvenc et al., 2007). There are many methods for clarification of the determined fuzzy numbers. Median (mean value) method will be preferred because it is easy to apply. It is to find the value that divides the area formed by the membership function equally into two. In the method where the arithmetic mean of the fuzzy number elements is found, the sum of the elements in the quadruple structure for the trapezoidal fuzzy number is divided by four, and for the triangular fuzzy numbers, the sum of the elements in the triple structure is divided into three, and the fuzzy number is clarified using the median method, and the sharp value is reached (Sarı, 2012).

$\tilde{A} = (l, m, u)$ of the media method representation of defuzzification in triangular fuzzy number ;

$$x = (l + m + u)/\ 3) \quad (4.5)$$

4.3. Fuzzy SWARA

Fuzzy SWARA is a method in which fuzzy expressions are used during comparisons in the SWARA method. The SWARA method is used to determine criterion weights in multi-criteria decision making problems. Within the framework of the evaluations within the scope of expert opinions, it is possible to obtain the importance weights of each criterion consistently (Moniri, Tabriz, Ayough, & Zandieh, 2021). The fuzzy SWARA method is simple and easy to understand. It is also known to have less pairwise comparisons compared to AHP, ANP and BWM methods (Alvand et al., 2021).

The fuzzy SWARA method consists of 6 steps. The steps are performed as indicated below.

Step 1

The ranking is made starting with the most important criterion. When ranking the n options, experts say that the most important option is "1st" and the least important option is "n." is ensured.

Step 2

Beginning with the second criteria, Table 5 is used to assess the relative relevance level of each criterion (Chang, 1996).

Table 5. Triangular fuzzy numbers for Fuzzy SWARA

Linguistic Terms	Linguistic Number
Equally important(EI)	(1.000,1.000,1.000)
Moderately important(MI)	(0.667,1.000,1.500)
Less important(LI)	(0.400,0.500,0.667)
Very less important(VLI)	(0.286,0.333,0.400)
Much less important(MLI)	(0.222,0.250,0.286)

Step 3

Using the equation below, the comparative importance coefficient (k) is calculated for each criterion (Keršuliene et al. ,2010).

$$\{Kj = \begin{cases} 1, & j = 1 \\ s + 1, & j > 1 \end{cases} \quad (4.6)$$

Step 4

Calculation of the importance vector (Q j). Since fuzzy numbers will be processed, it is integrated into the formula as (1,1,1) instead of 1 (Kayapınar, 2020).

$$Qj = \begin{cases} 1, & j = 1 \\ (x\ -1)/Kj, & j > 1 \end{cases} \quad (4.7)$$

Step 5

The following equation provides the means by which the fuzzy weight values (wj) of the problem's criteria are calculated (Keršuliene et al. ,2010).

$$Wj = QJ\ \frac{Qj}{\sum_{j=1}^{n} \binom{n}{k} Q^j} \quad (4.8)$$

Step 6

The arithmetic averages of the decision makers are taken. Fuzzy numbers are defuzzified.

$x\ = (l + m + u)/\ 3$

4.3. Fuzzy DEMATEL

By developing the fuzzy DEMATEL method, they aimed to evaluate the interaction in complex problems in a fuzzy environment. (Lin, 2004)) DEMATEL organizes the criteria in order of priority in terms of the type of relationships and the importance of their effects on each other. This method allows the system to be examined more easily and it has been observed that the decision-making process is more reliable (Alp, 2016).

The steps of the fuzzy DEMATEL method can be summarized as follows:

Step 1

Decision makers have been identified.

step 2

The criteria to be evaluated are determined and a question form is created according to

the fuzzy scale. The table below was used to evaluate the criteria (Chang et al., 2011).

Table 6. Linguistic variables for the ratings

Linguistic Terms	Influence Score	Triangular Fuzzy Numbers
No influence (No)	0	(0, 0, 0.25)
Very low influence (VL)	1	(0, 0.25, 0.50)
Low influence (L)	2	(0.25, 0.50, 0.75)
High influence (H)	3	(0.50, 0.75, 1.00)
Very high influence (VH)	4	(0.75, 1.00, 1.00)

Step 3

A binary comparison matrix is used for the criteria. The average of the evaluations of the decision makers is calculated. Thus, the arithmetic mean of triangular fuzzy numbers, each corresponding to an expert, is taken. (Çakın, 2017).

Step 4

The normalized direct relationship fuzzy matrix (X) is calculated by applying the formulas below.

$r = max1 \leq i \leq n \quad (\sum uij \; n \; j=1)$

$$x\check{}ij = z\check{}ij \; r = (\; lij/\; r \;,\; mij/\; r \;,\; uij/\; r \;) \qquad (4.9)$$

Step 5

Fuzzy Total Relationship Matrix Will Be Created. In order to facilitate the calculations, three matrices are obtained from $x\check{}ij = (lij, mij, uij)$, which forms the normalized direct relationship matrix $X\check{}$.

$$Xl = \begin{matrix} 0 & L1n & \dots \\ L21 & 0 & \dots \\ Ln1 & \dots & 0 \end{matrix}$$

$$Xm = \begin{matrix} 0 & M1n & \dots \\ M21 & 0 & \dots \\ Mn1 & \dots & 0 \end{matrix}$$

$$Xu = \begin{matrix} 0 & U1n & \dots \\ U21 & 0 & \dots \\ Un1 & \dots & 0 \end{matrix}$$

The X matrix is subtracted from the identity matrix, inverted and multiplied by itself.

Matrix[lij'] = $Xl(I - Xl) -1$ (4.10)

Matrix[mij'] = $Xm(I - Xm) -1$ (4.11)

Matrix[uij'] = $Xu(I - Xu) -1$ (4.12)

The elements of the total relationship fuzzy matrix $\tilde{T}$ are calculated.

T=$\tilde{X}(I - \tilde{X}) -1$ (4.13)

CFCS is used to convert fuzzy numbers into clear values. CFCS (Converting Fuzzy data into Crisp Scores) method is based on determining the fuzzy maximum and minimum of the fuzzy number range. The total score can be found as a weighted average according to membership functions .

The CFCS method includes the following steps (Chang et al. ,2010):

$\tilde{T} = (lij, mij, uij)$

$R = maxuij$, $L = minlij$ ve $\Delta = R - L$ (4.14)

$tlj = (lij - L)/\Delta$ $tmj = (mij - L)/\Delta$ (4.15)

$tuj = (uij - L)/\Delta$ $tlj\ ls = tmj/(1 + tmj - tlj)$ (4.16)

$tuj\ rs = tuj/(1 + tuj - tmj)$ (4.17)

$tj\ crisp = [tlj\ ls \times (1 - tlj\ ls) + tuj\ rs \times tuj\ rs]/[1 - tlj\ ls + tuj\ rs]$ (4.18)

$\tilde{f}\ ij\ crisp = L + tj\ crisp \times \Delta$ (4.19)

Step 6

Affected and Affected (Sender and Receiver) Groups will be determined. Interactions between the criteria are determined by calculating the values of $\tilde{D}i + \tilde{R}\ i$ and $\tilde{D}i - \tilde{R}\ i$. If the $\tilde{D}i - \tilde{R}\ i$ value is a positive value, it is in the influencing group, and if it is a negative value, it is in the affected group (Tzeng and Huang 2011, Çınar 2013). According to the

determined relationships, criterion weights are calculated with the help of the formula below. (Steel, 2022)

$$wi = \{(\tilde{D}\ \text{i def} + \tilde{R}\ \text{i def})^2 + (\tilde{D}\text{i def} - \tilde{R}\ \text{i def})^2\}^{1/2},\ Wi = wi / \sum wi \quad (4.20)$$

4.4. Fuzzy TOPSIS

TOPSIS method is a widely used MCDM method developed by Hwang and Yoon in 1981 (Perçin and Çakır, 2013). The TOPSIS method, like other MCDM methods, is used in the evaluation of alternatives in the decision-making process by taking expert opinions. The TOPSIS method works according to the rules of the shortest distance to the solution and the longest distance of the decision points. In the main purpose of the method, the necessary proximities for the ideal solution is calculated and these proximity are evaluated separately as the distance to the positive ideal solution and the distance to the negative ideal solution. The aim is to choose the best alternative among the alternatives. By sorting, the best alternative solution is the closest to the positive ideal solution and the alternative that is the farthest from the negative ideal solution.

The TOPSIS method has advantages over AHP or other simple weighted aggregation methods. Because it calculates the best alternative solution among the alternatives according to the rule of the closest to the positive ideal solution and the longest distance to the negative ideal solution. And the method is intuitive, understandable and simple (Bottani & Rizzi, 2006).

In 2000, Chen stated that decision makers should use linguistic variables in order to reflect more reality in decision making problems where there is uncertainty and there are many decision makers. These linguistic variables were also expanded within the scope of fuzzy set theory, and he stated that the solution should be done in a fuzzy environment, thus revealing the Fuzzy TOPSIS method (Chen, 2000).

In the classical TOPSIS method, the weights of the criteria and the ratings of the alternatives are known precisely and net values are used in the evaluation process, but the exact values are not sufficient for real-life problems.

The following steps are followed in order to apply the fuzzy TOPSIS method (Chen, 2000). Expert weights were considered equal in my study.

Step 1

Establishment of criteria by decision makers; The criteria to be used in the evaluation are determined by the group consisting of decision makers.

Step 2

Evaluations are made with linguistic variables; First of all, appropriate linguistic variables to be used in order to determine the importance weights of the criteria are selected, and then the evaluation of alternatives based on the criteria is provided by using linguistic variables.

Step 3

Conversion of Evaluations into Fuzzy Numbers: The verbal variables determined by the decision makers in the 2nd step for the importance weights and evaluation of the alternatives are converted into triangular or trapezoidal fuzzy numbers according to preference. The fuzzy numbers to be used are given below (Chen, 2000).

Table 7. Linguistic variables for the ratings

Terms	**Numbers**
Very Poor (VP)	(0,0,1)
Poor (P)	(0,1,3)
Medium Poor (MP)	(1,3,5)
Fair (f)	(3,5,7)
Medium Good (MG)	(5,7,9)
Good (G)	(7,9,10)
Very Good (VG)	(9,10,10)

Step 4

A fuzzy decision matrix is created; At this stage, as a result of transforming the decisions made by each of the decision makers into fuzzy numbers, a fuzzy decision matrix is formed by taking the average of these numbers. Decision makers (K) make their evaluations among $A1, A2, \cdots, Am$ alternative solutions, taking into account the decision criteria defined with $C = \{Ci\backslash i = 1, 2, \cdots, n\}$. The $\tilde{D}$ fuzzy decision matrix consists of ,as shown in the formulation, and these elements show the performance of the Ai ($i = 1, 2, \cdots, m$) alternatives according to the Cj ($j = 1, 2, \cdots, n$) criteria. W is the matrix of the

decision criteria formed by the $\tilde{w}i$ elements representing the importance weights of the Cj (j = 1, 2, ⋯ , n) criteria.

$$Wj = \frac{1}{K}\,[Wj^{1} + Wj^{2} + \cdots + Wj^{K}\,] \tag{4.21}$$

Step 5

Normalized fuzzy decision matrix is created: Fuzzy decision matrix is converted to normalized fuzzy decision matrix with the help of the following formulation. Here, B is the benefit criterion and C is the cost criterion.

$$\tilde{r}ij = (\,aij/\,cj*\,,\,bij/\,cj*\,,\,cij\,/cj*\,)\,,\quad j \in B\quad,\ cj* = \max i\ cij \tag{4.22}$$

$$\tilde{r}ij = (\ aj^{-}/cij,\ \ aj^{-}/bij\ ,\ \ aj^{-}/aij\ )\ ,\quad j \in C\quad,\ aj^{-} = \min i\ aij \tag{4.23}$$

Step 6

Generating a weighted normalized fuzzy decision matrix; After the normalized fuzzy criterion matrix, the weighted normalized decision matrix is calculated.

$$\tilde{V} = [\tilde{v}ij] = \tilde{r}ij\ x\ \tilde{w}j\ ,\qquad i = 1, 2,\ldots, m\ ,\qquad j = 1, 2,\ldots, n \tag{4.24}$$

Step 7

Determination of fuzzy positive and negative ideal solutions (Gürsoy, 2019).

$A*$= Expresses the fuzzy positive ideal solution, calculated according to the formula

$A-$= Represents fuzzy negative ideal solution, calculated according to formula

$$A* = (\tilde{v}1*\,,\,\tilde{v}2*\,,\cdots,\tilde{v}n*\ )\qquad j = 1, 2, \ldots, n \tag{4.25}$$

$$A^{-} = (\tilde{v}1-\,,\,\tilde{v}2-\,,\cdots,\ \ \tilde{v}n^{-}\ )\qquad j = 1, 2, \ldots, n \tag{4.26}$$

Step 8

The distances of each solution alternative from the fuzzy positive ideal solution and the fuzzy negative ideal solution are calculated. $di*$ is the distance from the fuzzy positive ideal solution, and $di-$ is the distance from the fuzzy negative ideal solution (Gürsoy, 2019).

$di* = \sum d\,n\,j{=}1\,(\tilde{v}ij, \tilde{v}j*)\,,\ i = 1, 2, \ldots,\ \mathrm{m}$ (4.27)

$di- = \sum d\,n\,j{=}1\,(\tilde{v}ij, \tilde{v}j-)\,,\ i = 1, 2, \ldots, \mathrm{m}$ (4.28)

It expresses the distance between two fuzzy numbers and is calculated according to the Vertex method. In this method, the distance between two triangular fuzzy numbers such as $\tilde{m} = (m1\,, m2\,, m3\,)$, $\tilde{n} = (n1\,, n2\,, n3\,)$ is calculated according to the equation below (Gürsoy, 2019).

$$\mathrm{d}(\tilde{\mathrm{m}}, \tilde{\mathrm{n}}) = \sqrt{1/3[(\mathrm{m1} - \mathrm{n1})^2 + (\mathrm{m2} - \mathrm{n2})^2 + (\mathrm{m3} - \mathrm{n3})^2]} \quad (4.29)$$

Step 9

Finding the closeness coefficients for the alternatives The closeness coefficients for all alternatives are calculated according to the following equation.

$$\mathrm{CCi} = \frac{\mathrm{di}^-}{\mathrm{di}^* + \mathrm{di}^-}, \qquad i = 1, 2, \ldots, \mathrm{m} \quad (4.30)$$

Step 10

Ranking of Alternatives According to the closeness coefficients calculated for each alternative, the order is made from the largest number to the smallest. The alternative with the largest closeness coefficient is chosen as the best solution. If the closeness coefficient is high, it is closer to the alternative fuzzy positive ideal solution and further away from the fuzzy negative ideal solution.

5. DECISION SUPPORT SYSTEM FOR INVESTING OF CRYPTOCURRENCIES

In this section, there are definition of decision problem, determination of decision makers, determination of criteria, determination of alternatives, application of Fuzzy TOPSIS method for alternative selection, fuzzy SWARA method and fuzzy dematel and comparison of criterion weights. The flow chart in the example case is given below.

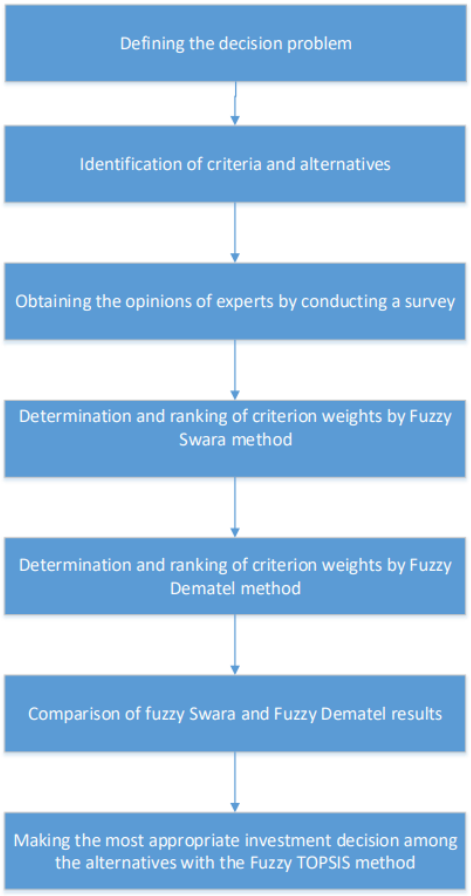

***Figure 6**. The flow chart in the case study*

For those new to cryptocurrencies, Bitcoin is often the first stop when it comes to investing. It is the most famous blockchain project and one of the largest cryptocurrency by market cap. But there are thousands of different cryptocurrencies (altcoins). Some altcoins have their own blockchain, while others use a pre-existing network (like BNB Smart Chain or Ethereum). Every project has a different proposal and each has its own potential risks and benefits. The criteria that can be used while making the selection for this subject will be mentioned.

While determining the criteria, a detailed literature review was made and factors that could affect the investment process were taken into account. In addition, the environmental impact, decentralization and tokenomic structure of crypto money, which were not addressed in previous studies, will be added to the evaluation as criteria with this study. It is thought that adding these criteria, which were not included in previous studies, will contribute to the literature on this subject.

First of all, if an unknown cryptocurrency is researched, the first place to look is the whitepaper. The presence of a whitepaper is an important factor that indicates the seriousness of the crypto asset involved. A cryptocurrency whitepaper allows projects to explain their product and purpose to their audience. Projects can freely choose what information they want to present, but whitepapers often include an overview of the project's purpose, token economy, products, features, and team. So whitepapers can be a good starting point when researching a particular project. The whitepaper summarizes information about a blockchain or cryptocurrency project under a single document. It is a popular way to describe how a project works and what problems it aims to solve. The whitepaper can provide an overview of key data, along with statistics and charts. It can also explain the administrative structure of the project, current and future development plans (ie roadmap) and who is working on this project. A good white paper also provides technical explanations to demonstrate the adequacy of the project.

When buying a technological product, product information is checked; technological and functional features are available. The whitepaper is similar in structure to this. Nobody wants to buy a product that does not have a certified manual, because its properties and structure cannot be known clearly, so it does not inspire confidence. What features it has, how it provides security, what its goals are, what its technological infrastructure includes, all this information is included in the whitepaper and when the whitepaper is examined, it can get clear information. In the absence of a whitepaper, it is not recommended to evaluate it directly because there is no sufficient source of information about crypto money and it can only be obtained through people's referral or social media, but how safe it can be being discussed.

In many studies examining the factors affecting the investment process, whitepaper gains the highest weight for these reasons. For example, in the research conducted by Ayarcı

N. (2019), it is shown that the most important factor for ICO (initial coin offering) investment is whitepaper factors.

Katrancı (2020), to evaluate the ten most suitable crypto currency alternatives determined for investors with fuzzy CODAS approach, total market value, average return, coin team/developers, roadmap, transaction speed, whitepaper, supporting institutions and organizations, security, stock market. They used the number of changes and the criteria of change from the highest value. Among these criteria, whitepaper was one of the highest criteria.

Fisch C. (Quote2019) investigated the role of technological capabilities in ICOs in his study. According to the results, he stated that the whitepaper review and the presence of high quality source codes increased the amount invested.

In summary, for the reasons explained in this study, whitepaper was not taken as a criterion, but it was assumed that the evaluated cryptocurrencies had whitepaper. In other words, the prerequisite for our investment evaluation is that the coin has a whitepaper. Only cryptocurrencies containing white paper will be included in the assessment. In this way, basic security will be provided as a priority. Some cryptocurrencies may publish their whitepapers later. While it will be reassuring in the future, it will not participate in the assessment as there will not be enough information if there is currently no whitepaper.

Cryptocurrency with proven reliability such as Bitcoin is not included in the evaluation, but anyone who wants can add it to their own evaluation using the criteria determined in this study. In this study, I will deal with altcoin projects with high market caps listed on major stock exchanges. In this way, I think cryptocurrencies can allow investors to diversify their portfolios in terms of altcoins as well as proven cryptocurrencies.

It has been gathered under 13 sub-criteria and 3 main criteria that are taken into account in the selection of the most suitable crypto money investment alternative. Criteria; Security, Transaction Speed, Roadmap, Decentralization, Market size, Transaction fee, Tokenomic, Token price history, Social media activity, competition, Environmental impact, team, Community support. The main criteria are divided into three as technical factor, economic factor, social and environmental factor. The criteria and the hierarchical structure of the alternatives are given in figure 7. In this study, which includes decision makers who have extensive knowledge about cryptocurrencies and who have previously

preferred cryptocurrencies as an investment alternative, the most appropriate one among the 5 most traded crypto money alternatives will be selected by the decision makers and the criterion weights will be determined. Ethereum, Solana, Polkadot, Polygon and XRP coins were chosen as alternative coins. The weights of the selected criteria will be evaluated with the help of Fuzzy Swara and Fuzzy Dematel methods. The evaluation will be made among the five altcoins with high market capitalization on coinmarketcap. Expert weights were assumed to be equal when using the methods.

While investigating the criteria, many different issues were looked at. The day-to-day cryptocurrencies are considered securities has been a hot topic lately. Shanaev Sh. The study by (2020) indicates that over-regulation of cryptocurrencies, at least at the current stage of their development, has the opposite effect, the government's commitments not to over-regulate cryptocurrencies and allow the industry to develop in a freer environment, lower market volatility and more stable coins and tokens. states that it can contribute to the prices. The US Securities and Exchange Commission (SEC) considers many cryptocurrencies to be securities. And he cites the importance of overseeing the regulation of crypto assets for the protection of investors. (Cumming, D.J ,2019) Cryptocurrencies are not considered as securities in Turkey (Uzumcu , 2022).

In summary, the treatment of the coin as a security is still a controversial issue, and it is an open issue that seems to be safe for the investor, but can cause price fluctuations in this way. This situation was not considered as a criterion because according to many countries, cryptocurrencies are still not securities and there is new information on this subject. There seems to be a long way to go on how to legally position cryptocurrencies and what effect this will have.

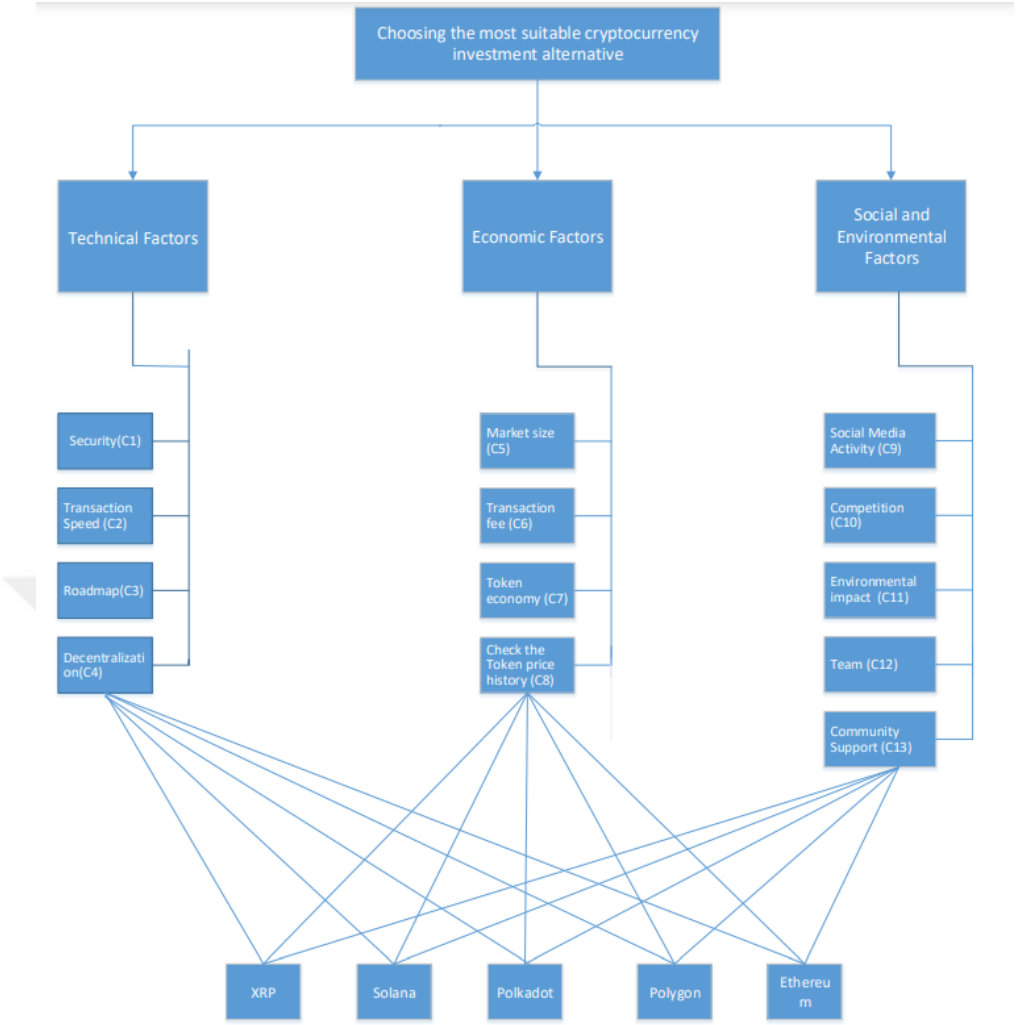

Figure 7. Hierarchy Structure for Multi-Criteria Decision Making Methods

5.1. Defining Criteria

5.1.1 Technological Factors (F1)

When evaluating the technology underlying the project, many sub-criteria should be applied. Does it offer something unique or innovative? Is the technology safe and reliable? Is it scalable and can it handle a large number of operations? It can identify the network or blockchain on which the cryptocurrency is built.

a.) Security(C1)

Given the value of traded assets, security is critical in any cryptocurrency project. Evaluate the security measures of the project, including encryption, access controls, and auditing, and whether there is a history of security breaches or vulnerabilities. The security of cryptocurrency projects depends on many different factors and is a complex

process to measure. However, there are some important indicators for the security of cryptocurrency projects. An effective consensus algorithm must perform these procedures in an objective and mathematically rigorous manner to ensure that all nodes agree on the state of the system, while preventing the system from failing due to erroneous or malicious behavior (Christian Cachin and Marko Vukolić, 2017). Many different consensus algorithms have been created to perform these actions as quickly and safely as possible.

Consensus mechanisms play a crucial role in achieving better performance and desired security in cryptocurrency-based applications. In the context of cryptocurrencies, according to the conclusion in section 1.1 of our review of various consensus mechanisms, including their key features, strengths, and challenges affecting the security of cryptocurrencies, the Pos,Pow,DPos=PBFT mechanisms can be preferred, respectively. Information about which mechanism the crypto currency uses can be accessed from its whitepaper, its official website or stock market platforms.

b.) Transaction Speed (C2)

In fact, it basically refers to Transaction speed and Scalability. Transaction speed defines how fast the network is running: that is, how many transactions per second it can process. It is very important for the digital coin market because most users trust cryptocurrencies for their security, transparency and short transaction time. When calculating Transactions Per Second for transaction speed, block size, transaction size and block duration are taken into account. Transactions Per Second (TPS) is the number of transactions a network can process in one second. It is a metric used to evaluate the processing speed of a network (Ledger Acamedy, 2023). Bitcoin transactions, for example, are very slow. In most cases, the transaction is confirmed within an hour. While this is still fast when it comes to international transactions, it is slow compared to other blockchains. Generally, transactions are considered successful with at least six confirmations, which takes an hour. As of 2023, Solana is one of the projects with high TPS (OKX ,2023). If the block size, transaction size and block time information for TPS is available, it can be calculated as follows, and this information can be easily accessed from various platforms. Calculation; (Block size/Transaction size) / Block time = Transactions Per Second (Coinmarketcap,2023). Block size is the amount of data about transactions that a block

can carry in the blockchain. The larger the block, the more people needed to run a full node.

Transaction Size: Different blockchains differ significantly in terms of data transmitted with each transaction. A simple Bitcoin transaction can be as small as 226 bytes or as large as 500 bytes. Higher transaction sizes lead to higher transaction times on the blockchain. Block time / Confirmation time: Confirmation time is the time it takes for a transaction to be verified and added to the blockchain. In the block explorer one can look up the average confirmation time for transactions, which is usually measured in minutes or seconds. Approval times calculated from various platforms can be reached (Blockchain,2023). The measured TPS and approval times for some cryptocurrencies are listed below (Phemex,2023).

Table 8. Number of TPS

Cryptocurrency	**Transactions Per Second (TPS)**	**Average Transaction (Block) Confirmation Time**
Bitcoin	3-7	10 min
Ethereum	15-25	6 min
Solana	2825	0.4 sec
Polkadot	1000	4-5 sec
EOS	4000	0.5 sec
Cosmos	10000	2-3 min
Stellar	1000	2-5 sec
Dogecoin	30	1 min
Litecoin	56	30 min
Ripple (XRP)	1500	4 sec
Bitcoin Cash	61	60 min
Aptos	10	4 sec

c.) Roadmap(C3)

A Roadmap is a business planning technique which lays out the short and long term goals of a particular project within a flexible estimated timeline. For an emerging product or a startup, the roadmap should articulate the goals and vision of the project, while laying out the development milestones with a rough time estimate for achieving these milestones. Internally, the roadmap is used as a strategic vision for focussing the development team

and providing clear goals and milestones for shipping a completed product. It also gives a sense of priority to specific tasks based upon the intended structure of the finished product. For investors, the roadmap provides insight into the direction and vision for the project, while also serving as a measure for the pace and success of the evolving product. Often the roadmap is presented in a simplified form as a flow diagram with development goals in boxes with rough completion times, indicating the various stages of significant development and significant product milestones. The following steps can be used to find the roadmap of a cryptocurrency.

Visit the official website: The first step is to visit the official website of the cryptocurrency. Look for a "roadmap" or "timeline" section on the website. This section typically outlines the milestones and goals of the project over a specific period. The terms explained below are some of the points to consider in the roadmap.

Emission, refers to how quickly new cryptocurrencies are released.

Token distribution; Tokens are made available and no early access or special allocations are made before they are distributed to the public.

It is expected to match the roadmap on issues such as maximum token supply, emission, distribution schedule, if not, the coin will experience a price drop and confidence will decrease.

d.) Decentralization(C4)

Bitcoin and similar blockchains are designed to be decentralized. The whole system is based on the absence of a person or organization in control. That is, control is distributed rather than in the hands of a single unit. Everyone has access to the same data. If someone tries to trick the system into changing the records in their own interest, other participants will reject the erroneous data.

Audil Khaki(2023) Re-evaluating portfolio diversification and design using cryptocurrencies: Are decentralized cryptocurrencies enough? The study is to compare the efficiency of centralized and decentralized cryptocurrencies. The approach allows us to test the theoretical limits of the diversification potential that each cryptocurrency class can provide to a potential investor. Using average variance and high-order moments optimization approaches to assess the diversification potential of centralized and

decentralized cryptocurrencies, it is stated that decentralized cryptocurrencies generally offer higher average returns compared to centralized cryptocurrencies. In addition, it is seen that the decentralized structure is more advantageous in the studies, since the manipulation of the data will be prevented thanks to the decentralization.

5.1.2 Economic Factors (F2)

The economic factors that are indispensable in the investment process are also valid in crypto investment, and the importance of the token economic concept and how it should be measured are mentioned in detail.

a.) Market size (C5)

Despite the exponential rise of Bitcoin and other cryptocurrencies, the sector is still relatively undeveloped (Caporale and Plastun 2017). Bitcoin was launched in 2009, but serious trading did not begin until 2013. Therefore, assessing the market potential of a cryptocurrency project can be a complex process, looking at the market value.

Market value (or network value) is calculated by multiplying the circulating supply by the current price. This represents the hypothetical cost of purchasing all available units of the crypto asset. Free float in traditional stock markets is similar to market value. Market value is a criterion taken into account by many authorities in the investment process. In Table 1, studies dealing with market value are mentioned.

In the investment process, it would not be right to invest by looking only at the unit price or the supply in circulation. Because if the unit price of A coin is $10 and its circulating supply is 1,000; Assuming that coin B has a unit price of $5 and a circulating supply of $10,000, it would be misleading to look only at the unit price or supply. Calculate by Market Cap = Current Price x Circulating Supply or arrive at market cap calculated from price tracking platforms like Coinmarketcap (2023).

b.) Transaction fee (C6)

Transaction fees can be high or low depending on the level of activity on the network. Market forces can also affect the amount of transaction fees paid. High fees can prevent widespread use of blockchain, but too low can create security issues.

For example, in some cases it has been observed that people pay an average of up to $28

to transact using Bitcoin (Brandvold et al. , 2015). It has been reported that users often incur significant transaction fees when using exchanges such as Coinbase to transfer funds to an external Bitcoin address (Scaillet et al., 2020). The price to be paid when purchasing can be found on various exchanges (Binance Academy, 2023).

c.) Tokenomic (C7)

Tokenomics refers to the design, distribution and management of tokens used in a particular blockchain ecosystem or cryptocurrency network. Tokenomics is a term that combines the words "token" and "economy". Tokenomics primarily refers to the structure of a cryptocurrency's economy designed by its creators. It identifies the factors that affect the use and value of a token. These include token creation and distribution, supply and demand, incentive mechanisms and token burning programs as well as other factors. For a crypto project to be successful, a well-designed token economy is necessary. Evaluating the token economy of a project before deciding to participate is crucial for investors and stakeholders. On the other hand, poorly designed tokenomics can lead to volatility, price manipulation and a lack of trust in the project, resulting in a decline in adoption and market capitalization.

In Auditing Tokenomics: A Case Study and Lessons from Auditing a Stablecoin Project, it is mentioned that Tokenomics is a vital part of any blockchain project. How crypto tokens are used within the ecosystem, their role in the project and how they are designed to incentivize should be examined.

In addition to looking at the growth of the whitepaper, founding team, roadmap, and community, examining the token economy allows one to evaluate what can be expected from a blockchain project in the future. There is no set framework for overseeing tokenomics, but here are some factors to consider when examining the token economy of cryptocurrency in our study:

Token supply: The main factors affecting the price of any product or service are supply and demand. The same is true for crypto. There are several important metrics that measure the supply of a token. The first of these is the maximum supply. This concept refers to the maximum number of tokens that the cryptocurrency can have over its lifetime. Bitcoin's maximum supply is 21 million coins. Litecoin has a maximum supply of 84 million coins and BNB has a maximum supply of 200 million coins. It is chosen by

investors because it has a limited maximum supply, even being one of the Deflationist cryptocurrencies, because they are resistant to inflation fluctuations. They can be designed to have a constant supply so that there is no inflation or deflation in the system. Tokenomic acts as a guide to understand how valuable an asset might be in the future. For example, considering its two tokens, Bitcoin Cash and Tron, Bitcoin Cash has the same total supply as Bitcoin. Therefore, it is theoretically possible to think that it may become as valuable as its predecessor over time. However, there are more than 100 billion Trons available. So for one coin to be worth thousands of dollars, Tron has to become the most valuable business model in world history, how likely is that to happen? (coinmarketcap) For this reason, paying attention to the maximum supply will affect our investment decision. Some tokens do not have a maximum supply. The ether supply of the Ethereum network increases every year. Stable coins like USDT, USD Coin (USDC), and Binance USD (BUSD) do not have a maximum supply as they are mined based on the reserves that support the coins. Theoretically, the number of these coins could continue to increase with no limits. Dogecoin and Polkadot are two other cryptos that do not have a maximum supply.The second metric is circulating supply, which refers to the number of tokens in circulation. Tokens can be mined and burned or locked in other ways. This also has an impact on the token price.

Looking at the token supply allows one to get an idea of how many tokens there will be in the end. The amount of its supply or its circulating supply can be found in the whitepaper of the cryptocurrency or on its official website. In A Control Theoretic Approach to Infrastructure-Centric Blockchain Tokenomics, Streit P. et al. argues that to manage inflation, it must be carefully balanced with consumer demand and designed to ultimately reach an equilibrium. To achieve such a balance, the decentralized token economy must be adaptable and controllable in such a way as to maximize the total utility of all users, such as achieving stable (generally non-inflationary) token economies. Streit P. et al. factored circulating token supply, price, and consumer demand into their calculations.

Token demand: Token demand refers to a cryptocurrency's desire to hold and acquire its tokens. Demand is as important as token supply and is a factor that affects price. When demand increases, token prices usually rise, and when demand decreases, token prices may fall. The potential demand for the token that could affect its value needs to be

evaluated.

d.) Check the token's Token price history (C8)

Check the token's price history, including its all-time high and low, and its performance compared to other tokens in the same category. Consider any major events or news that may have affected the token's price, such as partnership announcements or regulatory changes.

In Tokenomics, the stability of cryptocurrency prices needs to be checked. S. Kang (2019) stated and took into account in their work that in order to analyze and evaluate the effectiveness of a multi-token economy, data on the sufficient price history of tokens, internal transactions between tokens and the amount of economic activity should be looked at. In addition, many literature studies have examined the price history of tokens in order to make price predictions. J. Branny et al., while looking at how to predict Token (NFT) selling prices, examined the historical prices of bitcoin and etherium. If it is consistent or has a price history parallel to examples like bitcoin, this cryptocurrency may be considered for investment. The project under review can be considered for investment if it has been established for a long time and has consistently maintained value relative to other cryptos. In addition, balloon price rises or decreases may occur in some periods. By looking at the price history, the examination of the fluctuations, the highest and the lowest price levels should be considered during the investment phase. Price histories are available on many platforms and crypto exchanges.

5.1.3 Social and Environmental Factors (F3)

Overall, the environmental and social impacts of cryptocurrencies are significant and should be handled with care. It is important for the cryptocurrency industry to develop more sustainable solutions and for users to be aware of the environmental impact of their activities. Social criteria that affect the value of cryptocurrencies should also be included in the investment process.

a.) Social media Activity (C9)

It has been added to the model as a criterion examining the relationship between social media and cryptocurrency prices. Following social media accounts allows to be informed about the project at all times. The number of Twitter followers gives information about

the popularity of the project. It reveals people's perception of the project. In the study of Savaş S. named 'Analysis of the Social Media Impact on the Popularity of Cryptocurrencies', an exemplary study on cryptocurrencies was made on Twitter. The top 10 cryptocurrencies with high market value among global cryptocurrencies were used in the related study. The cryptocurrencies chosen to be used in the study are Bitcoin, Ethereum, Tether USD, Binance Coin, Ripple, Cardano, Dogecoin, Polkadot, Internet Computer and USD Coin. A total of 20 keywords with their abbreviations have been determined to get the opinions and comments of Twitter users about these cryptocurrencies. Data were obtained by Frequency Analysis of the Most Frequently Used Words in Tweet Data. The volume of data obtained and the interactions obtained as a result of the analysis showed that one of the biggest reasons for the intense interest in cryptocurrencies is social media routers. Investors and economists, even some technology and social media phenomena, are driving the masses on Twitter, causing an increase in interest in cryptocurrencies. As a result, the buying/selling equivalents of cryptocurrencies with different market values may also change in the society In addition, Başbuğ B.'s Cryptocurrency Review on Social Media Shares: The Case of Elon Musk as a Global Digital Opinion Leader, Musk's tweets that include or imply any cryptocurrency, Bitcoin and Dogecoin that he shares on social media affects the value of the cryptocurrency.It has been determined that the price of cryptocurrencies is sufficient to increase and decrease its prices by a significant margin, and therefore, the pricing of crypto money is largely shaped around Musk's shares. For these reasons, follow Cryptocurrency's official social media channels such as Twitter or Telegram and look for updates on the project's roadmap before investing. Many projects use social media to communicate their progress and goals.

Investors may perceive the amount of social media followers as a proxy for a project's popularity. A project with fewer followers may mean that the project is less popular with other investors. That's why it's important for ICOs to have excellent social media marketing strategies right from the start. On the other hand, avoiding using social media channels to market an ICO project may cause investors to look for other factors. The number of followers on Twitter and the interest an ICO will attract affect the success of the ICO. Specifically, the more followers on Twitter in an ICO, the higher the amount of funds raised (Sapkota N.,2023).

b.) Competition (C10)

It is important to identify the projects it competes with and the legacy infrastructure it is trying to replace. An asset may seem attractive on its own, but the same indicators applied to similar crypto-assets may reveal that ours is weaker than others. Having too many competitors can affect its value if it is created for similar purposes for the same problem. The number of crypto projects serving the same uncle in the same industry can be considered as a disadvantage. The purposes of cryptocurrencies can be reached from the whitepaper, official website or price monitoring platforms.

Cryptocurrencies that serve the same purpose are usually cryptocurrencies that are designed to meet a specific need or have similar characteristics. For example, these cryptocurrencies can be classified as:

1. Stablecoins: These cryptocurrencies are tied to a fixed value to ensure price stability. For example, many stablecoins such as USDT, USDC, TUSD are pegged to the US dollar.

2. Privacy-oriented cryptocurrencies: These cryptocurrencies are designed to keep users' identities and transactions private. For example, privacy-oriented cryptocurrencies such as Monero, Zcash, Dash stand out with their anonymous transactions.

3. Payment cryptocurrencies: These cryptocurrencies are designed for secure, fast and low-cost payment. For example, many payment cryptocurrencies such as Bitcoin, Bitcoin Cash, Litecoin, Ripple, Stellar, Nano make it possible to transfer money instantly and with low fees.

4. Platform cryptocurrencies: These cryptocurrencies are used to transact on a blockchain platform. For example, platform cryptocurrencies like Ethereum, EOS, Cardano, Tron, Binance Coin allow smart contracts and dApps to work.

c.) Sustainability and Environmental impact (C11)

The frequently expressed concern regarding cryptocurrencies is the criterion that takes into account the environmental impact associated with increased energy consumption and mining pollution. It is important for the cryptocurrency industry to develop more sustainable solutions and for users to be aware of the environmental impact of their activities. Overall, the environmental impacts of cryptocurrencies are significant and should be considered. Cryptocurrencies, particularly proof-of-work (PoW) consensus

mechanisms, can have significant environmental impacts.

Climate change and carbon emissions are now a fundamental problem for the environment and a concern for the world. This can be explained by the increased public and individual awareness of environmental issues, which has led investors to include sustainability in their investment decision-making processes. Few institutional investors, in particular, consider various environmental, social and governance criteria when creating a portfolio. Additionally, financial markets reward firms with environmental and social activities (Arx and Ziegler, 2014), and environmentally conscious firms tend to be more profitable and environmentally friendly in the long run. Because companies are rewarded for their reputation (Capelle-Blancard and Monjon, 2014). Cryptocurrency return predictability: What is the role of the environment? The results of the study (E. Clark 2023) support the results of Alvarez (2012), which emphasizes the negative impact of CO2 emissions on financial performance. E. Clark's (2023) study found that CO2 emissions have a statistically significant negative effect on the returns of cryptocurrencies. When the relationship with the fixed currencies TrueUSD and Tether is examined, this relationship is broken. Since there is no mining involved in the creation of these coins, there is no environmental pollution, and as a result, there is no reason for investors to attribute their returns to CO2 pollution. Overall, the results show that the development and scope of issued cryptocurrencies ultimately depend on the environmental costs of production. These results suggest that asset managers and investors, increasingly aware of crypto's sustainability issues, are considering the potential negative environmental impacts of cryptocurrencies when pricing these financial instruments. Such a high energy consumption and increase in carbon emissions may lead investors to green alternatives or alternatives that do not require mining.

Looking at another study, an index of cryptocurrency environmental attention studies by Wang Y. & Lucey B. (2022) concluded that general attention to cryptocurrency environmental issues will increase cryptocurrency price fluctuations. Therefore, the potential negative impacts of this technology on climate change should be evaluated and potential mitigation strategies should be included in global sustainability agendas.

In summary, the Consensus mechanisms used when evaluating a cryptocurrency and whether it is a stable coin can be examined. In case of stable coin, energy consumption

will be low as there will be no mining activities. In the Protocols and Consensus Mechanisms of Blockchain section, the effects of consensus mechanisms on the environment are mentioned. PoS is defined as a mechanism that consumes less energy compared to PoW (Bouraga, 2021; Köhler and Pizzol, 2019). Considering this, Pow consumes a high amount of energy and may be less preferred at the investment stage.

d.) Team (C12)

The Coin team includes the developers. Information regarding the founder and management team is considered as one of the success predictors for the investors (Frydrych et al., 2014). If there is a specific team behind the cryptocurrency network, the background records of its members can reveal whether the team has the necessary skills to bring the project to life. Have the members made successful ventures in this sector before? Is their expertise sufficient to reach the anticipated milestones? Are they involved in dubious projects or scams?

What does the developer community look like if there is no team? If the project has a public GitHub, check the number of contributors and how much activity. A constantly evolving coin may be more attractive than a coin whose store has not been updated for two years (Binance Academy,2023).

e.) Community support (C13)

While examining the community, it is necessary to examine especially the investment companies that support crypto money, one of the most important points is whether they have invested in crypto currency. Partnering with a reputable company makes the project more attractive and plays a significant role in inviting investors to put in their money (Ayarcı N.,2019). Also according to Hugo Jacques, CEO of BlockChain Impact LTD, recognized partner, investors interest are one of the main factors considered by the investors in order to invest in blockchain fund (Chan, 2019). So Examine the community of the project. Is there an active and engaged community around the project? Are there important investors or partners involved in the project? Does the community support the goals and vision of the project? For example, it is known that the support of Elon musk has a positive effect on cryptocurrencies (Basbug , 2021).

5.2. Determination of Weights of Criteria with Fuzzy SWARA

The created questionnaire was forwarded to academics, crypto exchange employees and people actively investing on the subject. After the alternatives and criteria are determined by the decision makers, first of all, criterion weights will be calculated with the fuzzy SWARA method. The weights will be determined with the help of the following steps:

In the first stage, Fuzzy SWARA was applied among the main criteria. In practice, 7 experts listed the main criteria among themselves. First, the experts were asked to rank the criteria in order of importance (starting with the most important 1), then, based on this order, the verbal expressions were transformed into fuzzy values by using the linguistic variables in Table 3 of the consecutive criteria.

Table 9. Fuzzy SWARA Significance Levels of Experts for the main criteria

Sorting	**Expert1**		**Expert2**		**Expert3**		**Expert4**	
1	F1		F3		F1		F1	
2	F2	MI	F1	MI	F2	EI	F2	MI
3	F3	MI	F2	LI	F3	LI	F3	MI
	Expert5		**Expert6**		**Expert7**			
1	F3		F1		F1			
2	F1	VLI	F2	VLI	F2	VLI		
3	F2	MLI	F3	EI	F3	MLI		

Based on the answers of the 1st expert, the importance (Sj) of the criteria for each other, the weight (Qj) and importance weights (Wj) of the calculated fuzzy numbers were calculated. While calculating the Sj values, the formula in Step 3 of the Fuzzy Swara section was used. While calculating the Qj values, the formula in Step 4 of the Fuzzy Swara section was used. Significance weights were calculated using the formula in Step 5. While dividing fuzzy numbers, they were done in accordance with the rule in (4.6). The operations performed in this step were performed for all decision makers. Appendix 1 contains the transactions of other experts.

Table 10. Calculations for the expert1

		L	M	U	L	M	U
Sorting		**Sj**			**Kj**		
1	F1	0	0	0	1	1	1
2	F2	0,667	1	1,5	1,667	2	2,5
3	F3	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		**Qj**			**Wj**		
1	F1	1	1	1	0,510273	0,571429	0,641026
2	F2	0,4	0,5	0,59988	0,204109	0,285714	0,384538
3	F3	0,16	0,25	0,359856	0,081644	0,142857	0,230677
	Sum	1,56	1,75	1,959736			

As in the examples in the literature, the final weights will be determined by taking the average of expert opinions. As in the thesis study by Taş M. A. in 2020, the arithmetic average of the fuzzy numbers of the experts was taken to determine the final fuzzy weights of the expert results. It is shown in Table 10.

Table 11. Arithmetic mean of fuzzy numbers belonging to experts

Wj	**L**	**M**	**U**
F1	0,418281	0,453746	0,495623
F2	0,235921	0,279069	0,3295
F3	0,23243	0,267185	0,31117

Median (mean value) method was used in the clarification process. The median clarification method has been chosen because it does not contain process redundancy and provides ease of use. Clarified weights for the main criteria are calculated below.

(F1=0.455883 , F2=0.281497, F3= 0.270262)

Fuzzy SWARA application was carried out for the sub-criteria by taking the opinions of the experts separately for the sub-criteria of each main criterion. Thus, the operations for the main criteria were made within the sub-criteria. Below are the experts' answers to the technical sub-criteria.

Table 12. Fuzzy SWARA Significance Levels of Experts for technical sub-criteria

Sorting	**Expert1**		**Expert2**		**Expert3**		**Expert4**	
1	C1		C2		C4		C2	
2	C2	MI	C4	LI	C1	MI	C3	MI
3	C3	LI	C3	MI	C2	LI	C4	LI
4	C4	LI	C1	MI	C3	VLI	C1	MI
	Expert5		**Expert6**		**Expert7**			
1	C2		C2		C3			
2	C3	EI	C3	MI	C2	LI		
3	C1	MI	C4	LI	C1	MI		
4	C4	MI	C1	LI	C4	EI		

Fuzzy SWARA was applied among the sub-criteria of the technical factor. In practice, 7 experts listed the sub-criteria among themselves. The order of the sub-criteria of the Technical Factor is given below. It was transformed into fuzzy numbers by using linguistic variables and calculations were made for each expert. Other experts' calculations are included in Appendix 1.

Table 13. 1st expert fuzzy swara calculations for sub-criteria of technical factor

		L	**M**	**U**	**L**	**M**	**U**
Sorting		**Sj**			**Kj**		
1	C1	0	0	0	1	1	1
2	C2	0,667	1	1,5	1,667	2	2,5
3	C3	0,4	0,5	0,66	1,4	1,5	1,66
4	C4	0,4	0,5	0,66	1,4	1,5	1,66
		L	M	U	L	M	U
Sorting		**Qj**			**Wj**		
1	C1	1	1	1	0,428371	0,486486	0,559872
2	C2	0,4	0,5	0,59988	0,171348	0,243243	0,335856
3	C3	0,240964	0,333333	0,428486	0,103222	0,162162	0,239897
4	C4	0,145159	0,222222	0,306061	0,062182	0,108108	0,171355
	Sum	1,786123	2,055556	2,334427			

The order of the sub-criteria of the Economic Factor made by the experts is given below.

Table 14. Fuzzy SWARA Significance Levels of Experts for Economic sub-criteria

Sorting	**Expert1**		**Expert2**		**Expert3**		**Expert4**	
1	C5		C5		C5		C6	
2	C7	MI	C6	EI	C7	EI	C5	MI
3	C8	MI	C7	LI	C6	LI	C7	VLI
4	C6	MI	C8	VLI	C8	VLI	C8	LI
	Expert5		**Expert6**		**Expert7**			
1	C6		C6		C8			
2	C7	EI	C7	EI	C7	LI		
3	C8	MI	C5	EI	C5	MI		
4	C5	MI	C8	VLI	C6	EI		

Fuzzy SWARA was applied among the sub-criteria included in the economic factor. In practice, 7 experts listed the sub-criteria among themselves. The order of the sub-criteria for the 1st expert for the Economic Factor is given below. Other experts' calculations are included in Appendix 1.

Table 15. 1st expert fuzzy swara calculations for sub-criteria of Economic factor

		L	**M**	**U**	**L**	**M**	**U**
Sorting		**Sj**			**Kj**		
1	C5	0	0	0	1	1	1
2	C7	0,667	1	1,5	1,667	2	2,5
3	C8	0,667	1	1,5	1,667	2	2,5
4	C6	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		**Qj**			**Wj**		
1	C5	1	1	1	0,459642	0,533333	0,615764
2	C7	0,4	0,5	0,59988	0,183857	0,266667	0,369384
3	C8	0,16	0,25	0,359856	0,073543	0,133333	0,221586
4	C6	0,064	0,125	0,21587	0,029417	0,066667	0,132925
	Sum	1,624	1,875	2,175607			

The order of the sub-criteria made by the experts of the Social and Environmental Factor is given below.

Table 16. Fuzzy SWARA Significance Levels of Experts for Social and Environmental sub-criteria

Sorting	**Expert1**		**Expert2**		**Expert3**		**Expert4**	
1	C13		C13		C12		C12	
2	C10	MI	C9	MI	C13	MI	C11	EI
3	C11	MI	C10	LI	C9	EI	C13	MI
4	C12	MI	C12	LI	C10	LI	C9	LI
5	C9	MI	C11	LI	C11	LI	C10	VLI
	Expert5		**Expert6**		**Expert7**			
1	C9		C11		C12			
2	C12	MI	C10	EI	C13	MI		
3	C13	MI	C12	EI	C10	LI		
4	C10	MI	C13	VLI	C11	VLI		
5	C11	MLI	C9	VLI	C9	VLI		

Fuzzy SWARA was applied among the sub-criteria of Social and Environmental main criteria. In practice, 7 experts listed the sub-criteria among themselves. The order of the sub-criteria for the 1st expert for the Social and Environmental Factor is given below. Other experts' calculations are in the appendices.

Table 17. 1st expert fuzzy swara calculations for sub-criteria of Social and Environmental factor

		L	**M**	**U**	**L**	**M**	**U**
Sorting		**Sj**			**Kj**		
1	C13	0	0	0	1	1	1
2	C10	0,667	1	1,5	1,667	2	2,5
3	C11	0,667	1	1,5	1,667	2	2,5
4	C12	0,667	1	1,5	1,667	2	2,5
5	C9	0,667	1	1,5	1,667	2	2,5
		L	**M**	**U**	**L**	**M**	**U**
Sorting		**Qj**			**Wj**		
1	C13	1	1	1	0,43382	0,516129	0,606208
2	C10	0,4	0,5	0,59988	0,173528	0,258065	0,363652
3	C11	0,16	0,25	0,359856	0,069411	0,129032	0,218147
4	C12	0,064	0,125	0,21587	0,027764	0,064516	0,130862
5	C9	0,0256	0,0625	0,129496	0,011106	0,032258	0,078502
	Sum	1,6496	1,9375	2,305103			

In order to determine the final fuzzy weights of the expert results, the arithmetic average of the fuzzy numbers of the sub-criteria in each main criterion group was taken separately.

Table 18. Average of expert responses for sub-criteria of technical factor

W	L	M	U
C1	0,133352	0,178691	0,238338
C2	0,330153	0,381049	0,443081
C3	0,197447	0,24599	0,306625
C4	0,147672	0,19427	0,252612

Table 19. Average of expert responses for sub-criteria of economic factor

W	L	M	U
C5	0,261994	0,296875	0,340156
C7	0,205976	0,239368	0,278678
C8	0,137543	0,16896	0,208046
C6	0,270164	0,294797	0,326655

Table 20. Average of expert responses for sub-criteria of Social and Environmental factor

W	L	M	U
C13	0,219621	0,271253	0,336902
C10	0,104703	0,146287	0,202683
C11	0,105197	0,135887	0,181007
C12	0,23648	0,280413	0,339328
C9	0,126002	0,16616	0,218634

The criterion weights are found by multiplying the averaged main criterion weights with the averaged sub-criteria weights. The following weights are obtained by multiplying the average sub-criteria values in Table 17, Table 18, Table 19 and the main criterion values in Table 11.

Table 21. Average fuzzy values

Criteria	L	M	U
F1	0,418281	0,453746	0,495623
C1	0,055779	0,08108	0,118126
C2	0,138097	0,172899	0,219601
C3	0,082588	0,111617	0,151971
C4	0,061768	0,088149	0,125201
F2	0,235921	0,279069	0,3295
C5	0,06181	0,082849	0,112081
C7	0,048594	0,0668	0,091824
C8	0,032449	0,047152	0,068551
C6	0,063737	0,082269	0,107633
F3	0,23243	0,267185	0,31117
C13	0,051046	0,072475	0,104834
C10	0,024336	0,039086	0,063069
C11	0,024451	0,036307	0,056324
C12	0,054965	0,074922	0,105589
C9	0,029287	0,044395	0,068032

The clear weights of the main criteria and sub-criteria calculated in the previous step are calculated below. The median (mean value) method was used. Final weights have been established. The importance weights and order of the criteria are given below;

Table 22. Clarified weights

Criteria	W
F1	0,455883
C1	0,084995
C2	0,176866
C3	0,115392
C4	0,091706
F2	0,281497
C5	0,08558
C7	0,069073
C8	0,049384
C6	0,084546
F3	0,270262
C13	0,076118
C10	0,042164
C11	0,039027
C12	0,078492
C9	0,047238

5.3. Determination of Weights of Criteria with Fuzzy DEMATEL

7 experts were asked to make comparisons for the main factors in accordance with the Fuzzy Dematel method. Below are answers from an expert. Fuzzy numbers were assigned according to the experts' answers. Pairwise comparison matrices were created to determine the relationship levels between the factors. The maximum of the sum of U values is found and divided by all values in the table.

Table 23. Answers of expert 1 in terms of main criteria

Main Criteria	**Technical Factors**			**Economic Factors**			**Social and Environmental Factors**		
	l	m	u	l	m	u	l	m	u
Technical Factors	0	0	0	0,5	0,75	1	0,5	0,75	1
Economic Factors	0,5	0,75	1	0	0	0	0,5	0,75	1
Social and Environmental Factors	0,25	0,5	0,75	0,25	0,5	0,75	0	0	0
Sum			1,75			1,75			2
r	2								

Each of the linguistic evaluations made by 7 experts was converted into fuzzy numbers. Afterwards, the Fuzzy Direct Relationship Matrix was created by taking the arithmetic averages of the experts' evaluations. In the literature, examples were found where the arithmetic mean was used to average the expert answers, and therefore the arithmetic mean was used. In his master's study, Koçak (2019) used the arithmetic mean to average the answers of decision makers.

Table 24. Fuzzy Direct Relationship Matrix

Main Criteria	Technical Factors			Economic Factors			Social and Environmental Factors		
	l	m	u	l	m	u	l	m	u
Technical Factors	0	0	0	0,31	0,46	0,56	0,26	0,41	0,51
Economic Factors	0,28	0,43	0,51	0	0	0	0,08	0,21	0,36
Social and Environmental Factors	0,15	0,3	0,45	0,1	0,23	0,38	0	0	0

At this stage, the fuzzy direct relationship matrix was clarified by applying the CFCS method according to the steps in the fifth step, and a direct relationship matrix was created.

Table 25. Values clarified by CFCS method

Tcrisp	F1	F2	F3	D
F1	1,31	1,59	1,48	4,38
F2	1,43	1,12	1,23	3,78
F3	1,26	1,21	0,95	3,43
R	4	3,93	3,66	

By calculating the $D'i + R'i$ and $D'i - R'i$ values, the affected and influencing values were determined. When D-R values are examined, Technical factors with positive values are in the affecting group. Economic factors, Social and Environmental factors are included in the affected group.

Table 26. $D'i + R'i$ and $D'i - R'i$ values

Main Criteria	D+R	D-R
F1	8,3853822	0,453176812
F2	7,7099785	-0,146130424
F3	7,0901817	-0,230949878

Criterion weights were calculated using the equation in Step 6. The highest emphasis is on technical factors like in Blurred Swara. Economic factors came second, while social and environmental factors were the main criteria with the third most important weight.

Table 27. Main criterion weights

Main Criteria	W	Wi
F1	8,3976	0,3619
F2	7,7114	0,3323
F3	7,0939	0,3057
sum	23,203	

The same operations are performed for the sub-criteria respectively. The process steps of the CFCS method are included in Annex 3. By calculating the $D'i + R'i$ and $D'i - R'i$ values, the affected and influencing values were determined. Security, token price history, Sustainability and Environmental Impact are the factors that affect the criteria.

Table 28. $D'i + R'i$ and $D'i - R'i$ values for subcriteria

Criteria	D+R	D-R	D	R
C1	1,233886	0,254138	0,744012	0,489874
C2	1,343409	-0,09382	0,624796	0,718613
C3	1,327053	-0,07746	0,624796	0,702258
C4	1,283742	-0,03415	0,624796	0,658946
C5	1,376143	-0,12655	0,624796	0,751348
C6	1,347359	-0,09777	0,624796	0,722563
C7	1,303525	-0,05393	0,624796	0,678729
C8	1,153706	0,095885	0,624796	0,52891
C9	1,275399	-0,02581	0,624796	0,650603
C10	1,2691	-0,01951	0,624796	0,644304
C11	1,246713	0,002878	0,624796	0,621917
C12	1,400555	-0,15096	0,624796	0,775759
C13	1,357697	-0,10811	0,624796	0,732901

The diagram created for D+R and D-R is shown below. It is included in the C1, C8 and C11 cause groups. Other criteria are included in the effect group.

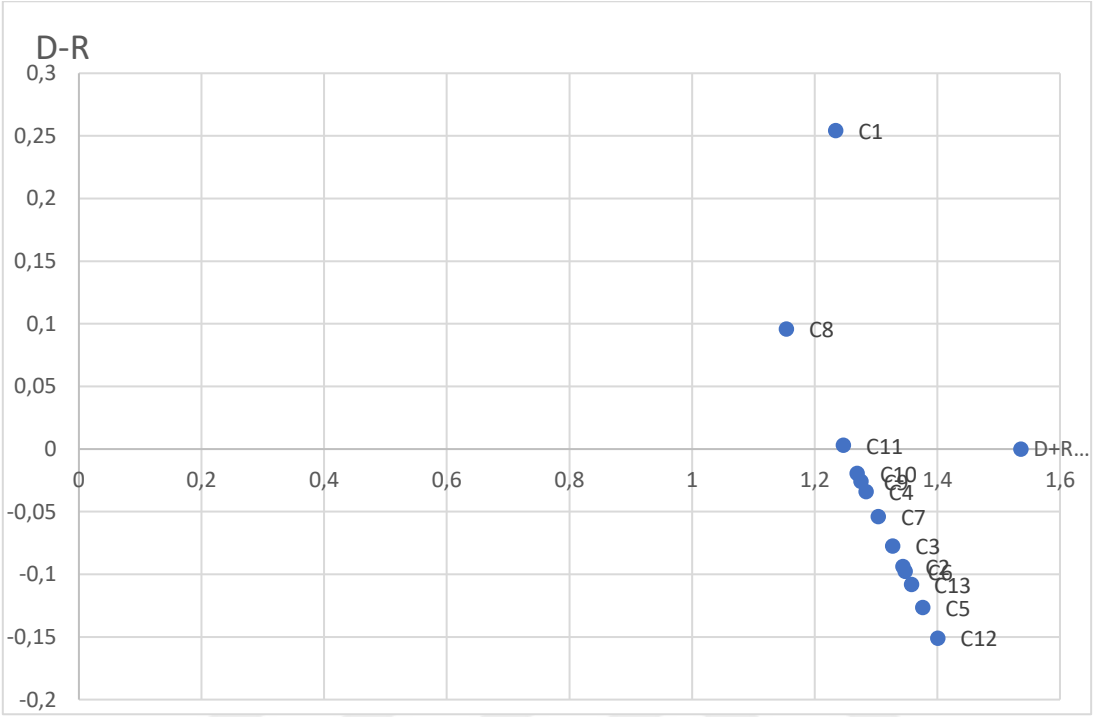

Figure 8. D+R and D-R Diagram for subcriteria

The final weights are reached by multiplying the weights of the sub-criteria with the weights of the main criteria they are connected to.

Table 29. Weights of sub-criteria

Criteria	Wi	W
C1	0,02912	0,08735
C2	0,03112	0,09337
C3	0,03072	0,09217
C4	0,02968	0,08904
C5	0,02947	0,08841
C6	0,02881	0,08642
C7	0,02782	0,08346
C8	0,02469	0,07406
C9	0,01981	0,05943
C10	0,01971	0,05913
C11	0,01936	0,05808
C12	0,02188	0,06563
C13	0,02115	0,06346
Sum	0,33333	1

While the weights of the economic main factor and the social and environmental main factors are very close in Fuzzy Swara, although the order is the same in Fuzzy Dematel, there is a greater difference between their weights. For this reason, there is a ranking difference between the sub-criteria of social and environmental factors and the sub-criteria of economic factors. Additionally, when making pairwise comparisons in the Fuzzy Dematel method, it was observed that there were differences in the weights due to lack of symmetry and differences in the linguistic variables used. This difference did not affect the choice result between the alternatives. However, there was a difference in the ranking of 4 criteria ((C7,C8,C12,C13). In the Fuzzy Dematel method, the criteria were compared in detail and the results were obtained. In the Fuzzy SWARA method, there is only the possibility of comparison according to the previous criterion. For this reason, the criterion ranking calculated with Fuzzy Dematel may be preferred during the investment process.

Table 30. Comparison of Fuzzy Dematel and Fuzzy Swara

Fuzzy Dematel		**Fuzzy Swara**	
Criteria	**W**	**Criteria**	**W**
F1	0,361921	F1	0,455883
F2	0,332344	F2	0,281497
F3	0,305735	F3	0,270262
C2	0,09337	C2	0,176866
C3	0,092166	C3	0,115392
C4	0,089038	C4	0,091706
C5	0,088406	C5	0,08558
C1	0,087346	C1	0,084995
C6	0,08642	C6	0,084546
C7	0,08346	C12	0,078492
C8	0,074059	C13	0,076118
C12	0,065629	C7	0,069073
C13	0,063455	C8	0,049384
C9	0,059433	C9	0,047238
C10	0,059134	C10	0,042164
C11	0,058084	C11	0,039027

5.4. Identifying Alternatives

Fewer experts were reached as specific information about altcoins is required. The question form was conducted by a single expert. Application steps were made via excel. The min values of the cost values and the max values of the benefit values were found,

and division was performed for the fuzzy number in each row. The following table contains the transaction results.

Table 31. Normalized Desicion Matrix

	Benefit			**Benefit**			**Benefit**		
	C1			C2			C3		
Alternative	L	M	U	L	M	U	L	M	U
XRP	0,3	0,5	0,7	0,7	0,9	1	0,1	0,3	0,5
POLYGON	0,7	0,9	1	0,3	0,5	0,7	0	0,1	0,3
ETC	0,7	0,9	1	0	0,1	0,3	0,7	0,9	1
SOLANA	0,3	0,5	0,7	0,9	1	1	0	0,1	0,3
POLKADOT	0,3	0,5	0,7	0,7	0,9	1	0,1	0,3	0,5
	Benefit			**Benefit**			**Cost**		
	C4			C5			C6		
	L	M	U	L	M	U	L	M	U
XRP	0	0,142857	0,428571	0,7	0,9	1	0,142857	0,2	0,333333
POLYGON	0,428571	0,714286	1	0,3	0,5	0,7	0,2	0,333333	1
ETC	0,428571	0,714286	1	0,9	1	1	0,111111	0,142857	0,2
SOLANA	0,428571	0,714286	1	0,5	0,7	0,9	0,2	0,333333	1
POLKADOT	0	0,142857	0,428571	0,1	0,3	0,5	0,2	0,333333	1
	Benefit			**Benefit**			**Benefit**		
	C7			C8			C9		
	L	M	U	L	M	U	L	M	U
XRP	0,428571	0,714286	1	0,5	0,7	0,9	0,1	0,3	0,5
POLYGON	0	0,142857	0,428571	0,3	0,5	0,7	0,7	0,9	1
ETC	0,428571	0,714286	1	0,7	0,9	1	0,3	0,5	0,7
SOLANA	0,142857	0,428571	0,714286	0	0,1	0,3	0,5	0,7	0,9
POLKADOT	0,428571	0,714286	1	0,5	0,7	0,9	0	0	0,1
	Cost			**Cost**			Benefit		
	C10			C11			C12		
	L	M	U	L	M	U	L	M	U
XRP	0	0	0	0,2	0,333333	1	0,9	1	1
POLYGON	0	0	1	0,142857	0,2	0,333333	0,3	0,5	0,7
ETC	0	0	2	0,2	0,333333	1	0,9	1	1
SOLANA	0	0	3	0,2	0,333333	1	0,3	0,5	0,7
POLKADOT	0	0	4	0,2	0,333333	1	0,1	0,3	0,5
	Benefit								
	C13								
	L	M	U						
XRP	0,7	0,9	1						
POLYGON	0,3	0,5	0,7						
ETC	0,7	0,9	1						
SOLANA	0,7	0,9	1						
POLKADOT	0,1	0,3	0,5						

While applying fuzzy SWARA, the decision matrices were multiplied with the criterion weights calculated in the last step. Appendix 2 includes the calculations of the weighted normalized decision matrix. Fuzzy positive and negative ideal solutions are determined. Below are the values.

Table 32. Closeness coefficients for each criterion, respectively

A*	0,08499	0,17686	0,11539	0,09170	0,0855	0,08454	0,06907	0,049384	0,047238	0	0,039027	0,078492	0,076118
A-	0,02549	0	0	0	0,00885	0,00120	0	0	0	0	0,00557	0,00784	0,00761

The distances from the 5 alternative solutions to the positive and negative ideal solutions are calculated below according to 13 criteria. Calculation was made using the weights obtained by Fuzzy Dematel and Fuzzy Swara methods.

Table 33. Distances from the positive and negative ideal solution

	d*(fuzzy Swara)	**d-(fuzzy Swara)**	**d*(fuzzy Dematel)**	**d-(fuzzy Dematel)**
XRP	0,423082554	0,5425586	0,435575359	0,48295742
POLYGON	0,533261566	0,444032607	0,501176763	0,420046755
ETC	0,387783716	0,5776762	0,337712314	0,575702493
SOLANA	0,440935608	0,543951699	0,456720666	0,478864915
POLKADOT	0,555329164	0,434795374	0,546782133	0,391009332

Finally, normalized values were obtained for ranking. It has been seen that the best alternative is Ethereum, the weight of the second one, XRP, and it seems very close to Solana. Calculation was made using the weights obtained by Fuzzy Dematel and Fuzzy Swara methods. The ranking gives the same rank in terms of the two criteria methods.

Table 34. Alternatives Weights

Alternatives	Cj	Normalized with Fuzzy Swara weights		Cj	Normalized with Fuzzy Dematel weights
XRP	0,561863584	0,215604	XRP	0,525792	0,206938
POLYGON	0,454348976	0,174348	POLYGON	0,455966	0,179456
ETC	0,598343018	0,229603	ETC	0,630275	0,248060
SOLANA	0,552298415	0,211934	SOLANA	0,511834	0,201444
POLKADOT	0,439132005	0,168508	POLKADOT	0,416947	0,164099

5.5. Analysis of Results

Sensitivity analysis is measuring sensitivity to small changes in criterion weights in the decision-making process. Sensitivity analysis can be obtained by slightly changing the values of the weights and observing their effects on the decision (Awasti et al. 2010). Sensitivity analysis was conducted to determine the impact of criterion weights on the evaluation of Cryptocurrency projects. Sensitivity analysis was performed for criteria C7, C12 and C1.

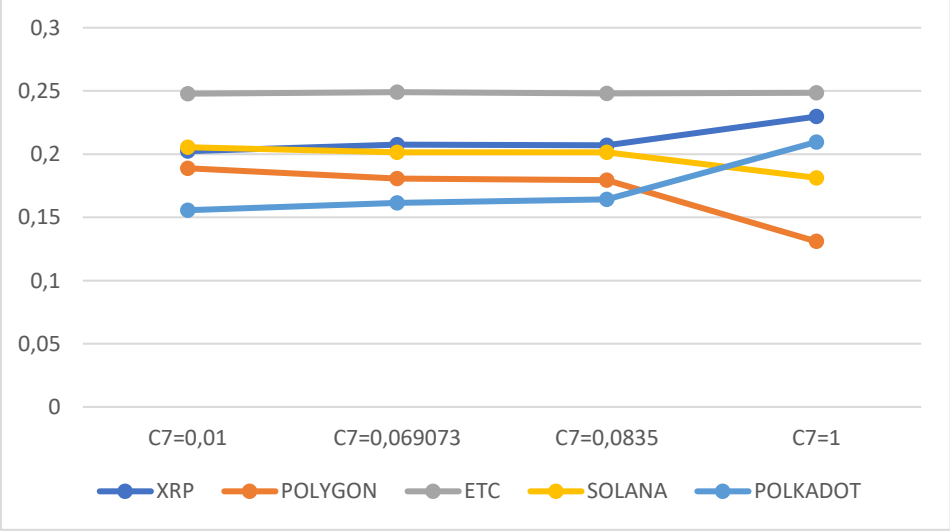

Figure 9. Sensitivity Analysis for C7

By changing the weight of each criterion, the fuzzy measurements of alternative projects are also changed. Three of the criteria were chosen as examples. It is presented in Figure 9. Figure 9 shows the change in the weight of criterion C7 and the change in the weight of alternative projects. While the other criterion values remained the same, values of 0.01; 0.069073; 0.0835; 1 were assigned to the C7 criterion, respectively. By increasing the

value of the C7 criterion, the ETC project gets similar values and there are no significant changes. The values of the Solana and Polygon projects are decreasing. The values of XRP and Polkadot are improving. C7 refers to the token economy. As the weight of the token economy increases, the value of Polkadot and XRP projects with strong token economies will also increase. The ETC project is the project with the best evaluation in terms of token economy.

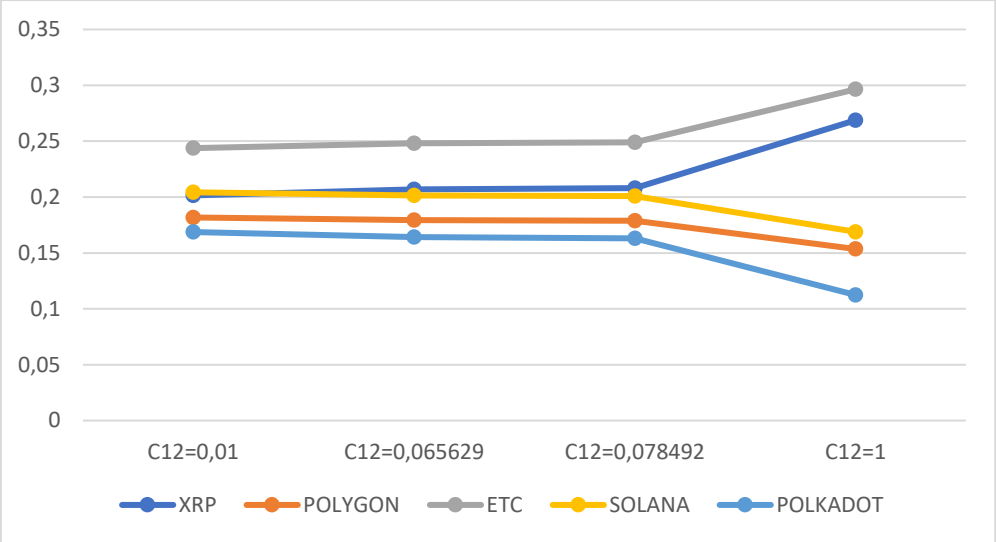

Figure 10. Sensitivity Analysis for C12

Figure 10 shows the change in the weight of the C12 criterion and the change in the weight of alternative projects. While other criterion values remain the same, the C12 criterion is 0.01; 0.065629; Values of 0.078492;1 were assigned. As the value of the C12 criterion increases, the values of Polkadot, Solana and Polygon projects decrease. The values of XRP and ETC projects are improving. C12 refers to the team. As the weight of the team criterion increases, the value of ETC and XRP projects with strong teams will increase.

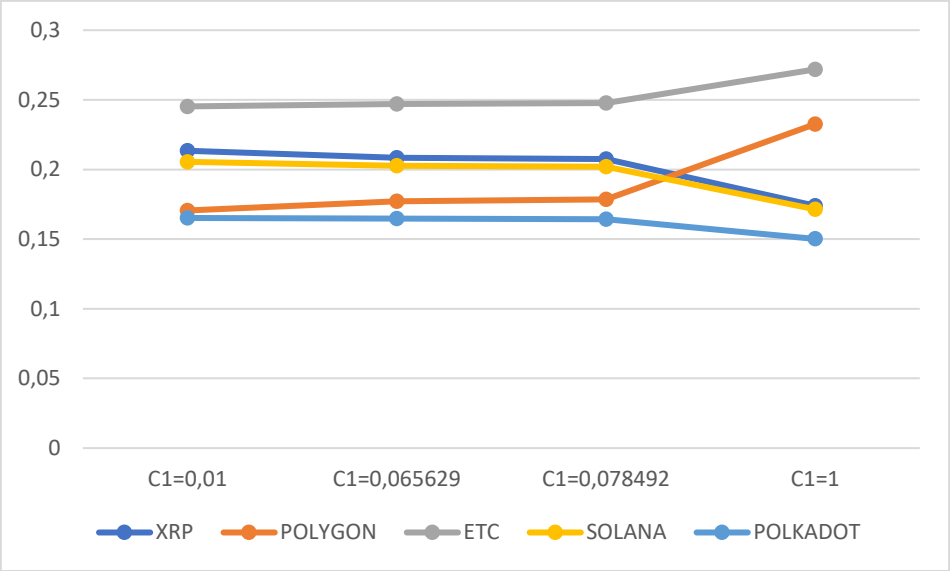

Figure 11. Sensitivity Analysis for C1

Figure 11 shows the change in the weight of criterion C1 and the change in the weight of alternative projects. While the other criterion values remain the same, the C1 criterion is 0.01; 0.065629; Values of 0.078492;1 were assigned. As the value of the C1 criterion increases, the values of Polkadot, Solana and XRP projects decrease. Values of Polygon and ETC projects are improving. C1 stands for security. As the weight of the security criterion increases, the value of ETC and Polygon projects will increase. The ETC project is the project with the best evaluation in terms of security.

6. RESULTS AND DISCUSSION

Blockchain, cryptocurrency concepts; Studies on fuzzy SWARA, fuzzy DEMATEL and fuzzy TOPSIS methods are reviewed and summarized. In order to choose among crypto projects that have become very popular in recent years, the literature was examined and the previously used criteria were also taken into account in order to determine which criteria are important when investing in these projects. For example, whitepaper, roadmap, security, change from the highest value, market value, transaction speed, team and community support, which were also discussed in previous studies, were also examined in this study. In addition, the environmental impact of cryptocurrency, transaction fee, competition, decentralization, social media activity and tokenomic structure, which were not discussed much in previous studies, were added as evaluation criteria with this study. Unlike other studies, the evaluation process was carried out by accepting the white paper as a prerequisite. As seen in previous studies, technical inspection is critical to coin information and accuracy. Since sufficient information cannot be obtained about a coin without a whitepaper, these coins should not be taken into consideration in the investment decision process.

In addition, in the study conducted by Kargı (2022) using Fuzzy TOPSIS, the Fuzzy TOPSIS method was used both in finding the weights of the criteria and in the selection of alternatives. In this study, Fuzzy SWARA and Fuzzy Dematel methods were used integrated with Fuzzy TOPSIS. The results were obtained by comparing the values obtained from the two methods. When other studies are examined, it is seen that such methods have not been used before in cryptocurrency investment studies. In the study conducted by Çilek (2020), only economic criteria were taken into account. In this study, the criteria were taken into account in three different dimensions: technical, economic, social and environmental factors.

In this thesis, a choice was made among Xrp, Etc, Solana, polkadot and polygon projects. As a result of the selection, Etc, Xrp, Solana, polygon and polkadot projects were respectively. The processing speed criterion had the highest weight, with 0.09337 in the Fuzzy DEMATEL method and 0.176866 in the Fuzzy SWARA method. Although Solana is the fastest cryptocurrency project among the alternatives, it did not rank first because it had low values in terms of roadmap and decentralization. Accordingly, it is seen that

other criteria also have a high impact on the selection. The sensitivities of some criteria on the outcome of the selection of alternative crypto assets were examined. While other criterion values remain the same, the team criterion is 0.01; 0.065629; Values of 0.078492;1 were assigned. As the value of the team criterion increases, the values of Polkadot, Solana and Polygon projects decrease. It has been observed that as the weight of the team criterion increases, the value of Etc and Xrp projects with strong teams also increases. When the security criterion is examined, as its value increases, the values of Polkadot, Solana and Xrp projects decrease. The values of Polygon and Etc projects are improving. If the security criterion had a higher weight, the value of Etc and Polygon projects would have been higher and the election result would have changed.

Additionally, in most studies, Bitcoin has been included in the evaluation as an alternative. In this study, a comparison was made between altcoins. Bitcoin is currently the most accepted crypto asset with the highest market capitalization. For this reason, Bitcoin was not included in the comparison because it would stand out in the comparisons and has resulted in this way in other studies. As a result, investors who want to invest according to the determined criteria can make the selection process for the cryptocurrency they want to evaluate.

7. CONCLUSION

Cryptocurrencies, which have been very popular lately, attract the attention of many investors. However, due to its structure, the investment process differs from other investment instruments. Various criteria are effective in the investment process and need attention. In order to create a decision system that will help this issue, the issues that should be considered in the investment process are mentioned. This study is not investment advice, but scientific research. People who read this research can learn about crypto money and its investment, and have an idea about which criteria are important when investing.

As seen in the whitepaper literature studies, it is a critical document for cryptocurrencies. For this reason, while selecting the criteria, the whitepaper was not considered as a criterion, but it was considered as a prerequisite. The criteria to be considered in the investment decision process are explained in detail. There has also been a study that guides readers on where to find information on these criteria.

According to the results of the study, the most important criteria as a result of the Fuzzy Swara question form made to the experts are transaction speed, Roadmap, Decentralization, Market size, Transaction fee, security, Team, Community support, Tokenomics, Token price history, social media activity, competition, Sustainability and Environmental impact. According to the results of the study, the most important criteria as a result of the Fuzzy Dematel question form made to the experts are transaction speed, Roadmap, Decentralization, Market size, Transaction fee, security, Tokenomics, Token price history, Team, Community support, social media activity, competition, Sustainability and Environmental impact. According to the result obtained, while transaction speed has the highest weight, Sustainability and Environmental Impact is the criterion with the lowest weight. In terms of main criteria, technical factors are the highest, Economic factor is the second, Social and Environmental factor is the main criterion with the lowest weight.

When the methods used in the literature are examined, various multi-criteria decision-making methods are preferred. In order to eliminate linguistic ambiguity and ambiguity arising from human judgments in group decision-making processes, the Fuzzy TOPSIS method was used in the study, extended with fuzzy set theory, to solve the alternatives.

Fuzzy logic gives better results in an environment of uncertainty. In addition, no other study has been found that applies fuzzy SWARA and fuzzy DEMATEL methods in the evaluation of criteria in the cryptocurrency investment process, and it contributes to the literature in this respect. Fuzzy TOPSIS was applied for five selected altcoins in the evaluation of alternative cryptocurrencies. According to the Fuzzy TOPSIS application, the most suitable crypto assets were determined as Etc, Xrp, Solana, Polygon, Polkadot, respectively. It was seen that the weights of Solana and Xrp were quite close.

The study focuses on key criteria that are current and important when choosing cryptocurrencies. In addition, the characterization of cryptocurrencies as securities is still a controversial issue, but it will be useful to consider it from this perspective in the future. In the current study, the decision may vary depending on the knowledge and comments of the experts. In future studies, without leaving it to the initiative of the person, a structure integrated with the internet or determined sites can be created. Artificial neural networks can make decisions by pulling this information from the internet. While doing this, these criteria can be used, and the criteria can be increased.

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APPENDIX

Appendıx 1. Fuzzy Swara Solutions

Appendix 1. Table 1. Calculations for the Expert2

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	F3	0	0	0	1	1	1
2	F1	0,667	1	1,5	1,667	2	2,5
3	F2	0,4	0,5	0,667	1,4	1,5	1,667
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	F3	1	1	1	0,493008	0,545455	0,609774
2	F1	0,4	0,5	0,59988	0,197203	0,272727	0,365791
3	F2	0,239952	0,333333	0,428486	0,118298	0,181818	0,261279
	Sum	1,639952	1,833333	2,028366			

Appendix 1. Table 2.Calculations for the expert 3

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	F1	0	0	0	1	1	1
2	F2	1	1	1	2	2	2
3	F3	0,4	0,5	0,667	1,4	1,5	1,667
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	F1	1	1	1	0,538462	0,545455	0,555574
2	F2	0,5	0,5	0,5	0,269231	0,272727	0,277787
3	F3	0,29994	0,333333	0,357143	0,161506	0,181818	0,198419
	Sum	1,79994	1,833333	1,857143			

Appendix 1. Table 3.Calculations for the expert 4

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	F1	0	0	0	1	1	1
2	F2	0,667	1	1,5	1,667	2	2,5
3	F3	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	F1	1	1	1	0,510273	0,571429	0,641026
2	F2	0,4	0,5	0,59988	0,204109	0,285714	0,384538
3	F3	0,16	0,25	0,359856	0,081644	0,142857	0,230677
	sum	1,56	1,75	1,959736			

Appendix 1. Table 4.Calculations for the expert 5

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	F3	0	0	0	1	1	1
2	F1	0,286	0,333	0,4	1,286	1,333	1,4
3	F2	0,222	0,25	0,286	1,222	1,25	1,286
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	F3	1	1	1	0,41426	0,425471	0,440583
2	F1	0,714286	0,750188	0,777605	0,2959	0,319183	0,3426
3	F2	0,555432	0,60015	0,636338	0,230093	0,255346	0,28036
	Sum	2,269718	2,350338	2,413943			

Appendix 1. Table 5.Calculations for the expert 6

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	F1	0	0	0	1	1	1
2	F2	0,286	0,333	0,4	1,286	1,333	1,4
3	F3	1	1	1	2	2	2
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	F1	1	1	1	0,461594	0,470526	0,482759
2	F2	0,714286	0,750188	0,777605	0,32971	0,352983	0,375396
3	F3	0,357143	0,375094	0,388802	0,164855	0,176491	0,187698
	Sum	2,071429	2,125281	2,166407			

Appendix 1. Table 6.Calculations for the expert 7

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	F1	0	0	0	1	1	1
2	F2	0,286	0,333	0,4	1,286	1,333	1,4
3	F3	0,222	0,25	0,286	1,222	1,25	1,286
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	F1	1	1	1	0,41426	0,425471	0,440583
2	F2	0,714286	0,750188	0,777605	0,2959	0,319183	0,3426
3	F3	0,555432	0,60015	0,636338	0,230093	0,255346	0,28036
	Sum	2,269718	2,350338	2,413943			

Appendix 1. Table 7.2nd expert fuzzy swara calculations for sub-criteria of technical factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C2	0	0	0	1	1	1
2	C4	0,4	0,5	0,667	1,4	1,5	1,667
3	C3	0,667	1	1,5	1,667	2	2,5
4	C1	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C2	1	1	1	0,416699	0,461538	0,516579
2	C4	0,59988	0,666667	0,714286	0,24997	0,307692	0,368985
3	C3	0,239952	0,333333	0,428486	0,099988	0,153846	0,221347
4	C1	0,095981	0,166667	0,25704	0,039995	0,076923	0,132781
	sum	1,935813	2,166667	2,399811			

Appendix 1. Table 8.3rd expert fuzzy swara calculations for sub-criteria of technical factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C4	0	0	0	1	1	1
2	C1	0,667	1	1,5	1,667	2	2,5
3	C2	0,4	0,5	0,667	1,4	1,5	1,667
4	C3	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C4	1	1	1	0,423449	0,479986	0,552076
2	C1	0,4	0,5	0,59988	0,16938	0,239993	0,331179
3	C2	0,239952	0,333333	0,428486	0,101607	0,159995	0,236556
4	C3	0,171394	0,250063	0,333193	0,072577	0,120026	0,183948
	sum	1,811346	2,083396	2,361558			

Appendix 1. Table 9.4th expert fuzzy swara calculations for sub-criteria of technical factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C2	0	0	0	1	1	1
2	C3	0,667	1	1,5	1,667	2	2,5
3	C4	0,4	0,5	0,667	1,4	1,5	1,667
4	C1	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C2	1	1	1	0,437559	0,5	0,576059
2	C3	0,4	0,5	0,59988	0,175024	0,25	0,345566
3	C4	0,239952	0,333333	0,428486	0,104993	0,166667	0,246833
4	C1	0,095981	0,166667	0,25704	0,041997	0,083333	0,14807
	sum	1,735933	2	2,285406			

Appendix 1. Table 10.5th expert fuzzy swara calculations for sub-criteria of technical factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C2	0	0	0	1	1	1
2	C3	1	1	1	2	2	2
3	C1	0,667	1	1,5	1,667	2	2,5
4	C4	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C2	1	1	1	0,505084	0,533333	0,561798
2	C3	0,5	0,5	0,5	0,252542	0,266667	0,280899
3	C1	0,2	0,25	0,29994	0,101017	0,133333	0,168506
4	C4	0,08	0,125	0,179928	0,040407	0,066667	0,101083
	sum	1,78	1,875	1,979868			

Appendix 1. Table 11.6th expert fuzzy swara calculations for sub-criteria of technical factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C2	0	0	0	1	1	1
2	C3	0,667	1	1,5	1,667	2	2,5
3	C4	0,4	0,5	0,667	1,4	1,5	1,667
4	C1	0,4	0,5	0,667	1,4	1,5	1,667
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C2	1	1	1	0,428371	0,486486	0,560571
2	C3	0,4	0,5	0,59988	0,171348	0,243243	0,336276
3	C4	0,239952	0,333333	0,428486	0,102788	0,162162	0,240197
4	C1	0,143942	0,222222	0,306061	0,061661	0,108108	0,171569
	sum	1,783894	2,055556	2,334427			

Appendix 1. Table 12.7th expert fuzzy swara calculations for sub-criteria of technical factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C3	0	0	0	1	1	1
2	C2	0,4	0,5	0,667	1,4	1,5	1,667
3	C1	0,667	1	1,5	1,667	2	2,5
4	C4	1	1	1	2	2	2
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C3	1	1	1	0,424266	0,461538	0,510254
2	C2	0,59988	0,666667	0,714286	0,254508	0,307692	0,364467
3	C1	0,239952	0,333333	0,428486	0,101803	0,153846	0,218637
4	C4	0,119976	0,166667	0,214243	0,050902	0,076923	0,109318
	sum	1,959808	2,166667	2,357014			

Appendix 1. Table 13.2nd expert fuzzy swara calculations for sub-criteria of Economic factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C5	0	0	0	1	1	1
2	C6	1	1	1	2	2	2
3	C7	0,4	0,5	0,667	1,4	1,5	1,667
4	C8	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C5	1	1	1	0,468415	0,479986	0,496479
2	C6	0,5	0,5	0,5	0,234208	0,239993	0,24824
3	C7	0,29994	0,333333	0,357143	0,140496	0,159995	0,177314
4	C8	0,214243	0,250063	0,277716	0,100355	0,120026	0,13788
	sum	2,014183	2,083396	2,134859			

Appendix 1. Table 14.3rd expert fuzzy swara calculations for sub-criteria of Economic factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C5	0	0	0	1	1	1
2	C7	1	1	1	2	2	2
3	C6	0,4	0,5	0,667	1,4	1,5	1,667
4	C8	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C5	1	1	1	0,468415	0,479986	0,496479
2	C7	0,5	0,5	0,5	0,234208	0,239993	0,24824
3	C6	0,29994	0,333333	0,357143	0,140496	0,159995	0,177314
4	C8	0,214243	0,250063	0,277716	0,100355	0,120026	0,13788
	sum	2,014183	2,083396	2,134859			

Appendix 1. Table 15.4th expert fuzzy swara calculations for sub-criteria of Economic factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C6	0	0	0	1	1	1
2	C5	0,667	1	1,5	1,667	2	2,5
3	C7	0,286	0,333	0,4	1,286	1,333	1,4
4	C8	0,4	0,5	0,667	1,4	1,5	1,667
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C6	1	1	1	0,416746	0,470554	0,538471
2	C5	0,4	0,5	0,59988	0,166698	0,235277	0,323018
3	C7	0,285714	0,375094	0,46647	0,11907	0,176502	0,251181
4	C8	0,171394	0,250063	0,333193	0,071428	0,117668	0,179415
	sum	1,857109	2,125156	2,399542			

Appendix 1. Table 16.5th expert fuzzy swara calculations for sub-criteria of Economic factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C6	0	0	0	1	1	1
2	C7	1	1	1	2	2	2
3	C8	0,667	1	1,5	1,667	2	2,5
4	C5	0,667	1	1,5	1,667	2	2,5
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C6	1	1	1	0,505084	0,533333	0,561798
2	C7	0,5	0,5	0,5	0,252542	0,266667	0,280899
3	C8	0,2	0,25	0,29994	0,101017	0,133333	0,168506
4	C5	0,08	0,125	0,179928	0,040407	0,066667	0,101083
	sum	1,78	1,875	1,979868			

Appendix 1. Table 17.6th expert fuzzy swara calculations for sub-criteria of Economic factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C6	0	0	0	1	1	1
2	C7	1	1	1	2	2	2
3	C5	1	1	1	2	2	2
4	C8	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C6	1	1	1	0,514297	0,516117	0,518519
2	C7	0,5	0,5	0,5	0,257149	0,258058	0,259259
3	C5	0,25	0,25	0,25	0,128574	0,129029	0,12963
4	C8	0,178571	0,187547	0,194401	0,091839	0,096796	0,100801
	sum	1,928571	1,937547	1,944401			

Appendix 1. Table 18.7th expert fuzzy swara calculations for sub-criteria of Economic factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C8	0	0	0	1	1	1
2	C7	0,4	0,5	0,667	1,4	1,5	1,667
3	C5	0,667	1	1,5	1,667	2	2,5
4	C6	1	1	1	2	2	2
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C8	1	1	1	0,424266	0,461538	0,510254
2	C7	0,59988	0,666667	0,714286	0,254508	0,307692	0,364467
3	C5	0,239952	0,333333	0,428486	0,101803	0,153846	0,218637
4	C6	0,119976	0,166667	0,214243	0,050902	0,076923	0,109318
	sum	1,959808	2,166667	2,357014			

Appendix 1. Table 19.2nd expert fuzzy swara calculations for sub-criteria of Social and Enviromental factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C13	0	0	0	1	1	1
2	C9	0,667	1	1,5	1,667	2	2,5
3	C10	0,4	0,5	0,667	1,4	1,5	1,667
4	C12	0,4	0,5	0,667	1,4	1,5	1,667
5	C11	0,4	0,5	0,667	1,4	1,5	1,667
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C13	1	1	1	0,39169	0,453782	0,53469
2	C9	0,4	0,5	0,59988	0,156676	0,226891	0,32075
3	C10	0,239952	0,333333	0,428486	0,093987	0,151261	0,229107
4	C12	0,143942	0,222222	0,306061	0,056381	0,10084	0,163648
5	C11	0,086348	0,148148	0,218615	0,033822	0,067227	0,116891
	sum	1,870243	2,203704	2,553042			

Appendix 1. Table 20.3rd expert fuzzy swara calculations for sub-criteria of Social and Enviromental factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C12	0	0	0	1	1	1
2	C13	0,667	1	1,5	1,667	2	2,5
3	C9	1	1	1	2	2	2
4	C10	0,4	0,5	0,667	1,4	1,5	1,667
5	C11	0,4	0,5	0,667	1,4	1,5	1,667
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C12	1	1	1	0,441093	0,493151	0,558052
2	C13	0,4	0,5	0,59988	0,176437	0,246575	0,334764
3	C9	0,2	0,25	0,29994	0,088219	0,123288	0,167382
4	C10	0,119976	0,166667	0,214243	0,052921	0,082192	0,119559
5	C11	0,071971	0,111111	0,153031	0,031746	0,054795	0,085399
	sum	1,791947	2,027778	2,267094			

Appendix 1. Table 21.4th expert fuzzy swara calculations for sub-criteria of Social and Enviromental factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C12	0	0	0	1	1	1
2	C13	1	1	1	2	2	2
3	C9	0,667	1	1,5	1,667	2	2,5
4	C10	0,4	0,5	0,667	1,4	1,5	1,667
5	C11	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C12	1	1	1	0,458552	0,489788	0,524749
2	C13	0,5	0,5	0,5	0,229276	0,244894	0,262374
3	C9	0,2	0,25	0,29994	0,09171	0,122447	0,157393
4	C10	0,119976	0,166667	0,214243	0,055015	0,081631	0,112424
5	C11	0,085697	0,125031	0,166596	0,039297	0,061239	0,087421
	sum	1,905673	2,041698	2,180779			

Appendix 1. Table 22.5th expert fuzzy swara calculations for sub-criteria of Social and Enviromental factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C9	0	0	0	1	1	1
2	C12	0,667	1	1,5	1,667	2	2,5
3	C13	0,667	1	1,5	1,667	2	2,5
4	C10	0,667	1	1,5	1,667	2	2,5
5	C11	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C9	1	1	1	0,426718	0,50793	0,598905
2	C12	0,4	0,5	0,59988	0,170687	0,253965	0,359271
3	C13	0,16	0,25	0,359856	0,068275	0,126983	0,21552
4	C10	0,064	0,125	0,21587	0,02731	0,063491	0,129286
5	C11	0,045714	0,093773	0,167862	0,019507	0,04763	0,100533
	sum	1,669714	1,968773	2,343468			

Appendix 1. Table 23.6th expert fuzzy swara calculations for sub-criteria of Social and Enviromental factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C11	0	0	0	1	1	1
2	C10	1	1	1	2	2	2
3	C12	1	1	1	2	2	2
4	C13	0,286	0,333	0,4	1,286	1,333	1,4
5	C9	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C11	1	1	1	0,477197	0,481176	0,486352
2	C10	0,5	0,5	0,5	0,238599	0,240588	0,243176
3	C12	0,25	0,25	0,25	0,119299	0,120294	0,121588
4	C13	0,178571	0,187547	0,194401	0,085214	0,090243	0,094548
5	C9	0,127551	0,140695	0,151167	0,060867	0,067699	0,073521
	sum	2,056122	2,078242	2,095569			

Appendix 1. Table 24.7th expert fuzzy swara calculations for sub-criteria of Social and Enviromental factor

		L	M	U	L	M	U
Sorting		Sj			Kj		
1	C12	0	0	0	1	1	1
2	C13	0,667	1	1,5	1,667	2	2,5
3	C10	0,4	0,5	0,667	1,4	1,5	1,667
4	C11	0,286	0,333	0,4	1,286	1,333	1,4
5	C9	0,286	0,333	0,4	1,286	1,333	1,4
		L	M	U	L	M	U
Sorting		Qj			Wj		
1	C12	1	1	1	0,381585	0,440337	0,517124
2	C13	0,4	0,5	0,59988	0,152634	0,220168	0,310213
3	C10	0,239952	0,333333	0,428486	0,091562	0,146779	0,22158
4	C11	0,171394	0,250063	0,333193	0,065401	0,110112	0,172302
5	C9	0,122424	0,187594	0,259092	0,046715	0,082604	0,133983
	sum	1,933771	2,27099	2,620651			

Appendıx 2. Fuzzy TOPSIS Solutions

Criteria		0,084995			0,176866			0,115392	
XRP	0,025499	0,042498	0,059497	0,123806	0,159179	0,176866	0,011539	0,034618	0,057696
POLYGON	0,059497	0,076496	0,084995	0,05306	0,088433	0,123806	0	0,011539	0,034618
ETC	0,059497	0,076496	0,084995	0	0,017687	0,05306	0,080774	0,103853	0,115392
SOLANA	0,025499	0,042498	0,059497	0,159179	0,176866	0,176866	0	0,011539	0,034618
POLKADOT	0,025499	0,042498	0,059497	0,123806	0,159179	0,176866	0,011539	0,034618	0,057696
Criteria		0,069073			0,049384			0,047238	
XRP	0,029603	0,049338	0,069073	0,024692	0,034569	0,044446	0,004724	0,014171	0,023619
POLYGON	0	0,009868	0,029603	0,014815	0,024692	0,034569	0,033067	0,042514	0,047238
ETC	0,029603	0,049338	0,069073	0,034569	0,044446	0,049384	0,014171	0,023619	0,033067
SOLANA	0,009868	0,029603	0,049338	0	0,004938	0,014815	0,023619	0,033067	0,042514
POLKADOT	0,029603	0,049338	0,069073	0,024692	0,034569	0,044446	0	0	0,004724
Criteria		0,039027			0,078492			0,076118	
XRP	0,007805	0,013009	0,039027	0,070643	0,078492	0,078492	0,053283	0,068506	0,076118
POLYGON	0,005575	0,007805	0,013009	0,023548	0,039246	0,054944	0,022835	0,038059	0,053283
ETC	0,007805	0,013009	0,039027	0,070643	0,078492	0,078492	0,068506	0,076118	0,076118
SOLANA	0,007805	0,013009	0,039027	0,023548	0,039246	0,054944	0,053283	0,068506	0,076118
POLKADOT	0,007805	0,013009	0,039027	0,007849	0,023548	0,039246	0,007612	0,022835	0,038059
Criteria		0,091706			0,08558			0,084546	
XRP	0	0,013101	0,039303	0,059906	0,077022	0,08558	0,012078	0,016909	0,028182
POLYGON	0,039303	0,065504	0,091706	0,025674	0,04279	0,059906	0,016909	0,028182	0,084546
ETC	0,039303	0,065504	0,091706	0,077022	0,08558	0,08558	0,012078	0,016909	0,028182
SOLANA	0,039303	0,065504	0,091706	0,04279	0,059906	0,077022	0,016909	0,028182	0,084546
POLKADOT	0	0,013101	0,039303	0,008558	0,025674	0,04279	0,016909	0,028182	0,084546
Criteria		0,042164							
XRP	0	0	0						
POLYGON	0	0	0						
ETC	0	0	0						
SOLANA	0	0	0						
POLKADOT	0	0	0						

Appendıx 3. Fuzzy Dematel Solutions

Appendix 3. calculations for Main criteria

TlJ	F1	F2	F3
F1	0	0,0577	0,05887
F2	0,0429	0	0,02499
F3	0,0109	0,01	0

TmJ	F1	F2	F3
F1	0,12	0,18	0,18
F2	0,17	0,09	0,14
F3	0,13	0,11	0,08

TuJ	F1	F2	F3
F1	1,01	1,01	1
F2	0,96	0,81	0,867673
F3	0,91	0,84	0,772391

T	F1	F2	F3
F1	0,1574445	0,388953137	0,328324683
F2	0,3411158	0,122646346	0,177334811
F3	0,2042079	0,168910302	0,065942469
L	0,1574445	0,122646346	0,065942469

T	F1	F2	F3
F1	4,48	4,78	4,523192
F2	4,27	3,88	3,93338
F3	4,06	3,98	3,508682
R	4,48	4,78	4,523192

Appendix 3. calculations for sub criteria

TlJ	**C1**	**C2**	**C3**	C4	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
C1	0	0,01752	0,027535	0,030397									
C2	0,180289	0	0,151451	0,16052									
C3	0,160528	0,0760801	0	0,126548									
C4	0,153363	0,056919	0,07039	0									
C5					0	0,129514	0,139844	0,184544					
C6					0,088521	0	0,115396	0,179171					
C7					0,078662	0,080233	0	0,133775					
C8					0,018859	0,016234	0,034479	0					
C9									0	0,082682	0,063455	0,054227	0,02452

C10									0,06682	0	0,091558	0,047339	0,040207
C11									0,067842	0,058377	0	0,019531	0,035032
C12									0,117944	0,1292	0,144372	0	0,113528
C13									0,143044	0,13552	0,142979	0,082599	0

T mJ	**C1**	**C2**	**C3**	C4	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
C1	0,134632	0,181302	0,195788	0,19436									
C2	0,449714	0,213229	0,407873	0,41543									
C3	0,40262	0,320121	0,184826	0,357458									
C4	0,386783	0,301462	0,299696	0,177474									
C5					0,202484	0,377689	0,389788	0,444754					
C6					0,324696	0,184968	0,351504	0,424585					
C7					0,299083	0,294356	0,174512	0,372223					
C8					0,192126	0,192057	0,209972	0,145821					
C9									0,14926	0,272786	0,261178	0,245828	0,222412
C10									0,259611	0,15218	0,285936	0,232894	0,236197
C11									0,254865	0,24944	0,147196	0,209154	0,225995
C12									0,355568	0,36966	0,378434	0,182108	0,346273

C13									0,368057	0,365115	0,372976	0,310785	0,182206
Tuj	**C1**	**C2**	**C3**	C4	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
C1	0,566397	0,762824	0,685878	0,680395									
C2	1	0,882571	1	1									
C3	0,93017	1	0,722261	0,912305									
C4	0,879015	0,949269	0,843444	0,682903									
C5					0,849611	1	1	1					
C6					1	0,769839	0,956192	0,962269					
C7					0,970425	0,915809	0,748438	0,934558					
C8					0,799395	0,755608	0,763765	0,628154					
C9									0,749771	0,908684	0,892231	0,913302	0,876858
C10									0,883819	0,735348	0,904125	0,890965	0,873495
C11									0,867889	0,861653	0,717014	0,856753	0,858016
C12									0,995354	0,994986	1	0,82907	1
C13									1	1	0,999363	1	0,815868

BACKGROUND

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