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Blockchain-based Cryptocurrency Price Prediction with Chaos Theory, Onchain Analysis, Sentiment Analysis and Fundamental-Technical Analysis

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ABSTRACT Crypto assets succeeded in making their name known to large masses with Bitcoin, which emerged as a result of the creation of the first genesis block in 2008. Until 2010, the aforementioned recognition showed itself mostly in areas such as games, but over time it managed to enter the portfolios of individual investors. Especially as of end of 2017, the rapid increases in monetary value quickly attracted the attention of corporate companies and then the (Central Banks). These assets have created different alternatives (also know as altcoins) by working and have managed to become one of the important financial instruments today. This study has examined in detail the techniques (Chaos theory, Onchain analysis and Sentiment analysis) developed on the price predictions of crypto assets, which are very important in terms of the number and quality of investors. In the study, findings were obtained that new techniques such as onchain and sentiment are more prominent in estimating crypto asset prices compared to traditional asset price estimation methods of crypto assets and that these techniques can make consistent estimations.

KEYWORDS
Blockchain
Cryptocurrency
Chaos theory
Onchain analysis
Sentiment analysis

INTRODUCTION

Blockchain is a revolutionary technology that allows transactions to be conducted without the need for intermediaries in peer-to-peer transfer. First mentioned in Satoshi Nakamoto's (2008) article "Bitcoin: A Peer-to-Peer Electronic Cash System", this system has the ability to perform financial/non-financial transactions on a decentralized infrastructure. The basic premise of the system initiated from Stuart Haber and W. Scott Stornetta's idea of presenting digital documents with a time stamp, which prevents these documents from being changed, while allowing for a computationally useful solution (AJ and Vanstone 1990). It has become known for its structure that can reliably organize different processes without a systems tool and without the need for a central authority, as well as through Bitcoin, a cryptocurrency that has affected the whole world. The production of Bitcoin started with the creation of the first block and currently has reached a weight that can be considered important in the portfolio of investors with its alternatives approaching 18000.

Cryptocurrencies are new currencies and are also among the popular investment tools. There are many questions about this type of money, which is newly included in the financial system, as they are decentralized and are separated from the conventional monetary system by their nature. Since cryptocurrencies are freely shaped according to supply and demand in the market, one of the most curious subjects in literature has been their value; what will they be and how they will be shaped. There are many studies and methods for determining the future price of a security in traditional financial markets. However after a brief introduction to the research topic in the first part, the second part includes a literature review, followed by a basic and technical analysis, the studies on chaos theory, onchain analysis, and sentiment analysis.

Hacinliyan and Kandiran (2015) investigated the possible fractal behaviors in the Istanbul Stock Exchange indices within the scope of chaos theory. To observe whether there were any chaotic and fractal behaviors, Higuchi and Katz methods were used to analyze the monofractal behavior of the selected indices while the Transformed Width (R/S) and Adjusted Fluctuation (DFA) ana-

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lyzes were used to examine the chaotic behavior. As a result, it was concluded that there is chaotic behavior in the relevant indices.

Alpar and Özge (2016) used the data between 1988-2004 in order to prove the existence of chaos theory in the stock market. Using the Lyapunov exponential model, the result was found to be 18. The time series analysis showed that the stock market is chaotic the direction of price movements can be predicted as the 2 days before and 4 days after repeated each other. Biswas *et al.* (2018) has defined the chaos theory for the sciences and gave information about the detection and management of chaos for the related sciences. In these areas, the boundaries of chaos theory were drawn and relevant literature studies were included.

Abraham *et al.* (2018) collected Twitter and Google trend data to analyse the Etherum and Bitcoin price changes. Sentiment analysis of VADER (Valence Aware Dictionary For Sentiment Reasoning) was used to analyze the collected data. This method was chosen in the study because VADER analysis provided several benefits, including not only classifying text as positive, negative, or neutral, but also measuring the density of words used. The sentiment of tweets was not included as it was said not to be a reliable indicator when crypto currency prices were falling. Tweet volume was taken into account. Both Google Trends and tweet volumes were found to be highly correlated with price. In addition, the correlation held during periods of increasing and decreasing prices shows that the relationship is robust against periods with high variance and nonlinearity. Direct one-to-one comparisons were made using a linear model, as the input variables followed the same nonlinear trends as the response. As a result, it was shown that it is partly due to work done at a time when cryptocurrency prices were always rising. Additionally, Twitter sentiment regarding cryptocurrencies tended to be positive regardless of the future price changes. A positive correlation was also observed by the author between Google searches and the value of cryptocurrencies, and the price changes in the relevant cryptocurrencies were followed, and it was concluded that it was indeed compatible with the model created.

In order to comprehend the temporal link between variables, Cortez *et al.* (2018) concentrated on the pricing of mineral commodities and used econometric techniques, machine learning, and chaos theory-based techniques. They concluded that while Gaussian and stochastic algorithms did not perform well enough, chaotic behavior may be seen when using machine learning techniques and methodologies based on chaos theory.

The study by Lahmiri and Bekiros (2018) focused on multiple fractalism and chaos theory in the Bitcoin market, where they investigated whether the prices followed the random law repetitively between the years 2010-2017. The Lyapunov exponent, Shannon entropy and generalized Hurst exponent models were applied and chaos, randomness and multi fractal stylized features of price and returns in the Bitcoin market were examined. As a result of the study, it was concluded that, contrary to returns, prices included and exhibited chaotic dynamics, but the prices did not repeat in a predictable way. It focused on three digital currencies namely Bitcoin, Digital Cash and Ripple. The analysis showed that all three tools have fractal dynamics, long memory and self-similarity.

By trying to predict Bitcoin and Litecoin prices two hours in advance, based on the sentiment expressed in the current Tweets, Jain *et al.* (2018) aimed to explore whether social factors can predict of cryptocurrency prices. Therefore, they used the Multiple Linear Regression (MLR) model to estimate a two-hour average price from the number of positive, neutral, and negative Tweets accumulated every two hours between March 1-11, 2018.

Bouri *et al.* (2019) examined the effect of herd behavior in the cryptocurrency market. As a result, strong evidence was found to support the existence of herd behavior in this market. The results of the logistic regression analysis, showed that the increase in uncertainty, the herd tendency also provides evidence for this.

To understand the relationship between Bitcoin and Etherum news and the price prediction, Vo *et al.* (2019) conducted an analysis based on the assumption that there is a relationship between the mood of the public and the cryptocurrency market, like traditional financial markets. Data were obtained using daily time series data from July 30, 2017 to October 5, 2018. For the sensitivity analysis, the news of the last 7 days were collected. An algorithm was created with a dictionary-based approach, with the thought of distinguishing the effect of the news about cryptocurrencies on the price movement, and with the thought that it can provide investors with a buying and selling advantage. They created a model that can directly predict the price direction by specifying whether to buy, sell or hold, and they concluded that the model they created correctly predicts the price movement in two cryptocurrencies.

Holiachenko *et al.* (2022) aimed to explain cryptocurrencies using fundamental and technical analysis. A technical analysis method was developed with different currencies in the same stock market in order to achieve maximum gain. In the conclusion part of the study, where many scenarios and graphics related to arbitrage were created, it was stated that the developed methodwas resistant to fluctuations in oil and gold prices.

Hudson and Urquhart (2021) conducted atechnical analysis of Bitcoin, Ethereum, Bitstamp and Litecoin in their study and although predictability continues in other cryptocurrency markets, it has been concluded that there is no predictability for Bitcoin in the out-of-sample period.

In order to test the validity of the efficient market hypothesis in the crypto money market, Kang *et al.* (2019) investigated the random walk theory. They concluded that among crypto exchanges established before November 2017, large exchanges are more likely to satisfy weak and semi-strong forms of market efficiency.

Pietrych *et al.* (2021) investigated the existence of chaos theory in cryptocurrencies. The nonlinearity and chaos in cryptocurrencies (Bitcoin, Ethereum, Ripple and Litecoin) were tested and concluded that these time series show strong evidence supporting the hypothesis that these time series come from an unknown production process that behaves nonlinearly and chaotically.

The effect of crypto money on the economy was analyzed by Yue *et al.* (2021) using a bibliometric analysis. Literature studies related to the subject were extensively covered. Bibliometric analysis aims to reveal previously unknown patterns by collecting a large number of relevant information in a specific area or a specific area of the subject. In this context, starting from the keywords in the literature, using the CiteSpace 5.7. the research outline of the economic effects of the study was created. Data obtained from the literature studies were clustered according to events that could affect the value of Bitcoin and its effects on the economy, and made available for analysis. the results obtained for direct economic effects are as follows:

1) While the impact of speculative trading on cryptocurrency differs in different studies, bitcoin price fluctuations will affect macroeconomic policy to some extent.

2) The hedging and safe-haven characteristics of cryptocurrencies continue to change over different periods of research. Some research finds that Bitcoin can act as a speculative asset.

3) External events such as the Covid pandemic can increase price fluctuations and improve the hedge effectiveness of cryp-

tocurrencies.

Another valuable result of the study is as follows: While computer science literature and interdisciplinary fields are concerned with the economic phenomenon caused by technologies, it has been concluded that previous researches are more concerned with economic results in economic fields.

Gözde (2021) examined sentiment analysis of Tweets posted as "Bitcoin" on Twitter. Orange Data Mining program was used for this. As a result; It has been observed that there is a predominant sense of joy about Bitcoin and investors feel happy when they buy Bitcoin.

Gurrib and Kamalov (2021) tried fluctuations in the crypto money market to be predicted by using sentiment analysis. It was determined that tweets about crypto money in a 3-week period were directly related to the market value of coins, and the model used in this study was determined to be critical. It is emphasized that it is a good model for predicting the value of pto money.

Jagannath *et al.* (2021) conducted an onchain analysis study in order not to predict Ethereum prices. It was chosen because it is Etherum, which is the most popular currency after Bitcoin, and because it uses an open network structure. In this paper, data has been collected from the public Ethereum blockchain and application programming interfaces (APIs) of online resources. In this study, the linear effect of each important Ethereum onchain metric on price is examined using Pearson's and Spearman correlation coefficients. In addition, there is a model study for calculating the estimated price using machine learning models. The author's working comment on the result obtained is: An LSTM model was developed that uses three different self-adaptive methods to determine the best hyperparameter values to predict Ethereum price. Each self-adaptive technique was compared with each other and with a traditional LSTM model. In contrast, self-adaptive algorithm-based LSTM models provide a faster and more accurate price prediction for Ethereum.

Gu *et al.* (2022) tried to detect abnormal transaction amount in cryptocurrency exchanges with On-Chain analysis. In order to obtain the most important factors affecting the trading volume of different exchanges, a correlation analysis was performed and a model was developed to predict the effect of various factors on the trading volume. A case study of the detection results revealed that some abnormal transaction amounts were related to policy changes and industry events, while others were legal. He calculated the deviation between the estimated transaction amount and the actual transaction amount based on deep learning to provide a basis for the abnormal transaction amount detection.

El Montasser *et al.* (2022) calculated the closing prices of different cryptocurrencies in his study. The results of the authors who made balloon studies in terms of market size were interpreted by comparing them with the Covid 19 period. As a result of the study, a high correlation was found between the Covid 19 period and the crypto market. This indicates that the market activity behavior of major traded cryptocurrencies has changed strongly following the COVID-19 pandemic announcement.

We examine the efficiency of cryptocurrency markets by exploring how cryptocurrency bubbles and the COVID-19 pandemic affect market efficiency that changes over time. Our results show that the market activity behavior of major traded cryptocurrencies has changed strongly following the COVID-19 pandemic announcement. However, the results identified three cryptocurrency bubbles; End of 2017, beginning of 2018 and throughout July 2020. It is concluded that these decentralized finance bubbles have a lower impact on cryptocurrency market efficiency. The purpose of the study is mainly the effectiveness of cryptocurrencies and the existence of price bubbles.

Nie (2022) used a network method to identify critical events in the correlation dynamics of cryptocurrencies, taking networks around January 6, 2021 as an example to illustrate local and drastic changes in the correlation structure, helping to analyze the dynamics of the emerging market, the correlation structure in the cryptocurrency market. analyze its stability and fragility. The basic analysis in the network method used is: Using the influence power of the relevant cryptocurrency network (IS). The empirical analysis concluded that the market index showed large fluctuations near the critical event and that there was a correlation between the dynamics of the correlation matrix and the market conditions. In addition, he found a synchronization between changes in correlation and changes in network structure, and a positive correlation is observed

Wasiuzzaman *et al.* (2022) examined the performance of Islamic gold-backed cryptocurrencies during the 2020 bear market. Price data was collected for three Islamic gold-backed cryptocurrencies, OneGram, HelloGold and X8X, and traditional gold-backed cryptocurrency PaxGold. Bitcoin, the traditional fiat-backed cryptocurrency from December 2019 to November 2020. Analysis through ARMA-EGARCH models shows that returns for all cryptocurrencies were lower during the bear market, but only with the Islamic gold-backed cryptocurrency. It was concluded that volatility is higher for all five cryptocurrencies, but the impact of the bear market on volatility is significant only for traditional cryptocurrencies.

BLOCKCHAIN TECHNOLOGY

Blockchain is the infrastructure technology that forms the basis of the relevant subject for the trading of cryptocurrencies and the execution of smart contracts. This system, which was first mentioned in Satoshi Nakamoto's article named "Bitcoin: A Peer-to-Peer Electronic Cash System", has found a wide application area not only in cryptocurrencies, but also in the traditional financial system, allowing new application areas to be opened. Since Blockchain is known for Bitcoin, negative attitudes towards Bitcoin were initially considered within the Blockchain, but over time, this technology brought by Bitcoin began to receive the attention it deserved. However, the emergence of Blockchain dates back to the early 1990s, when Stuart Haber and W. Scott Stornetta first applied cryptographic techniques as an alternative way of storing digital documents and protecting against cyber attack. Blockchain brought; transparency, decentralization, verifiable and strong structure and started to be the center of attention and multifaceted academic reviews were realized. After examining its definition, functions and potential in general terms, the following definition emerged: Blockchain Technology not only processes monetary transactions, but can also enable transactions to comply with programmable rules in the form of "smart contracts" (Tschorsch and Scheuermann 2016). Thus, the ability of the parties to carry out their transactions freely without any trust problems played a leading role in the interest in digital systems.

Although blockchain is anonymous, decentralized, what makes it unique is that it cannot be hacked. Data is stored in a network on the blockchain. Computers working connected to a network called miner, bring together the processed data, archive it in accordance with encryption standards, and turn it into blocks. Transactions turn into a Hash algorithm as a summary function, and either a thousand-page text or a one-line 64-character cryptography information is encrypted with the encryption system for the relevant network (for example, Hash-256 in Bitcoin). That is, as input, the

desired length of file data and etc. are. entered, but its output is called Hash or Digital Digest The information about the network participants, called "Node" is verified and added to the network.

Since each node is connected with the previous node, a change made in the related node causes a change in all other nodes. Since the core of the system is based on a decentralized and intermediary system, a ledger is required, for example for crypto money transfer or trading registration. In this system, the name of this notebook is "Ledger", which is responsible for keeping the necessary records transparently. It acts as an exceptionally secure intermediary between the sender and the receiver. Thanks to the e-signature, it assumes the function of confirming the amount sent by the sender to the recipient. In the digital world, transfer and registration transactions are more reliable thanks to this technology, compared to the type of fraud and insecurity, such as forged signature etc in real life. It is a database that is included and synchronized in the decentralized network (Sarmah 2018). Some of the areas where Blockchain is used are: Finance, Health, Logistics, Creation and storage of valuable documents and official documents, E-commerce, Tokens and cryptocurrencies, Insurance, Supply Chain. While many fields such as Games, Media, Real Estate and art collecting use it, research shows that Blockchain is used in the production and industry sector applications.

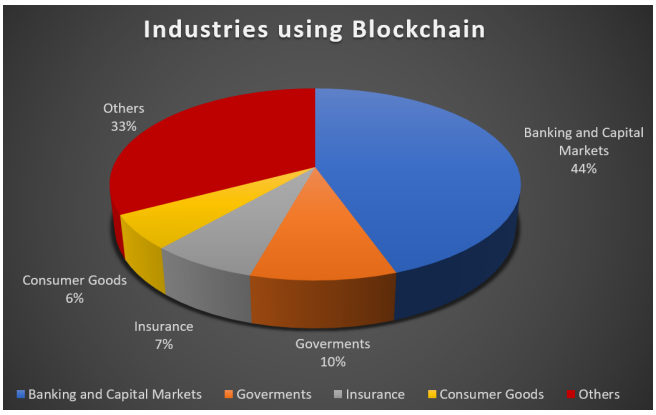

Figure 1 Blockchain usage area (Sarmah 2018)

Considering that the idea of decentralized digital money has just emerged with all this technology, when viewed chronologically, many steps are encountered in the way of creating digital money and the use of blockchain. In the first place, studies were made mostly on encryption and privacy, and with these encryption techniques that developed over time, the financial system and currency continued to develop with cryptographic and digitalization. The information obtained from the studies carried out are listed chronologically as follows:

In 1976, Diffie and Hellman published a paper and presented a method based on a secure exchange in an environment where there is no sense of trust by using private keys and cryptographic encryption techniques (Diffie and Hellman 2022).

An algorithm called RSA was proposed by Shamir, Rivest and Adleman in 1977. In this way, the RSA algorithm was developed in accordance with asymmetric encryption algorithms and e-signature, and authentication processes were developed. A system was developed to be used in secure key sharing operations (Yerlikaya 2006).

In 1980-1990, David Chaum developed a cryptographic encryption. In fact, there is quite a lot of work in this field. Although he first worked on encryption, the encryption system was not in demand because it was not sufficient in terms of mutual trust and confidentiality. He has also developed E-Cash, that is, electronic payment systems, and made innovations such as saving money or investing in the digital environment through the bank.

In 1995, DigiCash company created the first digital currency with e-Cash. In 1996, it introduced e-gold into the system. This system has received a lot of attention, because it allowed system users to open a gold account and then be able transfer this gold (Simsek *et al.* 2020). Then, he laid the foundations of the idea of creating an institution that can make money payments without an intermediary institution, called B-Money. Chaum, who is considered the inventor of digital money. It is known for his contribution to the system on privacy and cryptography. It was the first known proposal of a blockchain protocol. Dr. Chaum continued to develop the first digital currency, eCash, and made numerous contributions to secure voting systems in the 1990s. Today, Dr. Chaum Co-founded Elixxir and Praxxis networks, which combines decades of research and contributions in cryptography and privacy to deliver cutting-edge blockchain solutions.

- In 1999, the Napster program, which allows online and peer-to-peer file sharing, took its place on the market.
- In 2003, the Second Life game became one of the first stages of the transition to virtual currency and digital economy.
- In 2008, Satoshi Nakomato made a creative destruction in this process with his article describing the blockchain-based crypto currency that include all these systems announcing the creation of a decentralized and anonymous crypto currency without the need for a financial intermediary security-based transparent system has been outlined (Nakamoto 2008).

There is no government or banks in the system. A peer-to-peer transfer system has been created in a 24/7 open digital environment. Cryptocurrencies are created with a value whose rate is determined according to the supply and demand in the current system. The Prof of Work(POW) cryptography at the base of the system has solved two basic problems:

1) Problem with keeping records among network participants,
2) Resistance to cyber attack.

Before the emergence of Bitcoin, the function of transferring and preserving money could not be imagined without an intermediary institution, but after the emergence of Bitcoin, it was an important step to overcome the intermediary institution costs or transaction costs that were most criticized in the current financial system.

In this process starting from 2008, many different cryptocurrencies have emerged. There are cryptocurrencies, called Altcoin (Alternative Coin), that have the same production method as Bitcoin and exist on a completely different Blockchain network. These cryptocurrencies, whose number is about 2700, are based on smart contracts due to their organizational structure, and also include many corporate companies in its ecosystem (Şahin 2020). Although the system was created in 2008, it started to attract attention after 2015. At first it consisted of a crypto money given to the miners who contributed to the functioning of the system. Miners perform the most important task of the Blockchain system, for example, they approve the transfer process in a transfer transaction. The operations performed by the miners, who perform tasks such as adding a new Bitcoin to the system, solving the double-spending problem and posting unconfirmed Bitcoins, are as follows:

1) Announcing a new transaction to the entire network,
2) Collecting the node transaction to the relevant block,
3) Issuing a new block after each transaction,
4) Confirming the transactions made.

With each completed task, a new Bitcoin or cryptocurrency appears. According to the data of CoinMarketCap for 2022, there are over 12,954 cryptocurrencies, mainly Bitcoin, Ethereum, XRP, and Bitcoin Cash. According to literature, the ten most popular cryptocurrencies are Bitcoin, in particular, Etherum, Tether, Biancecoin, USDC, Binancecoin, USD, XRP, Cardano, Solana, Dogecoin.

Bitcoin is the most known and most invested in the world of crypto money. However, there are also Altcoins in the crypto money ecosystem. Altcoins were created right after Bitcoin became popular and its formation is clear. Altcoins that can be converted as alternative coins are essentially the name given to cryptocurrencies other than Bitcoin. The first Altcoin created was "Namecoin". The emergence of altcoins is used to eliminate the problems experienced during the formation of Bitcoin, for example, there is an intense energy consumption during the mining phase for the formation of Bitcoin and it is time-consuming. On the other hand, the "Proof of stake" system is used instead of the POW system. This system provides comparative advantage and speed. Although technically crypto investors often refer to low-value cryptocurrencies as Altcoins, which are easy to use and turn into cash faster, they are relatively more affordable than Bitcoin in mining equipment. The disadvantage is that they are very open to speculation. The most popular altcoins are Ethereum, XRP, Tether, Cardano, Polkadot, Stellar, Dogecoin, Chainlink, Uniswap.

METHODS USED FOR PRICE PREDICTION OF CRYPTO ASSETS

Fundamental-Technical Analysis

The analysis that investors basically use in their financial investments is fundamental and technical analysis. While fundamental analysis considers the macroeconomic trend, technical analysis is an analysis that helps predict future price movements of financial assets based on past price movements. The most widely used type of analysis is technical analysis, but whether it is possible to repeat past price movements in the future is a controversial issue. Both types of analysis contradict the Efficient Markets Hypothesis (EPH). The reason for this is the principle that no investor gets abnormal returns since all information is reflected in the prices (Malkiel 2003). With technical analysis, based on past price movements, current prices do not reflect the market.

Fundamental Analysis Various macroeconomic factors are brought together to try to predict the price of the security. The main goal is that the investor's security is overvalued? Is it low value? to seek answers to questions such as Fundamental analysis is examined in 3 groups as firm, sector and economic analysis. In economic analysis, the investor makes a general assessment of the current macroeconomic situation, examines the profitability of the firm during the expansion or contraction periods in the cyclical fluctuation of the economy and tries to predict the direction of the movement of the stock price. After the economic analysis, issues such as sector analysis, the competitive situation of the relevant company in the sector, how much the firm's sector will/will be affected during economic contraction and expansion periods are taken into consideration. After the economic and sector analysis, a firm analysis is made and the return of the stock of the relevant firm is calculated and expected.

The application of this analysis to the cryptocurrency market is to decide whether the price of an asset is higher or lower than its value, depending on how the intrinsic value of the asset is viewed. Fundamental analysis is done by looking at more objective indicators of the estimated value of the relevant crypto-asset, such as the usage density of the network, the activity status of the relevant network, or the business model and the roadmap (Lyashenko *et al.* 2021). Generally, the news and comments about crypto money are evaluated, and then if there are any, speculation or manipulation movements are tried to be detected. All information about the relevant crypto currency is tried to be collected. In order to calculate the returns of alternative investment instruments, domestic macroeconomic variables and investment instruments are also followed. However, using social media for this analysis will not generate correct results because of the possibility of fake accounts and manipulation. Therefore, fundamental analysis of cryptocurrency looks at 3 metrics: on-chain metrics, project metrics, and financial metrics.

To put it briefly:

- On-Chain Metrics, involves obtaining and looking at blockchain data. The node for the desired network is run and viewed by accessing the relevant information. However, since it is a time-consuming method, websites designed for this process are used for more practically. The network transaction count is also a good guide.
- Project Metric, where on-chain metrics relate to observable blockchain data, it includes a qualitative approach that looks at factors such as project metrics, team performance (if applicable), whitepaper, and upcoming roadmap.
- Financial Metrics are concerned with the value of the crypto asset in the relevant period, the price of which it was traded before. Interests can be useful in fundamental analysis. However, other metrics that might fall into this category include gathering information about the economics and incentives of the crypto-asset protocol. The importance of fundamental analysis in terms of cryptocurrencies helps us to determine the suspected values correctly, or to put it more clearly, to conduct a long-term value analysis for cryptocurrencies where there is doubt about buying and selling, or if there is investment hesitation.

Technical Analysis In technical analysis, the investor makes an investment decision with the price and volume information of the asset he wants to invest. Technical analysis defines it as the study of any market that uses price and volume information solely to predict future price movements and trends (Stevens 2002). The most widely used analysis tool for technical analysis is charts. Information is collected by using the graphics of the relevant financial asset. Trends and support and resistance points are also analyzed with the moving average method and various indicators. It is tried to make predictions about the future based on the price movements in the past. Dow theory forms the basis of technical analysis. To summarize this theory, the market consists of a cycle and all prices continue on a continuum. This event is like a tide event.Technical analysis is extremely helpful when reading charts in Cryptocurrencies. Some of these benefits are:

- A single graph reading gives information about an entire process.
- Even just reading charts on trading volume and prices can provide an understanding of the overall picture.
- It is tried to predict the direction of the market with the help of technical analysis.

- With Bitcoin technical analysis, the past and future of crypto money are followed.In general, movements in crypto currency exchanges occur downward, upward and horizontally.To summarize the usefulness of technical analysis in terms of cryptocurrencies, it helps about short-term price movements.

Chaos Theory

Chaos theory has been used in various branches of science to describe order within disorder. Its application in the field of economics was used by G.D.Cole while investigating the causes of the crisis, as well as of the Great Depression of 1929, with the view that nonlinear relations could be explained in the market under certainty conditions.

The most important contribution to chaos theory was by Lorenz during the preparation of the weather forecast report. Chaos theory is a sub-title of nonlinear systems. In the 19th and 20th centuries, it was called the 'butterfly effect' because the Lorenz Diagram is shaped like a Butterfly that popularizes this theory.

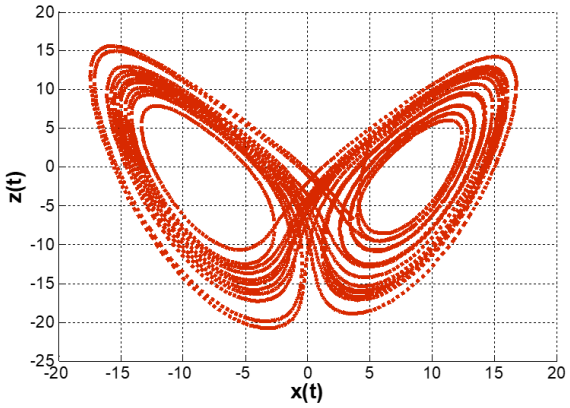

Figure 2 Lorenz chaotic system (x-z)

With the use of chaos theory in the economic sense, studies on, investor and decision-maker behaviors in stock markets and foreign exchange markets, foreign trade problems, crisis period cause-effect relations, hyperinflation periods and banks are the areas where nonlinear equations have also started. The financial application of nonlinear equations is the result of knowledge economy and some models have been developed within the scope of chaos theory. These models are: Logistics equation, One-dimensional discrete maps, High-order discrete maps, and continuous Time Models (Tosun 2006).

Chaos theory is not an induction or a mathematical method. In essence, it explains the tendency of the parts that make up the whole to form that whole separately. The reason for the interest in Chaos theory in economics stems from the fact that this theory can also offer a new perspective on system control strategies, which has some particularly interesting insights for economic policies (Faggini and Parziale 2012).

Chaotic behavior is used in a wide variety of scientific disciplines, including astronomy, biology, chemistry, ecology, engineering, and physics. In economic models, the chaotic existence and cause of the variable, which is tightly connected to the initial cause, is tried to be determined tightly, but it may be difficult to distinguish between random economic shocks and internal fluctuations. For this reason, some analyzes are made to investigate the compatibility with Chaos theory: Correlation, Lyapunov Test, and BDS Test (Klioutchnikov *et al.* 2017).

In order to investigate the chaos, randomness and multi-scale temporal correlation structure for the crypto money market, it is a suitable theory to measure the chaos in prices, the uncertainty in the returns during the high price period, or the change in the returns in the time period when the value decreases. However, when performing a chaos analysis for an econometric series, the basic question is if the fluctuation in the current variable from a stochastic system or if it comes from a deterministic, i.e. chaotic system. One of the most common approaches to answer these question is time series analysis The basic techniques used to measure chaotic systems in general are:

1) Lyapunov Exponent: It is the name given to the instruction that a signal follows along the phase space. It is a measure of the amount of separation between neighboring orbitals. It can measure the stability and instability of the chaotic system (Lv *et al.* 2022).

2) Dimensions (Fractal Dimension): The trend from unidentified disorder to identifiable order is proved with the help of fractal curves. Fractal structures can provide important information about the long-term and repetitive process of market behavior, since the parts are completely similar (Ural and Demireli 2009).

3) Unpredictability: Chaos theory sees the world not as a predictable mechanism, but as an open and flexible system. argues that we are never capable of reaching the initial conditions of necessary certainty related to the functioning of the physical world (Trigg and Yerci 1996).

4) Mixing and Feedback: The order formed in the chaos process shows commitment in a very short time and this is a kind of feedback.

5) Butterfly Effect (Dependence on Initial State): This concept emerged with Lorenz, and when considered for economics, it can be interpreted as that it is sensitive to the initial values for time series and subtle changes will affect the final shape and state of the whole structure (Su 2021).

The efficient market hypothesis, which is the most important theory in financial terms, states that the fluctuations in prices follow the normal distribution within the scope of the random walk feature and that a fair or efficient price will be formed in the market. However, in reality, the fluctuations in prices do not show a random walk feature and do not follow the normal distribution. As an explanation for this situation, the "Fractal Market Hypothesis" was developed. It highlights that the fractal feature can be seen in financial markets. Here, two important points are emphasized that are not included in the efficient market hypothesis: market liquidity and information (Erdoğan 2017).

Market liquidity consists of different opinions on the value of a security based on the trading transactions of investors with each other. In other words, one thinks that the value of the relevant security will increase, while the other thinks that the value of the related security will decrease. Because of the information they do not provide to each other, one party can gain because they reach the information before the other. The second factor, information, is that different values are attributed to the available information in different periods, since the periods in which the investors invest are different. Therefore, prices may consist of a short-term technical and long-term heuristic dimension. To express this differently, there is randomness in the short term and global determinism in the long term, which is related to the fractal dimension.

Fractalism has 3 basic dimensions: Power law, Self-similarity, and fixed scale. An object is fractal if it is similar to its smaller sized parts and is directly related to fractals. The fractal size of the object indicates the degree of similarity to itself. Fractal models are statistical and the standard deviation of the part is proportional

to the standard deviation of the whole, giving meaningful results. In addition to being statistical, it is similar to itself, that is, to be expressed mathematically as the similarity seen in printing an image vertically and horizontally.

In the literature, Chaos theory is generally applied for time series to show whether the time series move randomly. Instead of "Efficient Market Hypothesis" and "Random Walk Model", which are basically the bedside theories of finance science, "chaos theorem" has begun to be accepted. Because with globalization, fluctuations in financial markets have started to be seen much more. In financial markets, the chaos theorem is against the efficient market hypothesis, and each investor and system has taken on a very chaotic structure. As can be seen in the studies in the literature review section, chaotic behaviors have been observed in the crypto money market, especially after 2010.

Onchain Analysis

Onchain analysis is the study of data stored in a blockchain network. In essence, it can be called a blockchain analysis. It is possible to see the entire data as all transactions are recorded on the Blockchain and cannot be changed. In this way, the thoughts and investment direction of all system users can be predicted. To a bitcoin Merchant, it gives another idea of where the price might go depending on the transaction patterns, the type of Bitcoin owner making the transaction, and where the coins might move. This analysis is similar to technical analysis but is more fundamental. The data used to make the relevant analysis can be broadly classified into three different categories:

1) Transaction Data (sending and receiving address, amount transferred, remaining value for a given address),

2) Block Data (time stamps, miner fees, rewards),

3) Smart contract code (i.e. business logic encoded on a blockchain).

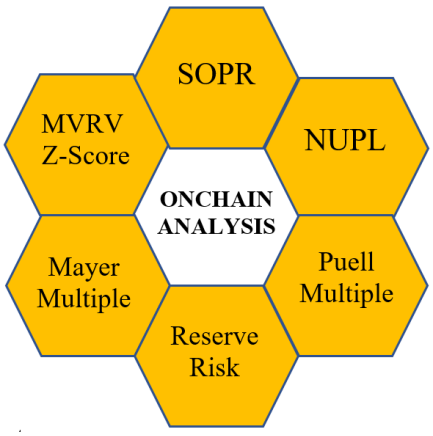

Figure 3 Onchain analysis indicators

Looking at its history, it dates back to 2011. By comparing the value of the network with the transaction volume recorded on the blockchain, it is possible to determine when a cryptocurrency is overvalued. For this, various ratios and indicators have been developed. In this way, market sentiment analysis is made, and the amount of traded /untraded crypto money or token can be determined because whales (people or organizations who own large amounts of crypto currency) sometimes pose a great danger for the crypto money world. Popularized by CoinMetrics, Chris Burniske and Jack Tatar developed the Network Value-to-Transaction (NVT) ratio in the summer of 2017 to measure the utility value of a cryptocurrency, specifically its transactional utility. It was one of the commonly used measures for cryptocurrencies. According to the NTV ratio if the network value is high, the NTV ratio decreases. Conversely, as the value of the network decreases, the NTV ratio increases. The explanation for this is that, if the network value is extremely low, it may indicate that a more substantial price is warranted given the trading volume.

The so-called UTXO (unspent transaction outputs) is a very important concept. It represents the amount of crypto money left over from each transaction. By using this, it is possible to see how long these funds are kept in the wallet. Based on the UTXO data, HODL waves are drawn. Using UTXO, the amount of unused crypto money in the wallets are determined and for how long they are kept.

Holder with an increasing number of investments means that the circulating supply is lower, that is, they do not decrease the sale and the circulating supply can said to be less. This indicator also reflects the investor psychology, allowing us to observe whether people want to sell coins or not. For example, considering investors who have started to sell the coins they have kept in their wallets for more than 1 year, Holder decreases, which means that the investor is selling his crypto asset because they are making a profit. With this indicator, investments can be made by looking at the buying/selling times. Warm colors, such as red, orange, yellow, represent Bitcoin that has been used within 1 year, while cold colors represent Bitcoin that has not been used for more than 1 year.

Another indicator used in onchain analysis is MVRV Z-SCORE. This indicator shows the period when Bitcoin is overvalued and undervalued. Certain values in the past are taken into account and the formula is as follows:

$$MVRVZ - Score : \frac{MarketCap_{USD} - RealizedCap_{USD}}{StdDev\,(orMarketCap_{USD})} \quad (1)$$

The MVRV Z-score is a function obtained by dividing the difference between the total market value and the realized market value by the standard deviation of the market value. This shows how many standard deviations the market value differs from the realized value. Market value indicates a peak if it is significantly higher than realized value, but a bottom vice versa. In other words, it shows whether the realized value with the market value is over or undervalued than the Bitcoin price. The ultimate goal is 7. The probability of a Balloon asset above 7 is high.

The Z-Score is a number used to measure the relationship of a value with the group average of that value. It is measured with a standard deviation, and for example, Z-Score 0 means the value is the same as the group mean, and if the Z-Score is 1, that value is 1 standard deviation from the group mean. It is more important in determining extraordinary movements. If the Z-Score -Red Line- enters the pink box, it means that there is an excessive increase beyond the true value. The probability of the price falling increases.

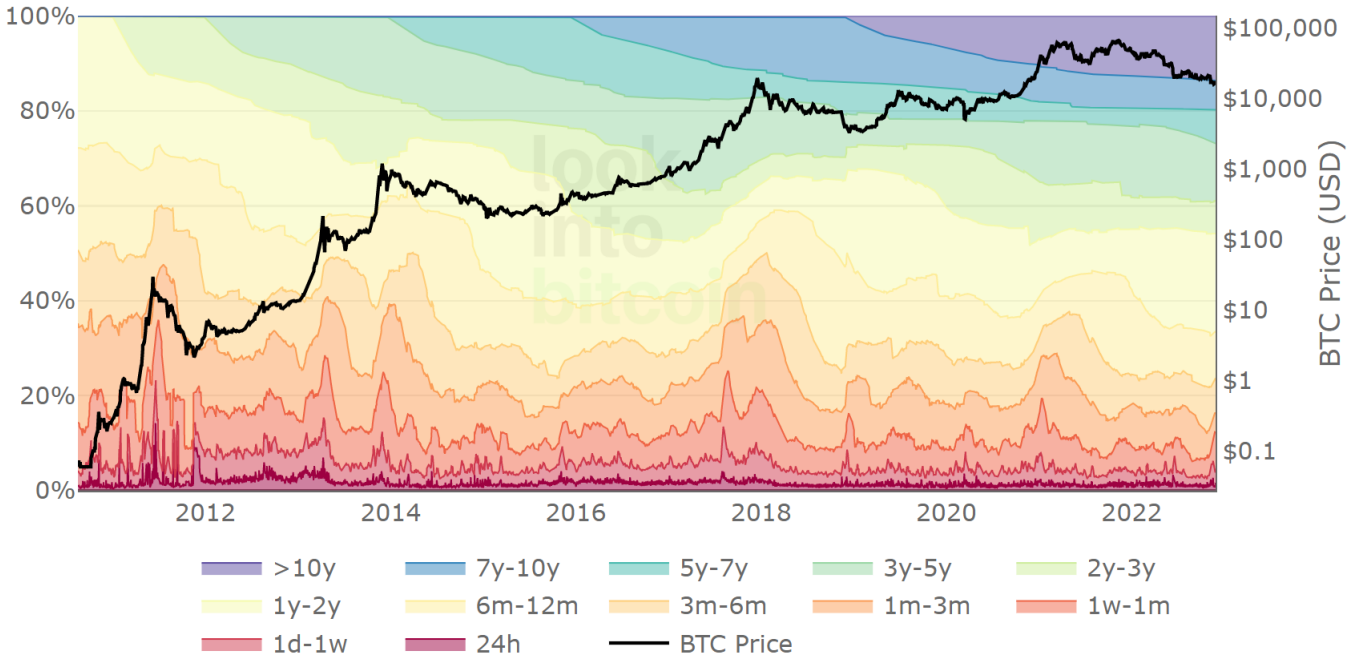

Figure 4 HODL Wave Graph (Lookintobitcoin 2022 (accessed November 7, 2022)

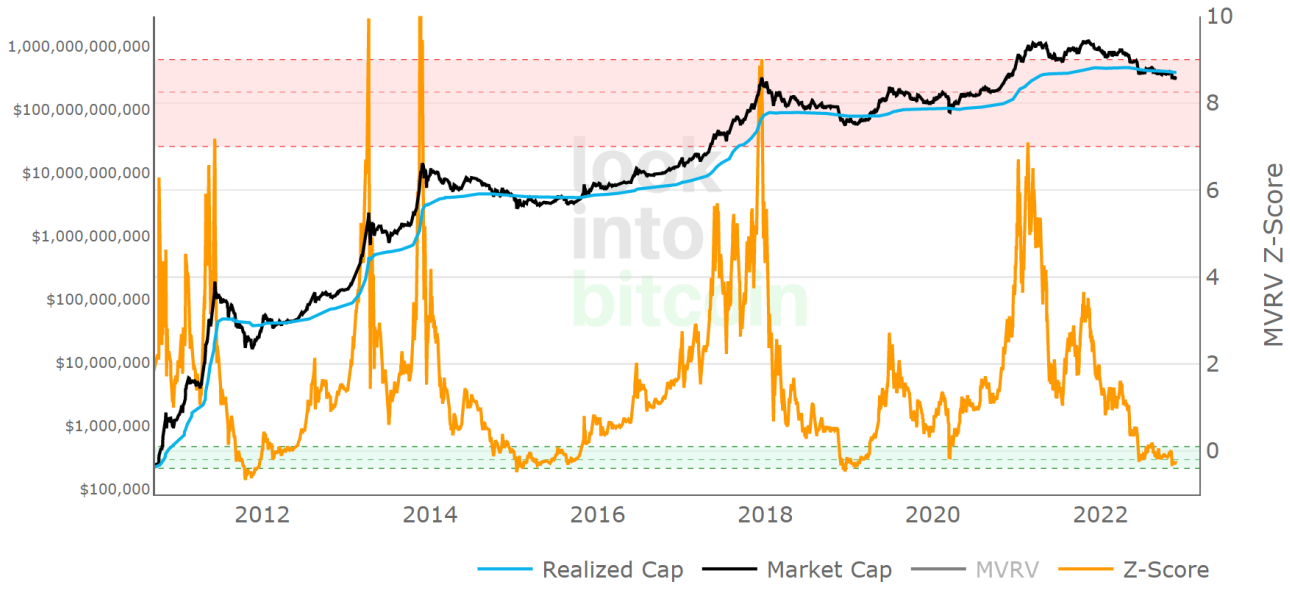

Figure 5 MVRV Z-Score (Lookintobitcoin 2022 (accessed November 7, 2022)

Another indicator is NUPL. NUPL is derived from both the market value and realizable value. Market Cap is the current price of Bitcoin multiplied by the number of coins in circulation. Actual Value is the price of Bitcoin at the time it was last transferred, that is, the last time it was transferred from one wallet to another. All these individual prices are then summed up and averaged, then multiplie with the total number of coins in circulation. It is the difference between the market value and the realized value. Formula NUPL value it is:

$$NUPL = \frac{MarketCap - RealizedCap}{MarketCap} \tag{2}$$

Net Unrealized Profit/Loss (NUPL) can use market participant data to help predict when Bitcoin price hits highs or lows. It is a convenient tool to show potential market participant sentiment at a given moment, which can be useful for predicting the Bitcoin price and where it may move over time. How this tool should be interpreted in its graph is shown in the Fig 6.

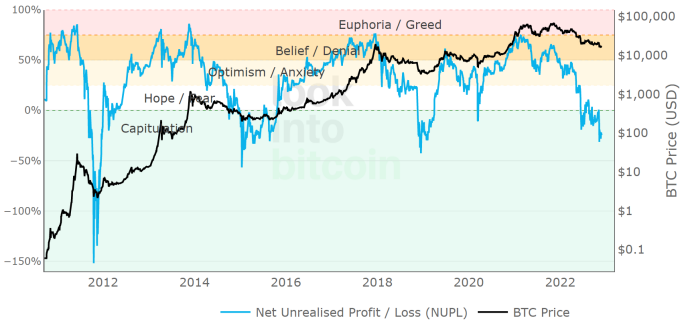

Figure 6 NUPL Graph (Lookintobitcoin 2022 (accessed November 7, 2022)

To generate this indicator, the difference between unrealized losses and unrealized gains is calculated, so that when it acquires a value greater than zero it indicates that at that moment the network is in profit, while values less than zero indicate a state of loss. The indicator is shown on a graph as a curve that oscillates between positive and negative values, and in general, the further the NUPL curve moves away from zero, the closer the prices are to the market highs or lows.

Puell Multiple metric focuses on the revenue of bitcoin miners. In this environment where prices are volatile, miners can affect prices in order to meet fixed costs. The daily issuance value of Bitcoins is calculated by averaging the 365-day issuance value. If the values are higher than the annual average it indicate the current miner profitability. Low values indicate that current miner profitability is lower than the annual average.

The Mayer Multiple shows the time period when it is overvalued and undervalued above the 200-day moving average. If this value falls below 1, it is a buying opportunity. In the short term, this value is desired to exceed 1. Falling below 1 is not a good indicator for the investor. It is calculated using the formula:

$$MayerMultiple = \frac{BTC_{USD}}{MA_{200}(BTC_{USD})} \tag{3}$$

Reserve Risk is a cyclical indicator that monitors the risk-reward balance based on the confidence and belief of long-term holders. It is an indicator that models the ratio between the current price (sell incentive) and long-term investors' opinion (opportunity cost of not selling). This indicator is compatible with bull and bear markets. If confidence is high and the price is low, the Reserve Risk is low, making it attractive to invest. If the confidence is low, the reserve risk is high, and this may mean a price peak. In other words, low reserve risk can mean low value and high reserve risk can mean overvaluation.

There are some free websites that provide on-chain analysis for cryptocurrencies : Glassnode offers simple on-chain metrics at zero cost, plus advanced metrics and high-frequency time series data for a fee. CoinMetrics offers free data for around 37 crypto assets. This includes on-chain metrics and correlations.

IntoTheBlock is also a platform that provides a wide range of analytical tools. It covers sentiment analysis, order book data, and on-chain analysis for various crypto assets.

Other sites include Santiment/Sanbase and CQ.Live. There can be various difficulties in performing Onchain analysis. Not all blockchains are evenly distributed. For example, the Bitcoin network has the motivation to make digital money, while the Etherum network has a wider range of services. Measurements may differ due to inequality in the blockchain. When comparing Bitcoin to other new Altcoins, Bitcoin has more than ten years of data to support historical analysis, while new altcoins have less data, as well as longer term analysis. It may not give the right buy-sell signal in the short term.

Sentiment Analysis

It is the formation of thoughts on the subject through the evaluation of the feelings and thoughts of a community. The idea is to obtain efficient and usable findings from these evaluations. Its other name is "Idea mining". Sentiment Analysis is used in many fields such as finance, medicine, stockbroking, media, politics. It is a widely used technique in product reviews to measure a consumers satisfaction with a product. The data related to the subject in question can be defined as positive, negative, or neutral. In terms of Sentiment Analysis research levels are examined under three main headings; document level, sentence level (sentence level) and view level (aspect level).

Sentiment analysis at the document level: In this method, without going into too much detail, the entire document is considered as a single idea and classified according to whether it expresses positive or negative emotions. However, this method cannot be used in cases where there is more than one variable, since it gives a single result.

Sentence Level Sentiment: After checking whether each sentence is subjective or objective, if the sentence is subjective, classification is made according to whether the sentence expresses positive or negative emotions (Medhat *et al.* 2014).

At The Level of View, Sentiment: Makes it possible to deal with all aspects of existence. In the classifications at the document and sentence levels, the comments do not have to be detailed, but at this view level, the comments are detailed because it is aimed to determine the direction of emotion regarding certain features of a certain entity (Medhat *et al.* 2014).

Sentiment Analysis Methods are divided into 3 as Machine Learning, Hybrid Model and Dictionary Based Approach.

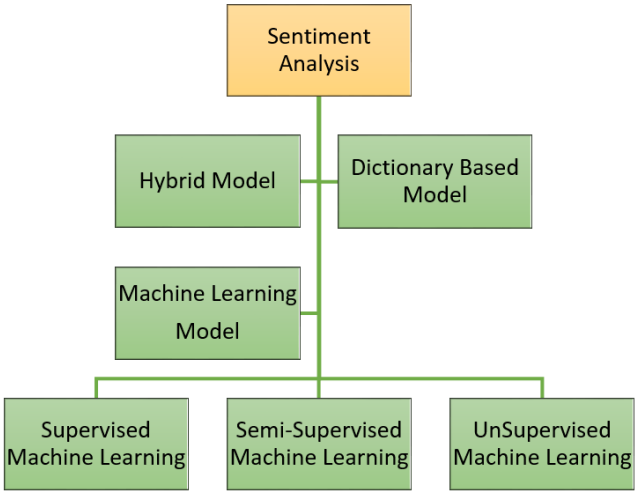

Figure 7 Types of sentiment analysis

Dictionary Based Approach Using natural language processing method and the tools of this method, methods based on emotional analysis of sentences are used. Here, sentences related to the relevant subject are analyzed and it is desired to reach a conclusion about these sentences. Three methods are used when applying this method are:

a) Conditional Random Fields: Based on the words in the sentence, the purpose of the chosen word is determined.

b) Dependency Tree: Elements are created in the sentence and the dependencies of the created elements are investigated. A sentiment analysis is performed by analyzing the relationships between the nodes in the created loyalty tree.

c) Rule Based Approach: Rules based on different natural language processing features, especially word types and word type patterns, are determined, and semantic inferences are made by analyzing sentence structures that comply with these rules.

Hybrid Approach They are approaches in which machine learning algorithms and dictionary-based approaches are used together. Sentiment analysis in crypto money is generally related to social media etc. about crypto money. It started to be implemented based on the findings that opinions affect the value of crypto money. If emotion is expressed in financial terms, they are an opinion expressed about the state of a market. Crypto market sentiment defines the general emotional views and attitudes of investors towards the asset. In essence, Sentiment analysis for cryptocurrencies can yield several notable statistics that can be used to analyze cryptocurrency market sentiment: funding rates, sentiment indices, social media and community analytics, and tracking of cryptocurrency whales, trajectory and movements of crypto assets.

The basis of this analysis is based on Sentiment analysis methods. It can answer many questions for the investor who has invested in the crypto money market for at least a year, such as coin transactions. For example, if a coin, which is stated to have given a "buy" order on social media, has been purchased and sufferes a loss in the future, this victimization of the investor may affect the view of the entire crypto money investment. Here, the concepts of "FOMO" and "FUD" come to the fore. These concepts are from everyday language, but are also used in literature to reflect the psychological state of the user.

Fear of missing out (FOMO) is the fear of people of not knowing or missing out on the news, developments and information in daily life. It is the concern that a crypto-related opportunity will be missed. Fud (fear, uncertainty and doubt) expresses the uneasiness that there will be a loss which will decrease the prices in the market.

The emotions expressed here may belong to the individual or the community. In the existing studies in the literature, for example Husband 2021, a Sentiment Analysis study with Twitter Data on Bitcoin was carried out. A predominant feeling of joy was observed. Another study in the literature included the relationship between news about Bitcoin and ether and price prediction. Sentiment Analysis related to the relevant crypto money can be made.

Machine Learning Approach Present data using mathematical and statistical methods is a sub-branch of artificial intelligence consisting of modeling and algorithms that make inferences from the future and make predictions about the unknown with these inferences. It is divided into three as supervised machine learning, unsupervised machine learning and semi-supervised machine learning.

a) Supervised Machine Learning: The target values corresponding to an existing group of input values are given, and it is aimed to produce the outputs closest to the target values by learning the dependency between the input and the target of the created model (Ciftci and Apaydin 2018). We can use supervised machine learning to learn a model for the relationship between example: x and y. It reason it is called supervised machine learning is because requires human oversight. The majority of the data that is currently available is unlabeled. For data to be adequately labeled and ready for supervised learning, human input is typically necessary. Supervised learning is used in financial applications for credit scoring, algorithmic trading, and bond classification. Supervised learning problems can be further grouped into regression and classification problems.

b) Semi-Supervised Machine Learning: Labeled and unlabeled data are separated in order to form the appropriate model. If unlabeled data is less, semi-supervised machine learning is preferred. It is a relatively more flexible model.

c) Unsupervised Machine Learning: It finds similar samples within the group and aims to model the underlying structure or distribution in the data to learn more. It is desired to make a meaning out of meaningless data. It is applied on raw data. It is used quite often to determine the trends, likes, etc. of the datasets we have.

The requirement for labeled training data distinguishes supervised learning from unsupervised learning. Unsupervised machine learning processes unlabeled or raw data, whereas supervised machine learning uses labelled input and output training data. The Possibilistic Fuzzy C-Means (PFCM) and Fuzzy C-Means (FCM) algorithms are frequently utilized techniques (Wang *et al.* 2020).

Deep learning techniques have been used recently in research projects to forecast bitcoin prices. compared cutting-edge deep neural networks for predicting Bitcoin price, including Long Short-Term Memory (LSTM), Deep Neural Networks (DNNs), deep residual network, and their combinations.

Cryptocurrencies give very successful results in terms of price prediction thanks to their own features. When the studies in the literature are examined, successful results are obtained (Chen *et al.* 2020). There is consensus in the literature that machine learning provides robust techniques for exploring the predictability of cryptocurrencies even in adverse market conditions and developing profitable trading strategies in these markets (Sebastião and God-

inho 2021). The combination of these trust frameworks, which hold the frontiers of machine-work analytics and blockchain, enables smarter decisions, increased trust, more automation, and decentralized intelligence.

As a result, a machine computer and blockchain duo sustain the positive effects of the workload and its financial performance. It creates a system for storing and sharing big data with the help of smart contracts in blockchain networks. Machine learning is the basis of system behaviors necessary to optimize blockchain mechanisms. Trade forecasting is known for its great forecasting capabilities and efficient data analysis methods. Also, ML models can be used to improve data validation procedures and detect malicious attacks or fraudulent transactions on the blockchain. Machine learning and blockchain build a mutually beneficial relationship that is all about data. However, if you use machine learning for blockchain management, you have a chance to gain unprecedented data security. But at the same time, machine learning can take advantage of the decentralized nature of blockchain to build better models and handle large volumes of data.

CONCLUSION

Cryptocurrency is a new unit that is used and there are many questions about it. One of these questions is what its value will be in the future. When we look at the studies in the literature, the value of this crypto money using onchain and sentiment analysis, which are couple of the chaotic behaviors and new analysis types, as well as fundamental and technical analyses. It is possible to monitor the correct predictions and crypto money behavior. Sentiment analysis is used in cryptocurrency forecasting, just as it is used in traditional finance, and produces successful analyzes about the investor's thoughts about the relevant currency. When viewed from the framework of chaotic behavior, it is highly dependent on initial conditions because it is not centralized. In most startups, this currency behaves chaotically and that small effects make big changes.

Fundamental and technical analysis in the Crypto market refers to the evaluation of the market environment and other important factors that can affect the market trend. It includes the analysis of numbers and statistics that can determine the price movements and trading volume of digital assets. Investors identify past market trends and price movements to determine whether digital assets are worth investing in. It seems to be a commonly used method. Technical analysts use a variety of indicators to identify market trends based on charts and historical price movements. One of the key premise of technical analysis is that market prices already reflect all fundamental factors. However, unlike the approach of technical analysis, which focuses heavily on historical price data, fundamental analysis adopts a broader research strategy with a greater emphasis on qualitative factors. For this reason, many investors seem to use a combination of both methods to get the most accurate insight.

Onchain analysis, on the other hand, needs to be able to look at various metrics for the analysis of Bitcoin and other cryptocurrencies. Traders and investors often pair On-Chain analysis with technical analysis to identify suitable short-term entry and exit points for crypto assets. In other words, it is not based on speculation, it will help to make more accurate short or long targeting by making an interpretation as a result of these metrics and analyzes that are shared regularly and consistently. It is mostly like technical analysis, but on-chain analysis is achieved by interpreting all transactions that have taken place completely on the blockchain. Just like in technical analysis, there are indicators used in on-chain analysis. On-chain analysis gives us ideas about where we are now and what may happen in the future. On-chain sentiment analysis means the interpretation of crypto money transfers that take place on-chain. These two new analyzes can contain the most reliable price predictions as they reflect the nature of crypto money. In short, on-chain analysis offers cryptographers a fascinating tool to explore real-time insights into a blockchain network. This gives them the opportunity to take advantage of a more abundant and transparent data encryption market.

In this study, analysis methods and explanations of these methods are included in order to make price estimation. The wide definition of sentiment analysis and onchain analysis, which are two new types of analysis, makes the study valuable. Besides all these, the discovery of the chaotic behavior of the decentralized currency will help us understand the nature of cryptocurrencies.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Availability of data and material

Not applicable.

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