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CAN THE INDEX MODEL BE USED IN CRYPTOCURRENCIES? EVIDENCE FROM TRADITIONAL METHODS AND NUMERICAL SIMULATION

Endeks Modeli Kripto Para Birimlerinde Kullanılabilir mi? Geleneksel Yöntemlerden ve Sayısal Simülasyondan Elde Edilen Kanıtlar

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Keywords:
Cryptocurrencies, Risk Level, Numerical Simulation.

JEL Kodes:
C15, G12, G15.

Abstract

The study aims to compare three different index models for crypto assets, offering investors new methods for risk management and contributing to the literature in this field. To this end, three different indices were calculated using traditional weighting, standardization, and numerical simulation methods to determine the accuracy of these models in predicting market volatility. The scope of the study is limited to seven crypto assets with the highest trading volumes and three additional crypto assets as a control group. The study is confined to examining the relationship between the index and volatility. Furthermore, analysis of index forecasting or the impact of other variables on the index remains an area for future development. The findings based on the calculated indices show that the traditional weighting model predicts market volatility with 65% accuracy, while the standardized index increases this rate to 78%. In contrast, the numerical simulation achieves only 42% accuracy, calling into question established assumptions in the literature. These results carry significant transformative potential for crypto investors' risk assessment processes. The index-based approach enhances market transparency and provides regulatory bodies with a new supervisory framework. The vital implication for policymakers is that data-driven regulation in crypto markets is now technically feasible.

Anahtar Kelimeler:
Kripto Paralar, Risk Düzeyi, Sayısal Simülasyon.

JEL Kodları:
C15, G12, G15.

Öz

Çalışma, kripto varlıklar için üç farklı endeks modelini karşılaştırarak yatırımcılara risk yönetiminde yeni yöntemler sunmayı ve literatüre bu alanda katkı sağlamayı amaçlamaktadır. Bu amaç doğrultusunda, endeks modellerinin piyasa volatilitesini tahmin etme doğruluğunu belirlemek için geleneksel ağırlıklandırma, standartlaştırma ve sayısal simülasyon yöntemleri kullanılarak üç farklı endeks hesaplanmıştır. Araştırmanın kapsamı, en yüksek işlem hacmine sahip yedi kripto varlık ile kontrol grubu olarak seçilen üç farklı kripto varlıkla sınırlıdır. Çalışmanın kapsamı yalnızca endeks ile volatilite arasındaki ilişkiyi incelemekle sınırlandırılmıştır. Bununla beraber endeksin tahmin edilmesi veya endeksi etkileyebilecek diğer değişkenlerin analizi çalışmanın gelişime açık alanlarıdır. Hesaplanan endeksler üzerinden elde edilen bulgular, geleneksel ağırlıklandırma modelinin piyasa volatilitesini %65 doğrulukla tahmin ettiğini, standartlaştırılmış endeksin ise bu oranı %78'e yükselttiğini göstermektedir. Buna karşın, sayısal simülasyonun yalnızca %42 doğruluk sağlaması, literatürdeki yerleşik varsayımların sorgulanmasına neden olmaktadır. Bu sonuçlar, özellikle kripto yatırımcılarının risk değerlendirme süreçlerinde önemli bir dönüşüm potansiyeli taşımaktadır. Endeks tabanlı bu yaklaşım, piyasa şeffaflığını artırırken düzenleyici kurumlar için yeni bir gözetim çerçevesi sunmaktadır. Çalışmanın politika yapıcılar açısından en önemli çıkarımı ise, kripto piyasalarında veriye dayalı düzenlemelerin teknik olarak mümkün olduğunu kanıtlamasıdır.

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1. Introduction

Today, developments in the field of technology have a great impact on every aspect of our lives. With the digital transformation, physical borders are disappearing and innovative applications are becoming widespread in many areas of life. The impact of these developments is also seen in the financial sector, and virtual (digital) currencies, called the digital revolution, are widely accepted by the masses as an alternative to traditional investment instruments such as gold, foreign exchange, precious metals, funds, and stocks (Zohar, 2015).

Digital money is a type of currency, usually issued by its developers, used between members of a particular virtual environment and not regulated by law (European Central Bank, 2012). Today, coins and tokens, defined as "cryptocurrencies", have become widespread around the world as a means of value and investment. Cryptocurrencies with a blockchain system are called "coins", while crypto assets without this system are called "altcoins". For example, Bitcoin is the most popular coin with its own blockchain system, while digital assets that run on an existing blockchain network are known as tokens. While coins usually function as a medium of exchange on their own independent blockchain networks, tokens are not only used as a medium of exchange, but also fulfill various functions that contribute to the functioning of the ecosystem (Kahraman, 2022).

Cryptocurrency is a type of digital money that has no physical form and uses blockchain technology (Teichmann and Falker, 2020). This currency relies on a technique called cryptography, which ensures secure communication by making information unreadable (Milutinović, 2018). The most prominent features of blockchain technology can be listed as decentralized structure, low transaction costs, ensuring confidentiality, and eliminating the need for third parties (Hossain, 2021). Blockchain-based cryptocurrencies provide a secure and unalterable record by storing transaction data permanently (Amsyar et al., 2020). Transactions on the blockchain can be examined by anyone who wants (Onay, 2018). This technology, which is at the core of crypto assets, provides significant innovations in the financial world by offering advantages such as peer-to-peer transactions, transparency, privacy, and security (Mendi, 2021).

In addition to their security, decentralization, or technology-based nature, another aspect of cryptocurrencies is their use as investment instruments. Over time, there has been a significant increase in the trading volumes of cryptocurrencies for investment purposes. In line with these developments, the applicability of an index for cryptocurrencies was investigated in this study. In the study, after presenting the history and theoretical background of cryptocurrencies, three different indices were created and tested with control variables. Then, recommendations are made according to the results of the analysis.

No index has been developed to measure the risk level associated with cryptocurrencies. An index to be developed for cryptocurrencies could provide market information to investors and could also be used to measure deviations from market conditions. In other words, having an accepted index would also indicate the risk level. This study will make a significant contribution to the literature in this regard. Additionally, three different methods have been used to calculate the index in the study. These methods are traditional weighting, standardization, and numerical simulation. The index has been calculated using test data with all three methods, and the findings have been tested with control data.

This study makes a significant contribution to the literature by proposing a risk measurement index model for crypto assets, which has not yet been developed. Unlike traditional financial instruments, accurately determining risk levels in cryptocurrencies is challenging due to their volatile and dynamic nature. The index models created using three different methods (traditional weighting, standardization, and numerical simulation) are compared in terms of their accuracy in predicting market volatility, filling a gap in the existing literature. Moreover, the developed indices demonstrate potential to enhance market transparency and provide new tools for risk management for both investors and regulatory bodies. In this respect, the study contributes to both academic and applied finance literature by showing that data-driven regulation in cryptocurrency markets is technically feasible.

2. Theoretical Framework

2.1. History of Cryptocurrencies

The first work on cryptocurrency belongs to David Chaum in 1983. Chaum discussed eCash protocols in his article and founded DigiCash. Chaum converted the money in the bank into eCash, enabling payment in a computerized environment. Although Stefan Brands was one of the founders, contributing to the development of DigiCash's protocols and rules with Chaum, DigiCash went bankrupt in 1998. Building on Chaum's work, the "Crypto Anarchist Manifesto" was published in 1993 by Eeric Hughes, a member of the Cypherpunk movement, to provide privacy for personal financial information through advanced technology and strong cryptography. Cypherpunks advocated both the optional provision of financial information and transactions and decentralized systems that cannot be deleted or shut down by computer software (Swartz, 2018). In 1998, Cypherpunk member Wie Dai developed B-money, an anonymous, peer-to-peer transferable and distributed electronic money system. Dai defined two protocols based on the assumption that a pseudonym would be defined between the two parties and that it would be signed by the sender and encrypted by the receiver in an untraceable network. In this way, the system prevents unrealized transactions and introduces a penalty-reward mechanism. Dai's main goal was the emergence of a currency in which there could be no state intervention and which could not be prohibited in any way (Dai, 1998). Developed in 1998 by Nick Szabo, Bit Gold, a decentralized payment system, was shared with the public in 2005. Szabo (2005) stated that the currencies that people currently use are not safe and that Bit Gold will be a safe harbor due to problems such as inflation in the twentieth century (Szabo, 2005). It is important to note here that B-money and Bit Gold remained only in theory as currencies that were not put into practice.

The Bitcoin currency emerged in 2008 when a person with the pseudonym Satoshi Nakamoto sent an article on software and encryption to a group of people via e-mail. The article described the systematics of how cryptocurrencies can be transferred between individuals without an intermediary institution and central authority through encryption. In the e-mail sent by Nakamoto; "I am working on a new electronic money system that is completely peer-to-peer and without a trusted third party" and "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto, 2008). It can be stated that the foundations of Bitcoin were laid after the economic crisis in 2008, especially with the decrease in trust in centralized systems (Ağaçkesen, 2022). Eğilmez (2013) defined Bitcoin as a currency in which transactions are made on the internet and which does not depend on a central authority or intermediary institution. Nakamoto (2008) defined electronic currencies as a signature chain, whereby the holders of the currency sign both their own signature

and the public key of the next holder, along with the summary of the previous transaction when sending it to the next holder. Therefore, since there is no reliable party, such as a bank, the transactions should be announced, and the information of these transactions should be accessible (Kesebir and Günceler, 2019).

Although Bitcoin, which is based on people's trust, is the largest virtual currency among cryptocurrencies, Bitcoin's virtual bank was robbed in 2011, and this trust was shaken. However, the crisis was overcome in a short time, and it was revalued, and it is estimated that there are around 20 million Bitcoins in the market. On the other hand, if the demand for Bitcoin increases, it means that its price will increase continuously (Erkuş and Gümüş, 2019). Virtual assets that are referred to under different names but work with the same logic as Bitcoin are called Altcoins. One of the most popular altcoins among these is Litecoin. Litecoin was launched by Charlie Lee in 2011. One of the important features of Litecoin is that it is not connected to any center, and it produces blocks faster than the Bitcoin blockchain. Therefore, money transfers through Litecoin are realized at very low costs (Kaplanhan, 2018). At the end of 2013, Ethereum was proposed by Vitalik Buterin. Buterin changed the certificate used by Bitcoin and developed blockchain-based software with a Secure Hash Algorithm (SHA-256) certificate. Ethereum enabled the production of documents consisting of code called smart contracts. Ethereum had the largest market capitalization after Bitcoin (Tevetoğlu, 2021). Ethereum is designed as a general-purpose and powerful blockchain platform to support the deployment of smart contracts for decentralized computations. However, a notable aspect of Ethereum is the variability in the security and accuracy of smart contracts. While the smart contract code may be of good quality, it can still conceal unforeseen errors (Gürgüç and Knottenbelt, 2018). Nikolic et al. (2018) found that there are thousands of live Ethereum smart contracts ready to be used for purposes such as indefinitely locking funds, leaking funds to ordinary users, or being terminated by random users. El Salvador and the Central African Republic were the first countries to accept cryptocurrencies as official currency.

2.2. The Importance and Features of Cryptocurrency Technology

People benefit from technological developments in order to realize their activities quickly and easily. In proportion to technological developments, various advances have been made in social life. Especially in this period, which we call the digital age, digital information technologies have transformed business models and money transfer processes. It has also initiated a new process that will change the definition and structure of money (Özpençe and Noyan, 2022).

In this era of easy and fast communication on a global scale, a suitable infrastructure has emerged for the transfer of digital assets in the digital environment. The technological solution that enables the transfer of digital assets using this infrastructure is cryptocurrencies based on blockchain technology (Doğan, 2020). With the widespread use of the internet and e-commerce, physical money has evolved into digital, virtual, and crypto money with the desire to reduce transaction costs and make transactions without intermediaries (Yıldırım, 2019). Cryptocurrencies, which have created significant changes in the financial system by removing the limitations in trade, have gained popularity since 2010 and have become an investment instrument (Turan, 2018). Cryptocurrencies are produced over the internet independently from central banks and operate securely in a digital environment with blockchain technology (Polat and Karakaya, 2023). Blockchain is defined as a distributed digital ledger that enables two or more participants

in a peer-to-peer network to directly exchange information and assets without intermediaries (Bozdoğanoğlu, 2023).

Blockchain technology forms the infrastructure of cryptocurrencies with its decentralized structure, high security, speed and cost advantages. The fact that it enables transparent and low-cost transactions without the need for intermediaries offers the potential for a disruptive transformation in the financial system and is seen as one of the most effective areas of digital transformation (Çetinkaya, 2018). In addition, blockchain technology enables cryptocurrencies to perform not only simple transactions such as money transfers, but also more complex transactions and applications. Although this technology was first developed for cryptocurrencies, it is also used in the financial sector to increase security, speed up transactions and reduce costs. For this reason, the use of blockchain in the financial sector is becoming increasingly widespread (Ceylan and Işık, 2023). Despite all these advantages of blockchain technology, it also has some disadvantages. The fact that it is not based on a central authority and user identities cannot be determined makes it difficult to audit cryptocurrencies. In addition, it is difficult to find expert auditors due to the limited knowledge about cryptocurrencies and the need for a high level of technical knowledge (Karyağdı and Yolci, 2023).

The most popular and most demanded cryptocurrency created in the digital environment is Bitcoin. Bitcoin emerged with the article published by Nakamoto (2008) and became the first globally accepted cryptocurrency (Serbest, 2023). Research shows that since 2009, the number of cryptocurrencies has been increasing day by day. However, only some of these currencies are preferred by users (Ceylan, 2019). As of March 2024, there are 13,217 cryptocurrencies worldwide. However, not all of them are active, and approximately 8,985 active cryptocurrencies are actively circulating. Approximately 420 million people worldwide use cryptocurrencies, and approximately 18,000 businesses are among these users. As of the second quarter of 2024, the total cryptocurrency market capitalization reached 2.43 trillion dollars (Coingecko, 2024). Despite the growing interest in cryptocurrencies today, the use and legalization of these currencies are still controversial. The acceptance of a currency as a medium of exchange depends on it fulfilling its basic functions and being a stable store of value (Macit, 2022). Cryptocurrencies, which are secured by strong cryptographic systems without central authority control, theoretically have all the characteristics of money (Yıldırım, 2019). However, conceptual discussions on cryptocurrencies emphasize that these currencies cannot fulfill all the functions of money. Cryptocurrencies fulfill the role of being a medium of exchange among the functions (medium of exchange, store of value, unit of account) that traditional currencies have (Macit, 2022). According to Gürgüç and Knottenbelt (2018), the use of cryptocurrencies as a means of payment by businesses depends on the implementation of regulatory and supervisory mechanisms. Therefore, providing a well-prepared and favorable regulatory environment is essential for cryptocurrencies to become units of account. Jeff Garzik, one of the contributors to the formation of Bitcoin, expressed hope that Bitcoin would be used as a payment method for businesses. Despite this not yet being realized, he stated that Bitcoin has been successful as a store of value and an investment vehicle (Konakçi, 2018). The top 10 most traded cryptocurrencies in the indices today are shown in Table 1.

Table 1. Most Traded Cryptocurrencies in Indices

Number	Name	Code
1	Bitcoin	BTC
2	Ethereum	ETH
3	Tether	USDT
4	BNB	BNB
5	Solana	SOL
6	USCD	USCD
7	XRP	XRP
8	Dogecoin	DOGE
9	Tron	TRX
10	Toncoin	TON

Source: (Coinmarket, 2024).

Cryptocurrencies, especially Bitcoin, are seen as an important technological innovation and have many advantages. In addition, the rise of the digital economy and the high return potential of cryptocurrencies direct new investors to this field (Aksoy et al., 2020). However, it is seen in swot analyses that cryptocurrencies, which are attracting more and more attention worldwide and have become an attractive currency, have weaknesses such as a lack of account security, use in money laundering, and threats such as a lack of centralized management and the inability to register accounts by name (Çetinkaya, 2018). One of the most important weaknesses of cryptocurrencies is that they do not have a complete legal framework and are sometimes used informally. The fact that they have reached a size of 600 billion dollars worldwide makes it necessary for countries to review policies and regulations regarding these currencies (Şahin, 2024).

Cryptocurrencies, whose trading volume is increasing day by day, are emerging as a new generation investment instrument. There is a greater need for tools that can guide investors regarding these assets, where savings are channeled with the motive of investment. For this purpose, the applicability of the index model, which is widely used in stock markets and includes risk measurements, in cryptocurrencies has been investigated. If an index created based on the data in cryptocurrencies can reflect the characteristics of the market, this index will significantly guide investors in determining their risk levels. As a matter of fact, if this indicator, which is expressed as a beta coefficient in stock markets, can be calculated for cryptocurrencies, investors will be able to use this variable to measure the risk level. On the other hand, the calculated index value will be able to guide investors by estimating the index instead of cryptocurrencies, which are quite high in the market.

3. Empirical Application

Considering that the trading volume of crypto assets for investment purposes is increasing day by day, it is more and more important to identify the factors that can be technically determinative for these assets. Developing an index that can be a risk level indicator for these assets and represent the market may benefit investors in their decision-making processes. For this purpose, an index that can both represent the crypto asset market and be used to measure the risk level has been developed in this study. Instead of a single index, three alternative indices were developed and compared, and the findings are presented in the study. On the other hand, empirical studies on the subject are presented below.

3.1. Literature Review

Cryptocurrencies, which emerged in recent years alongside advancements in digital technologies, have quickly gained a substantial presence in financial markets, attracting the attention of investors. Thanks to their high return potential, decentralized structure, and global accessibility, cryptocurrencies have become an alternative to traditional investment instruments and are now part of many investors' portfolios. This has sparked increased interest among researchers and paved the way for studies on various topics related to cryptocurrencies. Since the emergence of Bitcoin in 2009, when cryptocurrencies began trading in the markets, the number of academic studies examining the impact of cryptocurrencies on the global financial system has rapidly increased. These studies, available in national and international literature, cover a wide range of topics. These include the efficiency of Bitcoin as an asset and the cryptocurrency market. They also examine the relationship between cryptocurrencies and exchange rates, gold prices, and stock market indices, as well as the interactions among these variables. Additionally, the studies explore the impact of cryptocurrencies on the global economy and markets, along with their volatility characteristics.

Studies addressing the efficiency of the cryptocurrency market (Kurihara and Fukushima, 2017; Bariviera, 2017; Khuntia and Pattanayak, 2018; Özkan and Şahin, 2020; Münyas and Aydın, 2023) generally assess financial risks and market efficiency through implications for future price movements. Research investigating the relationship between cryptocurrencies and exchange rates (Dyhrberg, 2016; İçellioğlu and Öztürk, 2017; Chu et al., 2017; Koç and Çaykara, 2021) demonstrates the potential of these assets as tools for portfolio diversification and hedging. Studies on gold prices (Klein et al., 2018; Henriques and Sadorsky, 2018; Jareno et al., 2020; Akkuş, 2023; Xu and Kinkyo, 2023) analyze whether Bitcoin possesses safe haven properties. Research examining interactions with stock market indices (Öget and Kanat, 2018; Wang et al., 2020; Gökalp, 2022; Atabey and Karakuş, 2022) reveals the correlations of cryptocurrencies with stock markets, while studies on relationships with altcoins (Akçalı and Şişmanoğlu, 2019; Canh et al., 2019; Kim et al., 2021; Ay and Adıyaman, 2022; Kara and Demireli, 2023) investigate the leadership effect and price propagation mechanisms within the market. Finally, studies addressing the volatility structure (Kazova and Büyükyılmaz Ercan, 2021; Büberkökü, 2021; Gubadlı and Sarıkovanlık, 2023; Chen and Sun, 2024; Özdemir, 2025; Kaya, 2025) analyze the structure, dynamics, and changes over time of volatility in cryptocurrency markets.

The aim of this study will be to comparatively examine the applicability of index models in cryptocurrency markets through numerical simulations and traditional methods, and to assess the extent to which these methods accurately represent market dynamics. Therefore, upon examining the existing literature, we find that academic studies addressing the theoretical framework and mathematical modeling for the creation of cryptocurrency indices are limited, while a few studies on cryptocurrency indices exist in the international literature (Trimborn and Hardle, 2018; Chowdhury et al., 2020; Shah et al., 2021; Hausler and Xia, 2022). Cryptocurrency indices enable quick and practical tracking of the general market trend rather than analyzing cryptocurrencies individually. Furthermore, they allow investors to diversify their crypto portfolios without increasing the level of risk during the portfolio construction process (Shah et al., 2021). However, the very limited coverage of these indices, which serve as benchmarks and reference points for investors, represents a significant gap in the literature. In this context, our study aims to fill this gap and offers an original contribution that comprehensively and

comparatively addresses the applicability of index models in cryptocurrency markets using both traditional and numerical simulation methods.

3.2. Data Set and Method

This study investigates an index model that can determine the risk level of crypto assets for investors. For this purpose, six different crypto assets from the crypto market were used to create the index. Three other crypto assets were also used as test data. The main reason for this is that the number of crypto assets is quite high, and this number is increasing day by day. Another reason is the high volatility of crypto assets, which are still in their infancy. In the study, the data between 01.01.2023-16.10.2024 are considered as daily opening values. Data definitions and abbreviations are presented in the table below;

Table 2. Data Definition and Abbreviation

Data Definitions	Abbreviations	Sources
Data used in indexing		
Bitcoin	Btc	investing.com
Ethereum	Eth	investing.com
Solana	Sol	investing.com
Ripple	Xrp	investing.com
Dogecoin	Dog	investing.com
Tron	Trx	investing.com
Calculated index value	Total	-
Percentage change in calculated index value	Deltatotal	-
Data used for control		
Stellar	Ste	investing.com
Avalanche	Ave	investing.com
Polkadot	Pdt	investing.com

Three different methods were used for indexing the data in Table 2, and as a result, three different indices were obtained. In order to reveal the relationship between the index values obtained and the control variables, their distribution is shown on the graph. In addition, correlations between each index and each control variable were calculated. In addition to all these, in order to observe the level of risk, "beta" coefficients, which are generally accepted risk indicators in the financial market, were calculated, and all findings are presented in the study.

3.3. Analysis and Findings

Although the study differs methodologically at the point of index calculation, the procedures after the calculation of each index involve the same process. The methodology used in each index calculation is presented separately in the study under subheadings.

3.3.1. Index Method with Weighting and Its Relationship with the Market Index

Although indexation is a widely used method in economic life, it basically means fixing the data of a population containing similar characteristics. The most commonly used method is to determine the index value by taking into account the weight of each variable in the population.

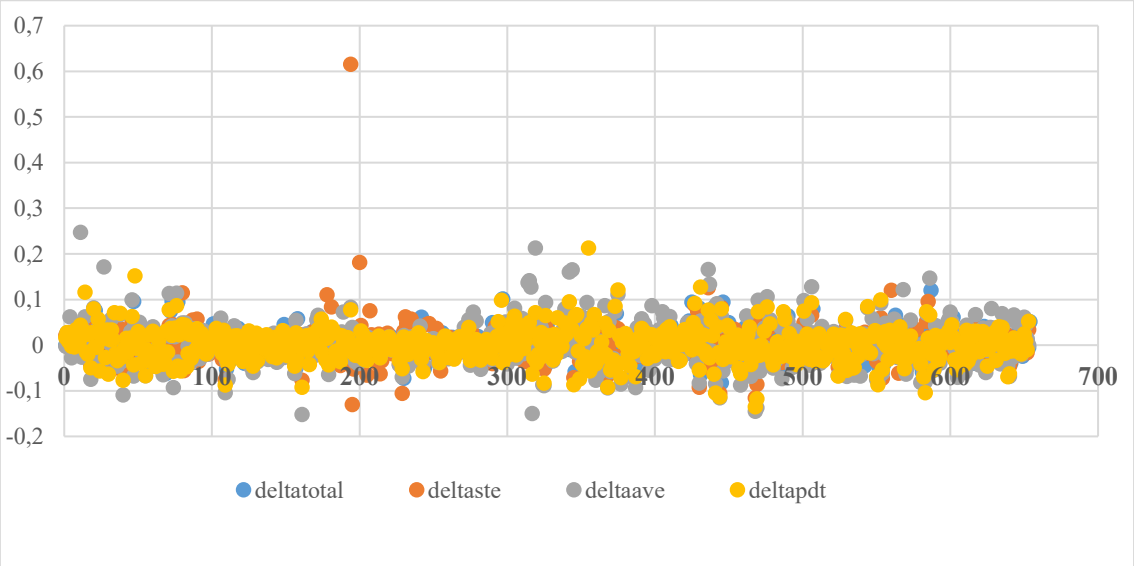
Our first index for crypto assets was obtained by this method and was obtained by summing the raw values of the crypto assets included in the index calculation in proportion to their weights. No action was taken to minimize the index value. Then, in order to determine the relationship between our control variables and this index value, the percentage change of both the index value and our control variables was calculated. On the other hand, the notation used for the index is as follows;

$$total: w.btc + w.eth + w.sol + w.xrp + w.dog + w.trx \quad (1)$$

w: weight,

$$deltatotal: total_n - total_{n-1} \,/total_n \quad (2)$$

These final data are presented in the Graph 1. When analyzing Graph 1, it is observed that the deviation of the variables in the analytical plane is quite low. This indicates that the change in the calculated index value and the change in the control variables are in very high agreement with each other. In other words, the movements of the index are highly correlated with the movements of the control variables, which enhances the reliability of the analysis.



Graph 1. Weighting Method Index and Control Variables

A low deviation serves as an important indicator for investors. This situation suggests that the index accurately reflects market conditions and risk levels. Since the calculated index value is obtained using a weighting method, it can be argued that the values determined by this method better represent market dynamics.

Investors can use such an index to gain a better understanding of the overall market condition and manage their risks more effectively. For instance, a high index value may indicate that the market is performing strongly, signaling investors to evaluate this situation. Conversely, a low index value may suggest that the market is weak, indicating that investors should exercise more caution.

Moreover, the high correlation of the index with the control variables allows investors to face less uncertainty when making strategic decisions. This enables them to make more informed and knowledge-based choices. In conclusion, the findings in Graph 1 highlight the significance of the calculated index as a crucial tool for market analysis and risk management. It is clear that such indices will assist investors in evaluating market conditions and shaping their strategies accordingly. Additionally, the notations for correlation and beta coefficient are as follows;

For correlation:

$$r = (n(\sum xy) - (\sum x)(\sum y)) / \sqrt{\left[(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)\right]} \quad (3)$$

For beta coefficent:

$$\beta = Cov(X,Y)/Var(X) \quad (4)$$

The correlation and beta values calculated between the index value calculated with the weighting method and the control variables are also presented below. Table 3 illustrates that the correlation value between the variables is notably high. This strong correlation indicates a significant relationship between the calculated index value and the control variables. The presence of this finding is crucial, as it suggests that the beta coefficient can be computed, and the calculated beta coefficients serve as essential risk indicators for investors.

Table 3. Correlation and Beta Coefficients Between Index and Control Variables

Variables	Beta Coefficents	Correlation Coefficient
For Ste	0.7405	0.4940
For Ave	1.1779	0.6565
For Pdt	0.9712	0.6938

The beta coefficient is a statistical measure that reflects the sensitivity of a security's returns to the overall market returns. In this context, the beta coefficient, which is derived by analyzing the relationship between the relevant variables, quantifies how the control variable responds to changes in the index. A beta value greater than one indicates that the control variable is more volatile than the market, while a beta value less than one suggests that it is less volatile. This characteristic makes the beta coefficient a valuable tool for investors seeking to understand the risk associated with their investments.

For investors, the beta coefficient is an important indicator as it helps in assessing the potential risk and return of an asset relative to the market. In traditional finance, it is widely used in the stock market to evaluate the risk profile of individual stocks or portfolios. However, the applicability of the beta coefficient is not limited to equities; it can also be effectively utilized in the context of cryptocurrencies, as demonstrated by the index calculated above.

The integration of the beta coefficient into cryptocurrency analysis provides investors with a more nuanced understanding of how these digital assets behave in relation to market movements. Given the unique characteristics of cryptocurrencies, such as their high volatility and rapid price fluctuations, the beta coefficient can offer insights into the risk dynamics of these assets. By incorporating the beta coefficient into their investment strategies, investors can make

more informed decisions, balancing their portfolios according to their risk tolerance and market expectations.

3.3.2. Index Method with Standardization and Market Relationship with Market Index

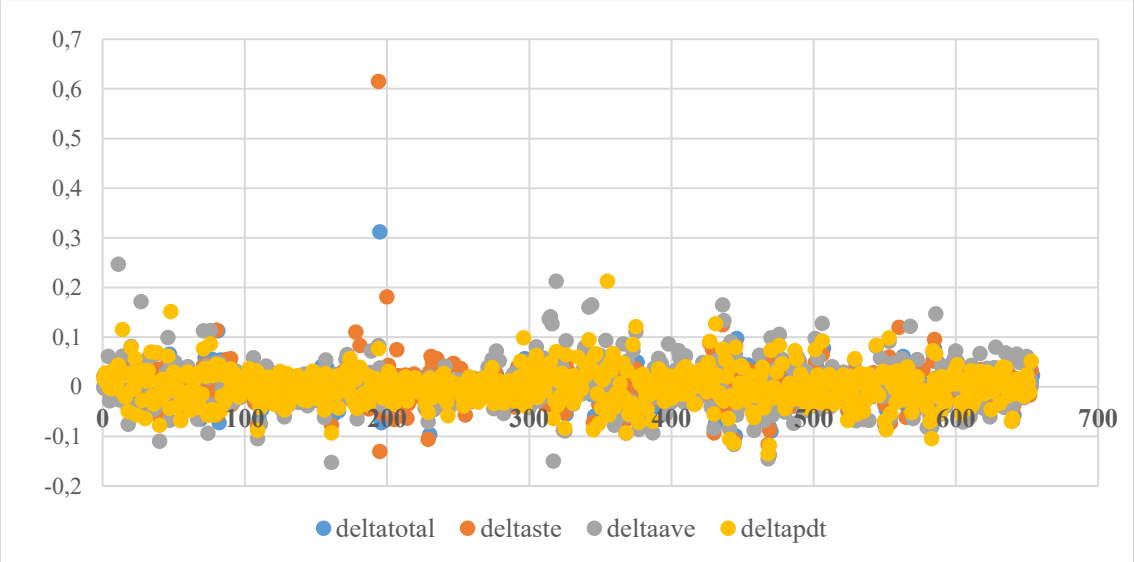
The technique used in index construction by standardization is to revise the variables to be used for the index on the scale of their standard deviation and use these values. The standard deviation of the variables is first calculated, and then new values are created by dividing each variable by its standard deviation. These values were taken into account when calculating the index. The advantage of this method over the weighting method is that the series is approximated to a normal distribution on a certain scale. This is because, as the distribution includes normalization, the detection of the relationship between variables will be stronger.

On the other hand, the notation used for the index is as follows;

$$total: btc/s + eth/s + sol/s + xrp/s + dog/s + trx/s \quad (5)$$

s: standard deviation,

$$deltatotal: total_n - total_{n-1}/total_n \quad (6)$$



Graph 2. Standardization Method Index and Control Variables

The relationship graph between the index value calculated with this method and the control variables is presented in Graph 2. When Graph 2 is examined, it becomes apparent that there is a strong relationship between the changes in the index value obtained through standardization and the changes in the control variables. This high correlation indicates that the movements of the index are closely aligned with the fluctuations of the control variables, suggesting that they are influenced by similar underlying factors. The graph illustrates that, despite some small deviations, the variables exhibit a consistent pattern of overlap. This regularity in their behavior enhances the reliability of the standardized index value, making it a valuable tool for analysis. The close

alignment between the index and the control variables implies that the standardized index effectively captures the dynamics of the market, providing insights that can aid investors in making informed decisions.

Moreover, the validity of the standardized index value is further supported by its similarity to the index value calculated using the weighting method. Both approaches yield index values that reflect the underlying trends and movements of the control variables, reinforcing the notion that these indices can serve as reliable indicators of market behavior. To deepen the understanding of the relationship between the index and the control variables, the beta coefficient and correlation coefficient for the standardized index value are presented Table 4.

Table 4. Correlation and Beta Coefficients Between Index and Control Variables

Variables	Beta Coefficents	Correlation Coefficient
For Ste	1.1412	0.8100
For Ave	1.0866	0.6444
For Pdt	0.9532	0.7241

Table 4 presents a compelling analysis of the correlation relationships among the variables, revealing that the correlation values are notably high. This strong correlation indicates that the variables are closely related and that changes in one variable are likely to be associated with changes in another. Among the control variables, the highest correlation value is attributed to the ste control variable, suggesting that it has a significant influence on the overall dynamics of the index. This finding underscores the importance of understanding the interrelationships among the variables, as they can provide valuable insights into market behavior and trends.

Furthermore, it can be asserted that the calculated index value derived from this analysis contains stronger findings compared to the index value calculated using the weighting method. The enhanced robustness of the calculated index suggests that it may be better equipped to capture the underlying patterns and fluctuations in the market. This improvement in the index's predictive power can be attributed to the methodology employed in its calculation, which appears to account for the relationships among the variables more effectively. As a result, investors may find this index to be a more reliable tool for assessing market conditions and making informed investment decisions.

In addition to the correlation findings, the calculated beta coefficients for the index are also higher than those derived from the previous weighting method. This increase in beta coefficients indicates a greater sensitivity of the index to changes in the market, suggesting that the index may exhibit more pronounced volatility in response to fluctuations in the control variables. A higher beta coefficient can be interpreted as a signal of increased risk, which is crucial information for investors as they evaluate their portfolios. Overall, the insights gained from Table 4 highlight the significance of the calculated index and its beta coefficients, reinforcing the notion that this approach provides a more nuanced understanding of market dynamics and risk assessment.

3.3.3. Index Method with Numerical Simulation and Market Index and Market Relationship

Numerical simulation is a common method that significantly contributes to increasing sample size and is used to predict possible alternative scenarios in areas relying on historical data. In this study, one of the main reasons for using this method in index calculation is to determine which method yields more favorable results by making a comparison. Numerical simulation was performed in the R Studio program, and new values were generated by allowing the standard deviation of the variables whose technical infrastructure is relevant to the study to oscillate on a certain scale. In the study, the standard deviation was allowed to oscillate randomly between 0 and 1, and 100 random values were generated as simulations. The index was then calculated by averaging these values. On the other hand, the notation used for the index is as follows;

$$nrand.\delta btc = nbtc, nrand.\delta eth = neth, nrand.\delta sol = nsol,$$
$$nrand.\delta xrp = nxrp, nrand.\delta dog = ndog, nrand.\delta trx = ntrx \quad (7)$$

ňrand: Set of random numbers,

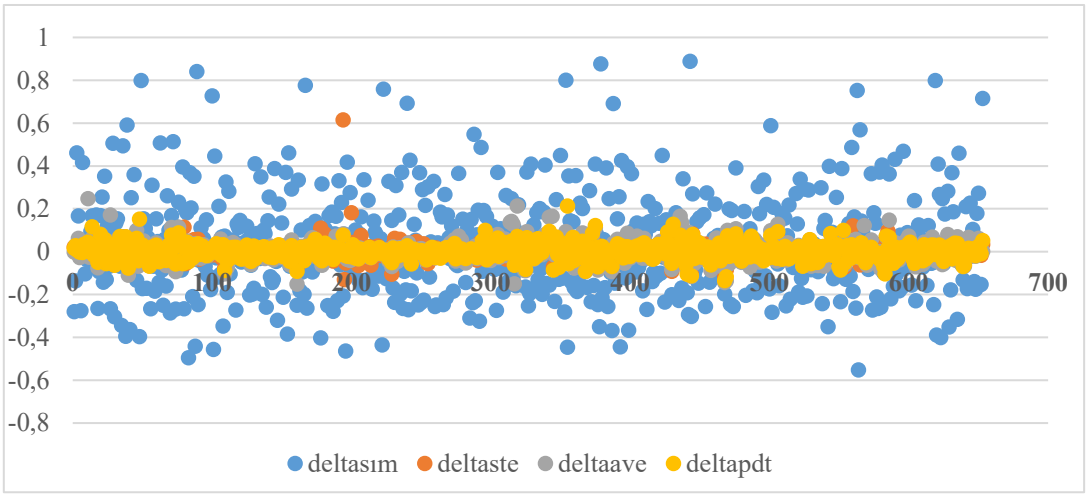
δ standard deviation

$$simbtc = nbtc.btc/100, simeth = neth.eth/100,$$
$$simsol = nsol.sol/100, simxrp = nxrp.xrp/100, \quad (8)$$
$$simdog = ndog.dog/100, simtrx = ntrx.trx/100$$

$$total: simbtc + simeth + simsol + simxrp + simdog + simtrx \quad (9)$$

$$deltatotal: total_n - total_{n-1}/total_n \quad (10)$$

The change in the calculated index and the change in the control variables are presented in Graph 3.



Graph 3. Numerical Simulation Method Index and Control Variables

Graph 3 illustrates that the changes in the index and the changes in the control variables are distributed in a notably different manner. This lack of correspondence between the two sets of data suggests that the movements of the index do not align with those of the control variables,

indicating a disconnect in their relationship. Furthermore, the standard deviation of the change in the index is quite high, which adds another layer of complexity to the analysis. While a high or low standard deviation of the calculated index variable does not inherently determine its applicability for control variables, the observed mismatch in distribution raises concerns about its usability in this context.

One of the primary reasons for this situation may stem from the characteristics of crypto assets, particularly those that allow futures trading. These assets often exhibit lower volatility compared to traditional assets, which can lead to a narrower range of price movements. However, the distribution of the index may contain a higher bandwidth due to oscillations resulting from numerical simulations. This discrepancy in distribution patterns suggests that the index may not effectively capture the dynamics of the control variables, thereby limiting its utility for analysis and decision-making.

In contrast, the correlation and beta coefficients for the index value calculated through numerical simulation are presented in Table 5. These coefficients provide valuable insights into the relationship between the index and the control variables, as well as the sensitivity of the index to market changes. By examining these metrics, investors can gain a better understanding of the risk dynamics associated with the index and its potential implications for their investment strategies. Overall, while Graph 3 highlights the challenges in using the index for control variables, the information in Table 5 can help contextualize these findings and guide future analyses.

Table 5. Correlation and Beta Coefficients between Index and Control Variables

Variables	Beta Coefficents	Correlation Coefficient
For Ste	0.0058	0.0354
For Ave	0.0216	0.1095
For Pdt	0.0117	0.0763

Table 5 clearly shows that the correlation coefficients between the index and the control variables are quite low. This calls into question the index's relationship with the control variables and reveals the weak interaction between these variables. Low correlation coefficients indicate that the index does not effectively reflect market dynamics and therefore may not be a reliable indicator for investors. In this context, the presence of the beta coefficient with low correlation values indicates its limited value in measuring the index's sensitivity to market movements. The beta coefficient is often used to determine how responsive an asset or index is to market fluctuations; however, in this case, due to low correlation, the information provided by the beta coefficient can be misleading for investors. This finding demonstrates that numerical simulation methods are less effective than other methods used in creating indexes for crypto assets.

Although the development of an index for crypto assets may provide positive contributions in terms of guiding investors, the method of developing an index for crypto assets is also an important research question. When the findings are taken as a whole, it is revealed that the index values calculated with the weighting method and the standardization method are statistically highly significant. On the other hand, numerical simulation, which is widely used, does not provide a valid result. In addition to the index calculation for crypto assets, beta coefficients and

correlation coefficients are also presented in the study. When the findings are examined, it is seen that the best result belongs to the index calculated by the standardization method.

4. Conclusion

This study on cryptocurrencies makes a significant contribution to the literature by demonstrating the applicability of index models. One of the primary challenges faced by investors in the cryptocurrency market is the uncertainty surrounding risk levels. Given that the value of cryptocurrencies, particularly those other than tokens, is determined solely in fiat currencies, an indicator of risk level serves as a critical guide for investors. In this context, the indices developed in this study have the potential to provide valuable insights into the overall market conditions.

As a result of the analysis, three distinct indices have been developed. The first index was calculated using a weighting method, revealing a strong correlation with control variables. The second index was created through standardization, and its compatibility with control variables was found to be quite high. The third index, calculated using numerical simulation, did not establish a statistically significant relationship with control variables. While numerical simulation can reveal the intrinsic characteristics of the data, it has proven ineffective in calculating indices related to cryptocurrencies. One reason for this may be that cryptocurrencies are subject to futures transactions, and the large number of market participants creates conditions of near-perfect competition.

This study fills a gap in the literature by providing evidence that index models can be applied to cryptocurrency assets. Previous research, including studies by Trimborn and Hardle (2018), Chowdhury et al. (2020), Shah et al. (2021), and Hausler and Xia (2022), has demonstrated the feasibility of applying index models to cryptocurrencies using machine learning and statistical methods. Adapting the index model to cryptocurrencies will enable investors to gain more information about market trends, allowing them to better assess risk levels. Furthermore, cryptocurrency exchanges can leverage their technological infrastructure to produce and disseminate this information to investors.

Exchange-like structures that facilitate cryptocurrency trading or countries that actively utilize cryptocurrencies can adopt the index or a similar framework presented in this study. In the rapidly growing cryptocurrency market, where individual participation is increasing daily, the existence of an index can serve as a valuable guide for those who may be less informed about the subject. Knowledgeable investors will also benefit from deeper insights into the direction of the cryptocurrency market and the associated risk levels. Therefore, promoting the use of an index for cryptocurrencies is of paramount importance.

Cryptocurrency investors will be able to anticipate the relationship between the cryptocurrency they invest in and the index through the index model. A high beta coefficient calculated specifically for the index indicates a high level of risk, while a low beta coefficient signifies a lower risk. In other words, cryptocurrencies with a high beta coefficient respond more strongly to changes in the index. On the other hand, investors can optimize their investment choices by predicting changes in the index. This application could evolve into a structure similar to the widely accepted index model in stock markets. In the future, indices developed specifically for cryptocurrency assets may even be considered as an investment instrument.

In conclusion, the indices developed for cryptocurrencies are expected to play a crucial role in the decision-making processes of investors. As a policy recommendation, it is essential to encourage collaboration between cryptocurrency exchanges and relevant regulatory bodies to facilitate the development and dissemination of such indices. Additionally, to raise investor awareness, educational programs and informative materials should be prepared. This initiative will not only enhance market transparency but also improve investors' risk perception.

To further elaborate, the implementation of educational programs could include workshops, webinars, and online courses that cover the fundamentals of cryptocurrency trading, risk management strategies, and the interpretation of index data. These programs should be tailored to different levels of investor knowledge, from beginners to more experienced traders, ensuring that all participants can benefit from the information provided.

Moreover, the creation of a standardized framework for the calculation and reporting of cryptocurrency indices would enhance credibility and trust among investors. Regulatory bodies could play a pivotal role in establishing guidelines for index construction, ensuring that they are based on robust methodologies and transparent data sources. This would not only protect investors but also foster a more stable and reliable market environment.

Finally, ongoing research into the dynamics of the cryptocurrency market and the effectiveness of index models should be encouraged. This could involve collaboration between academic institutions, industry experts, and regulatory bodies to continuously refine and improve the methodologies used in index construction. By fostering a culture of research and innovation, the cryptocurrency market can evolve in a way that benefits all stakeholders involved.

Declaration of Research and Publication Ethics
This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement
The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest
There is no potential conflict of interest in this study.

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