EGARCH Model: Volatility Spillover Analysis of Bitcoin Price on Altcoin and S&P 500 Index

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Abstract

This study aims to analyze the effect of Bitcoin price spillover volatility on Altcoin prices (Ethereum, Tether, Binance Coin) and the price of the S&P 500 Index. The data used is weekly data with a research period from January 2018 to December 2022. The analysis used in this study is the Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model. The results show a volatility spillover effect between Bitcoin and Binance Coin with more positive shocks than adverse shocks in Bitcoin price volatility on Binance Coin price. Meanwhile, the spillover volatility between Bitcoin and Ethereum, Tether, and the S&P 500 Index cannot be known because the price data is homoscedastic, so it cannot be continued with EGARCH modelling because the data needs to meet the modelling requirements.

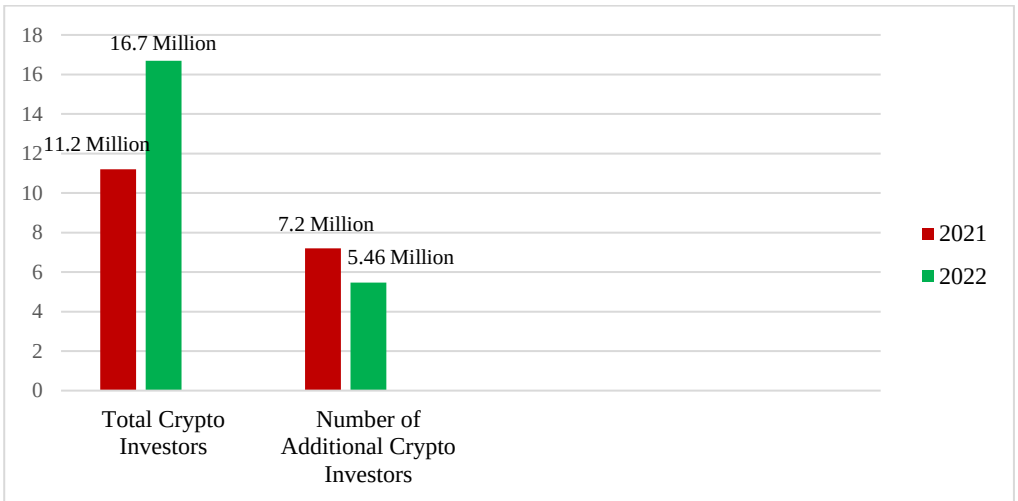
Keywords: EGARCH, Altcoin, Bitcoin, S&P 500 Index, Volatility

I. INTRODUCTION

The rapid development of technology has encouraged the process of digitalization in various aspects of people's lives. Similarly, the development of the world economy in Indonesia must be kept from technology. Technology will be interconnected with all fields, including finance. One form of technological development today is the existence of digital currencies that can replace paper currencies in transactions in the future [1]. A digital currency that is currently popular is cryptocurrency. Meera [2] cryptocurrency is digital money created with advanced cryptographic technology.

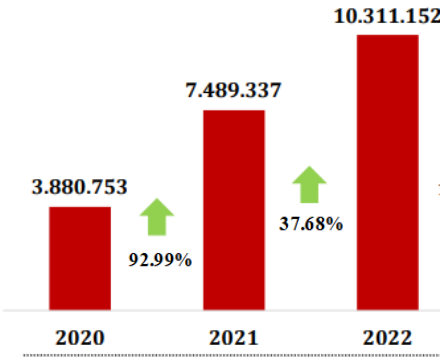
In 2008, a person used the pseudonym Satoshi Nakamoto [13]. He was the first to invent cryptocurrency. One of the oldest cryptocurrencies is Bitcoin. Bitcoin was found to be less than perfect, so Altcoins were born. Altcoins are all cryptocurrencies other than Bitcoin, such as Ethereum, Tether, Binance Coin, and others.

Figure 1. shows data reported by the Commodity Futures Trading Supervisory Agency that in 2022, the number of crypto investors in Indonesia increased by 5.46 million people. The addition is lower when compared to 2021, with 7.2 million people. By December 2022, the number of registered crypto investors was 16.7 million. This is an increase of 44.64% from the previous year. The number of crypto transactions amounted to IDR 306.4 trillion in 2022. Figure 2. shows that in 2022, the number of investors in the capital market was 10.31 million people. This indicates that the number of investors in crypto assets is more when compared to the number of investors in the capital market.



Source: https://dataindonesia.id

FIGURE 1. Number Of Registered Investors Of Crypto Assets In Indonesia



Source: https://www.ksei.co.id

FIGURE 2. Number Of Investors In The Capital Market

With the rapid development of crypto, crypto is often used as a medium of crime in the form of money laundering or illegal transactions. This is because crypto is anonymous, where users do not use their real identity, and no institution regulates it. CNBC Indonesia reported that Rafael Alun Trisambodo, a former Directorate General of Taxes of the Ministry of Finance employee, was named a suspect in an alleged Money Laundering Crime (TPPU). Some money was transacted to buy crypto assets in Bitcoin [4]. This impacted the value of crypto asset transactions in April 2023, which decreased by 14.15% from the previous month [5].

Crypto investors can get high profits in a short period but can also experience losses. In a case reported by Choo & Lim [6], an investor lost his money by 90% of the total investment in crypto assets and suffered losses of up to $2.3 million, making the investor depressed and suicidal. The crypto market tends to be more volatile than other investments, so it has high volatility and risk levels. The level of adaptation of crypto investors is also heavily influenced by Fear of Missing Out (FOMO) and not understanding the characteristics of their crypto assets, so investors only apply them as speculative assets. Therefore, before deciding to invest, investors must understand the features of the investment and the level of risk, and a strong mentality is also needed.

One crucial factor of investing is to pay attention to the high and low volatility. The higher the volatility, the higher the risk that investors will get. Volatility occurs in crypto. As of mid-January 2022, the price of Bitcoin decreased by 6.25% in a day and by 15.19% in 7 trading days. Other cryptocurrencies also experienced a decline, such as Ethereum, which fell by 10.22% daily and by a 22.28% decrease in 7 trading days. Tether has reduced by 0.01%, while Binance Coin has decreased by 9.91% daily and by 21.53% in 7-day trading [7]. Bitcoin's price volatility can affect other altcoins or cryptocurrencies, called a spillover [8].

The price movements of crypto assets also correlate with other assets, especially the S&P 500 Index. The S&P 500 Index comprises 500 companies in the United States with the largest market capitalization. The results of the analysis conducted by Palguna [9] explain that there are days when Bitcoin and the S&P 500 Index reach a correlation of +0.97. It shows that Bitcoin and the S&P 500 Index are positively correlated, as seen from the direction of movement of both Bitcoin and stocks, which are also treated as substitutes by investors. A decrease in the S&P 500 Index will encourage investors to sell stocks and replace them with Bitcoin [10]. Therefore, investors must also pay attention to crypto price movements with the S&P 500 Index because they are correlated.

This study aims to determine how much influence volatility spillover has and analyze the impact of shocks (positive/negative) that occur between Bitcoin with Altcoin (Ethereum, Tether, and Binance Coin) and the S&P 500 Index. Therefore, this study chose the EGARCH method because the model is the best. After all, it has the advantage of not having stationary conditions and not worrying about heteroscedasticity [11]. The EGARCH model can also provide good estimation results when the data is asymmetric or not normally distributed. Another reason for using the EGARCH model is that the Binance Coin and S&P 500 Index variables have yet to use the model in previous studies. Thus, it inspires researchers to conduct further research.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A. Cryptocurrency

Cryptocurrency is a digital currency system that functions like a common currency, where users can make payments for business transactions online. Cryptocurrency uses blockchain technology. Blockchain is a technological system that organizes and manages all cryptocurrency transaction data, making it challenging to manipulate every transaction. Blockchain technology can guarantee the security of cryptocurrencies so that they cannot be stolen or counterfeited [12]. Cryptocurrency has characteristics including physical intangibility, no owner data, and uses a peer-to-peer system or directly between users. In addition, cryptocurrency is decentralized, meaning that it does not have an official central institution that regulates its printing and circulation to be able to handle it.

According to Nubika [12], Cryptocurrencies have advantages and disadvantages. The benefits of cryptocurrency are that it can transact quickly at a lower cost, can be done anywhere and anytime, there is no third party as an intermediary when transactions are, and it cannot be falsified because the security standards are based on cryptography. Cryptocurrency can also be used for online shopping, bill payments, and investment assets. Meanwhile, the disadvantages of cryptocurrency are very high price fluctuations, often used as a medium for money laundering crimes and illegal transactions because crypto users do not use real identities. If there is theft of the cryptocurrency balance, the traces of theft are difficult to track, and if there is an excess of the amount sent or the wrong sender's address, the transaction that has been made cannot be cancelled.

B. Bitcoin

Bitcoin is a cryptocurrency that was first introduced by Satoshi Nakamoto in 2008. Bitcoin is a digital currency that allows people to make transactions with each other without going through a third party. Bitcoin can run on a peer-to-peer network. A peer-to-peer network is a structure where every network member is equal, and no centralized server exists. Bitcoin users can transact without using their real identity. Bitcoin implements a proof-of-woo mechanism that is used to minimize double-spending. Double spending is when the identical Bitcoin makes two different transactions. The parties related to the Bitcoin system are nodes, miners, and users.

Bitcoin has several advantages and disadvantages. The benefits of Bitcoin are that it can reach all places so that transactions between countries can be done quickly and minimize double-spending. If double spending occurs, the system will accept the first transaction sent to the network. Therefore, the Bitcoin system can confirm only one transaction. In addition, Bitcoin has a low transaction fee of 10.000 satoshi or in rupiah of IDR 500 for each transaction. Bitcoin can also receive up to 7 transactions per second, which can be confirmed in about 10 minutes. Bitcoin has disadvantages, including 51% attacks (attacks into the Bitcoin network and blockchain) and denial of service (attacks by filling servers with thousands to millions of data requests). In addition, Bitcoin mining requires more electrical energy to power electronic equipment [3].

C. Altcoin

Altcoin is an alternative coin, a crypto alternative to Bitcoin. The emergence of Altcoin aims to perfect the shortcomings of Bitcoin and complement the features that still need to be added to Bitcoin. The difference between Altcoin and Bitcoin is that Altcoin uses a proof of stake model that can save energy when creating blocks and validating new transactions. Altcoin also uses particular cryptography to maintain its users' anonymity, while Bitcoin is more pseudonymous than anonymous. Altcoin has the advantage of using intelligent contract features. The downside of Altcoin is that making Altcoin costs more [14].

D. Ethereum

Ethereum was created and developed by Vitalik Buterin starting in 2013 and officially launched in 2015 [15]. Ethereum is a network that uses blockchain technology, just like Bitcoin. The coin on Ethereum is called Ether. Ethereum has the advantage of being able to run smart contracts. Ethereum has pioneered the concept of an innovative contract blockchain platform. Competent contact is a computer program contact contained in the Ethereum blockchain that can be executed automatically when certain conditions are met. The advantage of smart contracts is that they can carry out various types of transactions automatically [16]. Ethereum developed an Ethereum Virtual Machine (EVM) that allows anyone to create a decentralized application (DAPP). Once the application is completed, the EVM will standardize the programs it can function on the Ethereum network [17]. In addition, Ethereum also has disadvantages, such as high processing costs when sending transactions on the Ethereum network to Ether.

E. Tether

Tether is a stablecoin cryptocurrency. A stablecoin is a cryptocurrency considered stable, and its value depends on tangible assets, such as gold, the US dollar, and so on. As a stablecoin, Tether is used to stabilize the price of other higher cryptocurrencies. Tether was created by the company Tether Limited in 2014. The company guarantees that real US dollars will cover every coin circulating in the market, so the coin's value will not be affected by price fluctuations. Tether can be used as a medium of exchange on cryptocurrency or online payment platforms. Tether has several advantages, such as its stable value and not affected by price fluctuations. Tether also has the disadvantage that its value can depreciate, and its usefulness is limited because it is only used as a medium of exchange on various cryptocurrency platforms [18].

F. Binance Coin

Binance Coin was released through an Initial Coin Offering (ICO) 2017 for 15 cents per token. Binance Coin can be traded in various assets on Binance, such as crypto, tokens, or other digital assets. The blockchain technology used by Binance Coin is Binance Chain, which increases transaction efficiency and speed. Binance Coin also has an innovative contract feature that can be used to make automatic transactions or manage an asset

called the Binance bright chain [16]. Binance Coin has the advantage of discounted transaction fees for Binance users. This coin is also used to buy various digital assets on the Binance platform, such as other cryptocurrencies, tokens, and other digital assets. Binance Coin also has the disadvantage that its price depends on the sustainability of Binance's performance. If Binance's performance decreases, the price of Binance Coin will also decrease.

G. S&P 500 Index

The S&P 500 Index is a market capitalization-weighted index of the 500 largest public companies in the United States based on market value [19]. The S&P 500 Index is used as one of the benchmarks to measure and assess how healthy equity and market performance are. Investors often use this index as a reference in analyzing market conditions and understanding investment asset movement and price trends using technical and fundamental indicator analysis.

The S&P 500 Index and cryptocurrency are investment assets with the principle of high risk and high return, meaning that the higher the profit level, the higher the risk of this type of investment. Crypto tends to be riskier than stocks because crypto has no tangible form or intrinsic value—crypto and the S&P 500 Index influence each other. When economic conditions are bad or the S&P 500 Index has decreased, investors will choose to secure their investments by moving their funds to crypto assets and reducing their investments in stocks. As a result, the demand and price of crypto assets will increase while the demand and price of stocks will decrease. When the price of crypto assets falls, and economic conditions begin to improve, investors will choose to invest in stocks so that the demand and price of crypto assets decrease while the demand and price of stocks increase.

H. Volatility spillover

Volatility measures price changes with a constant long-term level or trend, whereas volatility does not measure the direction of price changes. Still, it measures price variations around the average [20]. Volatility can be interpreted as unstable as indicated by a high increase, followed by a low decrease, and then back to high again. Volatility analysis can be used in price and portfolio formation to predict risk and risk management, significantly influencing investment decisions [21].

Spillover can be defined as the impact or contagious effect that can be caused when an event occurs. Volatility spillover is the impact or contagious effect that can be caused when an increase or decrease in a price can affect other asset prices. As in this study, we want to know the impact (positive/negative) that can be caused when there is an increase or decrease in the price of Bitcoin, which can affect the price of Altcoin and the S&P 500 Index.

I. Bitcoin Hypothesis with Ethereum

Aulia [8] and Pujiati [22] 's research results state a volatility spillover between the Bitcoin price and the Ethereum price. A positive shock from the Bitcoin price will increase volatility more on the Ethereum price than a negative shock. Angela & Sun's [23] research shows that Bitcoin significantly affects Ethereum, with a positive coefficient value obtained. Based on the explanation, the hypothesis in this study is:

H1: There is a positive relationship between Bitcoin price spillover volatility and Ethereum price

J. Bitcoin Hypothesis with Tether

The results of research by Pujiati [22] and Setiawati [24] state that the Tether variable cannot be proven because the variable price data is homoskedasticity, so it cannot be continued with the EGARCH model because it does not meet the modelling requirements. In contrast, Chen & Chang's [25] research concluded that Tether is slightly influenced by Bitcoin volatility and is positively related with a correlation that varies from +0.01 at the lowest point to almost +1 at the highest point. Based on the explanation above, researchers want to re-examine in a different period to find out whether Bitcoin price volatility affects the price of Tether or not. Based on the explanation, the hypothesis in this study is

H2: There is a positive relationship between Bitcoin price spillover volatility and Tether price

K. Bitcoin Hypothesis with Binance Coin

The results of Santosha & Mallick [26] state that the price of Bitcoin and Binance Coin affect each other, and the price of Binance Coin depends on the price of Bitcoin. During the Covid-19 pandemic, both are positively correlated, increasing to 0.84. Research conducted by Ciaian et al. [27] states that the price of Binance Coin is affected by natural shocks in the price of Bitcoin. Based on the explanation, the hypothesis in this study is:

H3: There is a positive relationship between Bitcoin price spillover volatility and Binance Coin price

L. Bitcoin Hypothesis with IndexS&P 500

The research results by Georgoula et al. [10] stated that Bitcoin is significantly negatively related to the S&P 500 Index. Research conducted by Conrad [23] concluded that S&P 500 volatility significantly negatively affects long-term Bitcoin volatility. Sovbetov's [29] research results state that the S&P 500 Index has a short-term

negative relationship with Bitcoin. Erdas & Caglar [19] concluded that a positive shock to Bitcoin causes a negative shock to the S&P 500 Index, and a negative shock to Bitcoin causes a negative and positive shock to the S&P 500 Index. Based on the explanation, the hypothesis in this study is:

H4: There is a positive relationship between Bitcoin price spillover volatility and the S&P 500 Index price

III. METHOD

The population of this study is cryptocurrency and the S&P 500 Index. This study used a purposive sampling technique in sampling. The samples used in this study are cryptocurrencies that occupy the top market cap based on dataindonesia. It consists of Bitcoin, Ethereum, Tether, Binance Coin, and the S&P 500 Index. The data used in this study are secondary in the form of daily data obtained through websites, namely www.coinmarketcap.com and www.investing.com. The daily data is converted into a weekly average from January 2018 to December 2022.

The volatility of the Bitcoin price, Ethereum price, Tether price, Binance Coin price, and the S&P 500 Index are measured using the closing price, then converted into return data with the following formula:

$$R_{it}=\frac{P_{it}-P_{it-1}}{P_{it}} \quad (1)$$

Where:
R_{it} = return cryptocurrency i, period t
P_{it} = closing price cryptocurrency i of period t
P_{it-1} = closing price cryptocurrency I of period t-1

The stages of data analysis in this study are:

1. Stationarity test (unit root test)

The stationary test is carried out to determine whether the research data is stationary. If the data is stationary, it will result in a better-estimated model. Therefore, in the initial stage, before conducting further analysis, stationary testing is carried out first using the Augmented Dickey-Fuller test developed by Dickey-Fuller.

The concept of the Augmented Dickey-Fuller test is that if the data is not stationary at zero order. To make the data stationary, it can be sought through the order at the nth order (first difference) or second difference [11]. The Augmented Dickey-Fuller Test formula is as follows:

$$\Delta Yt = \beta 1 + \beta 2 + \delta \Delta Yt\text{-}1 + \alpha 1 \Delta Yt\text{-}1 + \alpha 2 \Delta Yt\text{-}2 + \ldots + \alpha m \Delta Yt\text{-}m + \varepsilon t \quad (2)$$

Where:
α = constant
β = time trend coefficient
δ = hypothesis
m = length of lag used
Y = observed variable

The decision-making criterion is if the probability ≥ 0.05, the time series data is not stationary, but if the probability < 0.05, the time series data is stationary.

2. White test

To detect the presence or absence of heteroscedasticity in data using the white test and used as a test requirement with the EGARCH method [11]. The decision-making criterion is if prob. chi-square ≥ 0.05, there is no heteroscedasticity, but If prob. chi-square < 0.05, there is heteroscedasticity.

3. EGARCH Model

The EGARCH model was first introduced by Nelson (1991). In an EGARCH model, the smaller the Akaike Info Criterion (AIC) and Schwarz Criterion (SIC) values, the better. The advantage of the EGARCH model is that it does not have stationary conditions [11]. The data in this study are asymmetrical and in the form of time series data. Time series data which experiences high data volatility can cause heteroscedasticity problems that result in non-constant error variants. Therefore, there is a requirement that the variance and error are constant or homoscedastic to get accurate results. One of the models for analyzing time series data that does not question the existence of heteroscedasticity is the EGARCH model. Hence, the heteroscedasticity problem becomes an important factor in this study because it utilizes this condition in making a model. The EGARCH model can also provide good estimation results when the data is asymmetric or not normally distributed. The following is the specification for the conditional variance EGARCH model [11]:

$$n(\sigma^2 t)=\omega+\sum_{j=1}^{q}\beta_j \ln(\sigma^2 t)+\sum_{i=1}^{p}\alpha_i\left|\frac{\varepsilon_{t-i}}{\sigma_{t-1}}\right|+\sum_{k=1}^{r}y_k\frac{\varepsilon_{t-k}}{\sigma_{t-k}}$$

$$\ln(\sigma^2 t)=\omega+\beta_1\ln(\sigma^2_{t-1})+..+\beta_1\ln(\sigma^2_{t-q})+a_i\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right|+Y_1\frac{\varepsilon_{t-1}}{\sigma_{t-1}}+\ldots+\alpha_p\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right|+Y_r\frac{\varepsilon_{t-r}}{\sigma_{t-r}} \quad (3)$$

Where:
ln = natural log
β = coefficient log GARCH (GARCH effect of prior volatility.)
γ = asymmetric effect
α = impact of the shock or spillover effect
$\boldsymbol{\sigma^2}t$ = conditional variance
ω = intercept or constant

The left-hand side uses ln conditional variance. It indicates that the leverage effect is exponential, not quadratic. Using ln for the variance equation already guarantees the non-negative nature of the variance. γ indicates that asymmetric volatility has a positive or negative value. Suppose γ = 0, a negative or positive shock has the same impact. If γ < 0, a negative shock will increase volatility more than a positive shock. If γ > 0, a positive shock will increase volatility more than a negative shock.
The parameter value of the ARCH term consists of two parts [11]:

$$\text{magnitude effect}=\frac{\varepsilon_{t-1}}{\sigma_{t-1}} \quad (4)$$

$$\text{sign effect}=\frac{\varepsilon_{t-k}}{\sigma_{t-k}} \quad (5)$$

The magnitude effect shows how much influence the volatility in period t-p has on the current variance. The sign effect shows the difference in the impact of positive and negative shocks in period t on the present variance.

4. Diagnostics test

Diagnostics tests are carried out to determine whether the results of the EGARCH modelling test are good. The first diagnostic test, the serial correlation test, is carried out to determine the presence of autocorrelation or relationship (correlation) in the same data between times [11]. If the prob. chi-square value ≥ 0.05, there is no autocorrelation; if the prob. chi-square value <0.05, there is autocorrelation. Second, the ARCH effect test is conducted to test whether there is heteroscedasticity in the data. If the chi-square value ≥ 0.05, there is no ARCH effect, but if the chi-square value < 0.05, there is an ARCH effect. Third, the normality test is carried out to test whether an independent variable and a dependent variable have a normal or abnormal distribution in a regression model equation. A variable is normally distributed if the prob value. ≥ 0.05, but if the prob value. < 0.05, the data is not normally distributed.

IV. RESULTS AND DISCUSSION

Data stationarity testing is carried out before applying a research model to determine whether the data is stationary at the level, differencing 1 or differencing 2. Table I shows the results of ADF test processing at the level. Table I shows that the variables of Bitcoin, Ethereum, Binance Coin, and the S&P 500 Index have a probability> 0.05, so the data is not stationary at this level. The Tether variable has a probability of 0.000 <0.05, so the data is stationary at the level.

The next step is to conduct the Augmented Dickey-Fuller First Difference test to make all data stationary. The weekly average price data is converted into weekly returns according to the data type. Then, the first difference test, the Augmented Dickey-Fuller, was performed on the Bitcoin, Ethereum, Binance Coin, and S&P 500 Index variables. Table II shows the results of the Augmented Dickey-Fuller first difference test.

Based on Table II, the first difference, Augmented Dickey-Fuller (ADF) stationary test results, show that the variables Bitcoin, Ethereum, Binance Coin, and the S&P 500 Index have a prob value. 0.000 <0.05. It means that the data is stationary at the first difference level. After all the data is stationary, the white test is used to determine whether the data has heteroscedasticity. Table III shows the results of the white test.

Based on Table III. It shows that only the Binance Coin-Bitcoin variable has a prob. chi-square value <0.05. The data has heteroscedasticity properties so that the variable can be continued with EGARCH modelling.

Table IV shows that the Binance Coin-Bitcoin variable has an α value of 0.599018 and that the impact of the shock or spillover effect of Bitcoin on Binance Coin is 59.90%. This means that the increase and decrease in Bitcoin price volatility caused Binance Coin's price volatility by 59.90%. The value of γ in the Binance Coin-Bitcoin variable is 0.204059> 0, that a positive shock from the Bitcoin price will increase volatility more on the Binance Coin price than a negative shock. This means a positive shock is more than a negative shock to the Bitcoin price volatility on the Binance Coin price.

TABLE I. STATIONARITY TEST AT LEVEL

Variable	Prob Value.	Description
Bitcoin	0.6883	data is not stationary
Ethereum	0.6654	data is not stationary
Tether	0.0000	stationary data
Binance Coin	0.4882	data is not stationary
S&P 500 Index	0.6403	data is not stationary

TABLE II. STATIONARITY TEST AT ADF FIRST DIFFERENCE

Variable	Prob Value.	Description
Bitcoin	0.0000	stationary data
Ethereum	0.0000	stationary data
Binance Coin	0.0000	stationary data
S&P 500 Index	0.0000	stationary data

TABLE III. WHITE TEST RESULT

Variable	Pro Value. Chi-Square	Description
Ethereum-Bitcoin	0.4803	No Heteroscedasticity
Tether-Bitcoin	0.0596	No Heteroscedasticity
Binance Coin-Bitcoin	0.0110	No Heteroscedasticity
S&P 500 Index-Bitcoin	0.5711	No Heteroscedasticity

TABLE IV. EGARCH MODELING RESULTS

Variable	EGARCH Modeling		
	AIC	SIC	Variance Equation $\ln(\sigma^2 t)=\omega+\beta_1 \ln(\sigma^2_{t-1})+a_1\left\lvert\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right\rvert+Y_1\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$
Binance Coin-Bitcoin	-4.501861	-4.414845	$\ln(\sigma^2 t)= -3{,}899394 + 0{,}534392\ (\sigma^2_{t-1}) + 0{,}599018\left\lvert\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right\rvert + 0{,}204059\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$

TABLE 1. DIAGNOSTICS TEST RESULT

Variable	Prob Value. Chi-Square		Jarque-Bera Value	Probability
	Serial Correlation LM Test	ARCH Effect Test	Normality Test	
Binance Coin-Bitcoin	0.0777	0.7972	205.2969	0.0000

Based on Table V, the diagnostic test results from EGARCH modelling are good because they are free from autocorrelation problems, have no ARCH effect, or are homogeneous. However, the data is not normally distributed.

A. Bitcoin price volatility affects Ethereum price movements

H1 cannot be proven because the Ethereum price data is homoskedastic, so the data does not meet the requirements and cannot be continued in EGARCH modelling. This study cannot determine whether there is an effect of spillover volatility between Bitcoin and Ethereum prices. The difference in the results of this study compared to previous studies is due to the use of different research data periods and changes in Ethereum price data from year to year, so there are differences in the data from heteroscedasticity to homoscedasticity. This study uses the latest research period compared to previous studies, using weekly data from January 2018 to December 2022.

The results of this study differ from the research conducted by Aulia [8], Pujiati [22], Setiawati [24], and Angela & Sun [23], which prove that there is a volatility spillover between Bitcoin prices and Ethereum prices. Meanwhile, Warsito's [30] research shows that Bitcoin volatility is not affected by Ethereum.

B. Bitcoin price volatility affects Tether price movements

H2 cannot be proven because Tether price data is homoskedastic, so the data does not meet the requirements and cannot be continued in EGARCH modelling. This study cannot determine whether a volatility spillover effect exists between Bitcoin and Tether prices. The difference in the results of this study compared to previous studies is due to the use of different research data periods and changes in Tether price data from year to year. Therefore, there are differences in the data from heteroscedasticity to homoscedasticity. This study uses the latest research period compared to previous studies, using weekly data from January 2018 to December 2022.

The results of this study are in line with research conducted by Pujiati [22] and Setiawati [24], which shows that the effect of spillover volatility between Bitcoin and Tether prices cannot be proven due to the nature of homoskedasticity data that it cannot meet the requirements of EGARCH modelling. The results of Viswanath-Natraj & Lyons [31] do not show systematic evidence that the price of cryptocurrencies, such as Bitcoin, influences Tether. According to Gul [32], Tether was not included in his study because Tether is a stablecoin whose price is indexed to the US dollar and exhibits different return and volatility characteristics than other cryptocurrencies.

C. Bitcoin price volatility affects Binance Coin price movements

H3 is accepted. There is a positive relationship between the spillover volatility of Bitcoin prices and the price of Binance Coin, which shows that if the price of Bitcoin increases, there will also be an increase in the price of Binance Coin. On the other hand, if there is a decrease in the price of Bitcoin, there will also be a decrease in the price of Binance Coin. The EGARCH model's test results show that volatility spillover's effect on Bitcoin and Binance Coin prices is 59.90%. It means that every increase and decrease in Bitcoin prices has a 59.90% effect on the increase and decrease in Binance Coin prices. The positive shock is more than the negative shock in Bitcoin price volatility on the price of Binance Coin. It is indicated by the γ value on the Binance Coin-Bitcoin variable of 0.204059> 0.

This study's results align with research conducted by Santosha & Mallick [26], proving that the price of Bitcoin and the price of Binance Coin affect each other. The price of Binance Coin depends on the price of Bitcoin, and during the COVID-19 pandemic, both are positively correlated. The price increases to 0.84. The research results of Ciaian et al. [27] prove that the price of Binance Coin is affected by real shocks in the price of Bitcoin.

Investors realize that Bitcoin volatility can affect the price of Binance Coin. It is a warning for investors to be more careful when investing in Binance Coin because the cost of Binance Coin can increase or decrease simultaneously with the increase or decrease in the price of Bitcoin. Investors who invest in Binance Coin must follow issues or information from Bitcoin because it has an influence of 59.90% on the rise and fall of the price of Binance Coin.

D. Bitcoin price volatility affects the price movement of the S&P 500 Index

H4 cannot be proven because the S&P 500 Index price data is homoskedastic, so the data does not meet the requirements and cannot be continued in EGARCH modelling. This study cannot determine whether there is a volatility spillover effect between Bitcoin and the price of the S&P 500 Index.

The results of this study differ from research studies conducted by Georgoula et al. [10] and Conrad [28] that Bitcoin is significantly negatively related to the S&P 500 Index. Research conducted by Sovbetov [29] shows that the S&P 500 Index has a weak long-term positive relationship with Bitcoin. Still, in the short term, it turns negative because it loses its significance. At the same time, the research results by Kjærland et al. [33] prove that the S&P 500 Index positively impacts Bitcoin. When the S&P 500 Index rises 1%, the price of Bitcoin rises 1.77%.

V. CONCLUSION

Based on the data analysis that has been tested in this study, it can be concluded that based on the white test results, the heteroscedasticity data is Bitcoin-Binance Coin, so these variables can be used as modelling requirements in EGARCH. Based on the results of testing the EGARCH model, there is spillover volatility between Bitcoin and Binance Coin. Therefore, every increase and decrease in the price of Bitcoin will also increase and decrease in the price of Binance Coin. There are more positive shocks than adverse shocks to the Bitcoin price volatility on the price of Binance Coin. Meanwhile, the Ethereum, Tether, and S&P 500 Index variables cannot be known because the Ethereum price data is homoskedastic, so it cannot be continued with EGARCH modelling because the data needs to meet the modelling requirements.

The results of this study imply that investors who want to invest in crypto must be aware of crypto price movements because crypto prices tend to fluctuate more than other investment assets and, therefore, have a high level of volatility and risk. In addition, investors should be aware of crypto price movements, especially Bitcoin, which can affect the price of Altcoins and the S&P 500 Index. When the price of Bitcoin decreases, other cryptocurrencies, such as Binance Coin, will decrease. Bitcoin and S&P 500 Index are treated as asset substitutes. When the price of Bitcoin decreases, investors tend to sell Bitcoin and replace it with stocks.

This study has several limitations. It can only test one variable with the EGARCH model and assess the price of Bitcoin against the price of Binance Coin. Limited sources of previous research whose research results state

that Bitcoin affects Tether. This study also provides several suggestions. First, researchers suggest that investors can use information from this study as one of the considerations in making decisions when investing in cryptocurrency, especially in Bitcoin and Binance Coin, because Bitcoin has an influence of 59.90% on the ups and downs of Binance Coin prices. Second, future researchers can add research variables such as Litecoin, XRP, Dogecoin, Stellar, Monera, other stock indices such as the Dow Jones Index, Nasdaq Index, JCI, and commodities such as world gold prices, Brent oil, and exchange rates. Researchers also suggest not using Altcoin variables included in the stablecoin type because they are seen as stable cryptocurrencies such as Tether, USD Coin, Binance USD, etc. Third, future researchers can develop this research by using other spillover volatility testing models such as GARCH (1,1), TARCH, or other models, and can also change and extend the research period.

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