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Bitcoin, Gold, The Indonesian Stock Market, and Exchange Rate: GARCH Volatility Analysis

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ABSTRACT

Bitcoin has gained popularity as an investment asset because of its similarity to gold, which sparked the idea that bitcoin can be used as a hedging instrument to the fiat currency exchange rate. This paper aims to analyze bitcoin's volatility and return to gauge its feasibility as an investment asset, and hedging tool for the USD-IDR exchange rate with the GARCH and EGARCH models. With data on the daily closing price of bitcoin, gold, IDX composite index, and USD-IDR exchange rate from January 1, 2016, to December 31, 2020, the study attempts to find factors affecting bitcoin returns with the independent variables of bitcoin's price, gold, and USD-IDR exchange rate by estimating their correlation. Following the analysis, this study shows that the volatility of USD-IDR exchange rates negatively influences bitcoin returns, making it a relatively safe investment asset. Additionally, the study found that bitcoin returns are not affected by the variables of gold price and the IDX composite index. However, we found that the USD-IDR exchange rate significantly affects bitcoin returns, while gold price and bitcoin's price does not significantly affect bitcoin returns. Further, the analysis found that bitcoin is unsuitable for hedging due to its sensitivity to asymmetric shocks.

Keywords: *Bitcoin; Volatility; Gold Price; Stock Price; USD-IDR Exchange Rate, Investment Assets; Hedging Instrument*

INTRODUCTION

Since being invented by Satoshi Nakamoto in 2008, bitcoin, which developed into various cryptocurrencies, has proliferated in the financial sector, including Indonesia. As expected from the pioneer, the widely known cryptocurrency used by the public in developed countries is bitcoin. According to Nakamoto (2008), bitcoin's non-reversible nature makes it better than fiat money because bitcoin can eliminate transaction mediation fees that are still needed by financial institutions when processing fiat money. These mediation fees can increase transaction costs because financial institutions need to ensure the correctness of transactions.

Transactions using cryptocurrencies such as bitcoin are difficult to counterfeit or manipulate due to its cryptographic protocol, which allow for secure asset transfers, without involving trusted and centralized third party (Zaghloul et al., 2020). Transactions on the internet are almost entirely dependent on financial institutions that serve as trusted third parties to process electronic payments. Although most transaction systems on the internet had worked well, these systems still have trust-related weaknesses (Nakamoto, 2008). For example, someone makes an online transaction using a credit card, at the same time, the bank will send a one-time password to ensure that the user is a legitimate holder. Financial institutions cannot make Non-reversible transactions with fiat money, but these systems can be done by bitcoin. (Bhosale & Mavale, 2018).

Bitcoin was initially designed as a medium of exchange, similar to money. Over time bitcoin was used as an investment instrument because it met a lot of resistance and ban from governments as a medium of exchange (Ram,

2019). As a result, bitcoin is better known as an investment instrument such as gold and stocks because bitcoin is a digital coin and is limited in supply. In Indonesia, bitcoin is already used as an investment tool, although it cannot be used as a means of payment. Bitcoin's ban as a means of payment outside of regulatory decisions stems from being seen as highly volatile, high risk, and not having a physical form (Hendrickson & Luther, 2017).

Research by Glaser et al. (2014) found that most users treat bitcoin as an investment instrument rather than as a means of payment. Bitcoin is likely to be more useful as an asset than a currency. Bitcoin represents a particular value for each user in both current and future values because as it stores value over time, users need to gauge their expectations about the currency's future value (Glaser et al., 2014). Additionally, Dyhrberg (2016) found that bitcoin is positioned within the financial markets and portfolio management. Bitcoin and gold has their similarities because both derive most of their value due to being rare and expensive to extract (Henriques & Sadorsky, 2018). Gold was used as a medium of exchange during the era of the gold standard. However, the method was abandoned due to liquidity issues. Similar problems may occur to bitcoin if its number of users develops further.

Nevertheless, in some measures, gold and bitcoin are different. Primarily, gold is traded because of its ability to store value, and it negatively correlates with the USD and can be used for hedging (Arfaoui & Ben Rejeb, 2017). Stocks are also traded because of their ability to store value and negatively correlate with exchange rates of fiat money (Wong, 2017). However, such capabilities are uncertain for bitcoin.

Consequently, the ARCH/GARCH model was used by previous pieces of literature, such as Dyhrberg (2016), to analyze the volatility of an asset. With the GARCH (Generalized ARCH) and EGARCH (Exponential ARCH) method, Dyhrberg (2016) studied the relationship between bitcoin returns with the volatility of gold and the USD-EUR along with the USD-GBP exchange rate. Following Dyhrberg (2016), Warsito (2020) utilized the GARCH method to study the effect of bitcoin and ethereum returns on the gold, stock, and dollar index. However, the research analyzing bitcoin's volatility on the USD-IDR exchange rate has not been found.

Thus, based on the background of the study, this paper aims to answer the following questions: first, does gold price affect bitcoin returns?, second, do stock prices affect bitcoin returns?, third, does the USD-IDR exchange rate affect bitcoin returns?, fourth, can bitcoin be used as a hedging instrument?, and finally, can bitcoin be considered as a safe investment asset? To answer those questions, this study begins by discussing recent developments in the utilization of bitcoin as an investment asset, usage as a hedging instrument, and definitions relating to the issue.

A cryptocurrency is a form of digital currency, which has no physical form. This currency is used to transact virtually in the internet network. Legally, cryptocurrencies categorized as assets or currencies are still unclear. Cryptocurrency uses a decentralized network system that is used to prevent interference with the system. Data confidentiality is protected with cryptography applications, which keep cryptocurrency databases safe from being changed by anyone. The mechanism of cryptocurrency transactions is peer-to-peer.

The cryptocurrency employs peer-to-peer technology to enable its independent operation without the involvement of official authorities or banks. Moreover, for cryptocurrencies, the issuance and management of are done collectively using a network (Gersbach, 2019). Bitcoin and other cryptocurrency transactions can be done anywhere and by anyone without an intermediary while connected to the internet (Nakamoto, 2008).

Bitcoin transactions can be run between decentralized agents. Similar to fiat money, bitcoin can be used as a medium of exchange and hedging. There is no physical coin for bitcoin transactions, unlike standard currency. Instead, there are "digital bitcoins" stored digitally in the blockchain database (Ciaian et al., 2018). This peer-to-peer blockchain system is used to record cryptocurrency asset transactions, where every transaction is stored in an open ledger, distributed into one interconnected network with the blockchain technology (Acharjamayum et al., 2019).

Volatility measures the level of price variability or quantity that occurs from day to day, week to week, month to month, or year to year. The concept of volatility can be misinterpreted by only measuring price increases; Nevertheless, volatility measures how much price changes either with a constant long-term level or its trend. Meaning, volatility does not measure the direction of price changes; it measures the price variation around the mean. High data frequency typically indicates higher volatility, and volatility is less when the frequency decreases (Algieri, 2012).

The function of gold as a medium of exchange is still used in the 1900s to trade with other countries. Along with its development, gold became an asset that was not only used as jewelry. Gold investment is one of the most

predictable and attractive form of investment (Shakil et al., 2018). Investing in gold can be in the form of jewelry, coins, and bars. The advantages of investing in gold are easy to store and resell, unaffected by inflation, and in some case a tax-free investment tool.

A stock is an indicator that shows the movement of the stock price. The measure of stock price used is the IDX composite index (locally known as IHSG). A stock price index is an indicator that shows January stock market price movements. The index serves as an indicator of market trends, meaning that the movement of the index describes the condition whether it is active or sluggish. With the January index, the movement of stocks at any time can be known. There are several types of indices using the January index, and the IDX composite index is one of them.

The dollar is the official currency name of some countries, colonies, and other regions such as the United States Dollar, Australia, and Hong Kong. Before 1944, the world's countries preferred gold over paper money to gauge bilateral and multilateral trade (Bordo, 2021). The use of gold as a tool of international trade created unhealthy competition between countries that could not produce started buying gold. This uncertainty initiated the Bretton Wood Agreement in 1944, where the Soviet Union, China, and the United Kingdom pledged to control the exchange rate of their own local currencies with the U.S. dollar. Thus, the U.S. dollar reserve currency because, at that time, the United States had the largest gold reserves, almost three-quarters of all reserves on earth.

METHODS

Data for the closing price of bitcoin, gold, IDX composite index, and the USD-IDR exchange rate are detailed as follows.

Table 1. Sample Criterion

Criterion	Sample
Bitcoin's Closing Price from January 1, 2016, to December 31, 2020	1826
Gold's Closing Price from January 1, 2016, to December 31, 2020	1259
Stock's Closing Price from January 1, 2016, to December 31, 2020	1260
USD-IDR Closing Price from January 01, 2016, to December 31, 2020	1227
Total Observations	5572

Source: *finance.yahoo.com*

Data documentation methods were used for this research project, and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) along with Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) method were used to test the hypotheses with Eview10. According to Hartati & Saluza (2017), a time series model such as the moving average or GARCH is generally used to analyze the volatility of financial data statistically. Applying this statistical model to historical data will estimate statistical volatility of the past, where time-series data is available. To statistically analyze the volatility of each financial instrument, two models will be employed.

The first model will utilize GARCH, a statistical time series model formed by Bollerslev, which states that residual variants depend not only on past residual periods but also past periods' residual variance (Ghozali, 2017, p. 422). Knowing Ghozali (2017), the statistical models of this paper are as follows

GARCH model with explanatory variables and mean equation:

$$\triangle ln\, price_t = \beta_0 + \beta_1 lnprice_{t-1} + \beta_2 lnprice_{t-2} + \beta_3 Gold_{t-1} + \beta_4 Stock_{t-1} + \beta_5 USDIDR_{t-1} + \varepsilon_t$$

GARCH model with explanatory variables and variance equation:

$$\sigma_t^2 = \exp(\lambda_0 + \lambda_1 Gold_{t-1} + \lambda_2 Stock_{t-1} + \lambda_3 USDIDR_{t-1}) + \alpha\varepsilon_{t-1}^2 + \beta_{\sigma_{t-1}^2}$$

Then, the second model will utilize EGARCH, a statistical model introduced by Nelson in 1991 to analyze the influence of leverage and asymmetric impact (Ghozali, 2017, p. 431).

The exponential GARCH model with explanatory variables and mean equation:

$$\triangle \ln price_t = \beta_0 + \beta_1 lnpriceBTC_{t-1} + \beta_3 Gold_{t-1} + \beta_4 Stock_{t-1} + \beta_5 USDIDR_{t-1} + Y_0 e_{t-1} + Y_1 e_{t-2} + \varepsilon_t$$

The exponential GARCH model with explanatory variables and variance equation:

$$ln(\sigma_t^2) = w + \alpha_1 \left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}^2}\right) + \alpha_2 \left(\left(\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}^2}\right|\right) - \sqrt{\frac{2}{\pi}} \right) + \alpha_3 ln\sigma_{t-1}^2 + \beta_1 Gold_{t-1} + \beta_1 Stock_{t-1} + \beta_1 USDIDR_{t-1} + V_t$$

After specification, the model has to pass the stationarity test, ARIMA model, and heteroscedasticity test with the ARCH-LM method. Time series data is determined as stationary if it meets three criteria: the mean value and its variety are constant over time, and the covariance between the two time-series data depends only on the lag between the two time periods. Data is stationary at the mean value if the data fluctuates from around a fixed mean value over time (Juanda, 2021). After the estimation satisfied the stationarity test, the ARIMA model developed by Box & Jenkins is employed to analyze the probabilistic or stochastic economic nature of the time series. This model explains time-series data with past values, lag or variable values, and stochastic errors (Gujarati, 2019).

Finally, the estimation will be tested for heteroscedasticity with the ARCH-LM. The test estimates the OLS estimation, which regresses residual squares with residual lag squares. The result of the regression will show the distribution of chi-square with a degree of freedom = p. If the estimated x^2 is greater than the predetermined critical value x^2, it indicates that heteroscedasticity is observed within the model (Juanda, 2021, p. 99).

RESULTS AND DISCUSSIONS

The following figures show a relatively low phase of fluctuation followed by high fluctuations and back lows again. Bitcoin's return movement experienced a very high increase at the beginning of 2018, which gradually dropped to its lowest in early February 2020 and rose again, and so on. Gold return movements have a relatively high and low decline that occurs continuously. Stock return movements increased very high at the end of March 2020 and again decreased gradually. The USD-IDR exchange return movement experienced a significant increase at the end of 2020 until it fell gradually. The movement shows that the returns of bitcoin, gold, stock and USD-IDR exchanges have undergone significant changes. The change can be observed from the mean of every data displayed on the chart, which starts from zero.

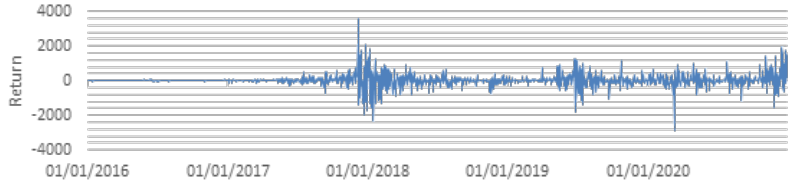

Figure 1. Bitcoin Return

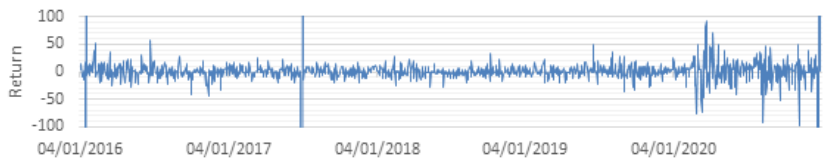

Figure 2. Gold Return

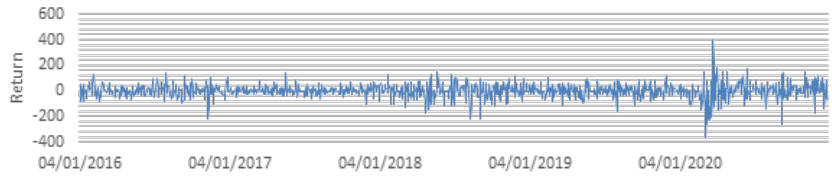

Figure 3. IDX Composite Return

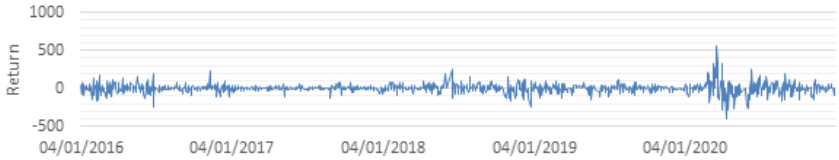

Figure 4. IDX Composite Return

Additionally, the time constant variance indicates that the return value of bitcoin, gold, stock, and USD-IDR exchange rate is stationary and has low volatility. It can also show that when bitcoin declines its lowest, the stock and exchange USD-IDR has increased and gradually decreases when bitcoin returns increase. However, to prove stationarity in the data, the visual analysis shown in the figures above should be accompanied by a unit root test.

Time series data is stationary if it meets three criteria: first, the mean value and its variance are constant over time, and the covariance between the two time series depends only on the lag between the two time periods. Second, data is stationary at the mean value if it fluctuates from around a fixed mean over time. Third, data is stationary in its variance if the data fluctuates with fixed variance over time (Juanda, 2021, p. 20).

The study's stationarity test employs bitcoin time-series data from the daily closing price during 2016-2020. With the unit root test, stationary testing tests time-series data of bitcoin, gold, stock, and USD-IDR exchange rate. Table 2 below is the result of the unit root test. This root test unit test is done using the Augmented Dickey-Fuller test (ADF) because data on bitcoin, gold, stock, and USD-IDR exchange rate either have an up or a downtrend.

Table 2 show that the return of bitcoin, gold, stock, and the USD-IDR exchange rate is stationary at the first point and is statistically significant when observing that the critical values are lower than 1%, 5%, and 10%. Once the stationarity problem is detected, the identification of the ARIMA model for bitcoin time series data is carried out. The model selection is made through the Autocorrelation Function (ACF), and Partial Autocorrelation Function (PACF) values correlograms, which were taken from data that are already stationary.

Table 2. ADF Test Result for First Differentiation of Variables (2016-2020)

Series	First Difference	Significance
Bitcoin	(43.73)	0.0001
Gold	(35.23)	0.0000
IHSG	(17.52)	0.0000
USD-IDR	(30.75)	0.0000
Test for Bitcoin	1% level	(3.433755)
	5% level	(2.862931)
	10% level	(2.567557)
Test for Gold	1% level	(3.435505)
	5% level	(2.863704)
	10% level	(2.567972)
Test for IHSG	1% level	(3.436100)
	5% level	(2.863967)
	10% level	(2.568113)
Test for USD-IDR	1% level	(3.435479)
	5% level	(2.863693)
	10% level	(2.567966)

The table above shows that the return of bitcoin, gold, stock, and the USD-IDR exchange rate is stationary at the first point and is statistically significant when observing that the critical values are lower than 1%, 5%, and 10%. Once the stationarity problem is detected, the identification of the ARIMA model for bitcoin time series data is carried out. The model selection is made through the Autocorrelation Function (ACF), and Partial Autocorrelation Function (PACF) values correlograms, which were taken from data that are already stationary.

Observations of the ACF pattern showed that the ACF spike at lag 10 and lag 19, and the PACF pattern also showed spikes at lag 10 and 19. Thus, the estimated ARIMA models selected are AR (10) and AR (19), shown in the following table 3, where it shows that the coefficients of AR(10) and AR(19) are statistically significant.

Table 3. ARIMA Model Result (2016-2020)

Variable	**Coef.**	***Std. Error***	**t-Stat**	**Prob.**
AR(10)	0.060015	0.020666	2.904024	0.0037
AR(19)	0.063979	0.020812	3.074070	0.0021
SIGMASQ	0.001567	1.85e-05	84.60369	0.0000
R-squared	0.004132	Dependent Variable LNBITCOIN		
Adjusted R-squared	0.003034	Obs. 1817	Convergence after 9 iterations	

After modeling the ARIMA, it is necessary to observe whether the data suffers from heteroskedasticity. This test aims to check for the feasibility of ARIMA modeling because not all data can be modeled using the method. The testing is done with the ARCH-LM test for heteroscedasticity. If the test did show no ARCH effect, then no further modeling is required and the ARIMA method is sufficient to explain the data.

Table 4. ARCH-LM Heteroscedasticity Testing Results

	F-statistic	**Obs*R-squared**	**Prob.**	**Remarks**
Bitcoin	9.098498	18.04548	0.0001	ARCH effect observed
Gold	25.19248	48.47708	0.0000	ARCH effect observed
Stock	76.32631	134.68779	0.0000	ARCH effect observed
USD-IDR	120.6695	201.9775	0.0000	ARCH effect observed

The table above shows that the results show that bitcoin has a calculated value of x^2 (Obs*R-squared) = 18.04548, which is greater than the statistical F-value of 9.098498 with a probability value = 0.0001. From these results, it can be concluded that bitcoin has an ARCH element. Gold has a calculated value of x^2 (Obs*R-squared) = 48.5, which is greater than the F-statistical value of 25.2 with a probability value = 0. From these results, it can be concluded that gold has ARCH elements. The stock index has a calculated value of x^2 (Obs*R-squared) = 134.7, which is greater than the F-statistical value of 76.3 with a p-value = 0. additionally, it can be concluded that the stock has ARCH elements. USD-IDR has a calculated value of x^2 (Obs*R-squared) = 201.9, which is greater than the F-statistical value of 120.7 with a probability value = 0. From these results, it can be concluded that USD-IDR exchange rate has ARCH elements.

After testing for heteroscedasticity, this model uses the ARCH/GARCH model to test the probability of bitcoin dependent variables occurring with independent variables of gold, stock, and the USD-IDR exchange rate. The GARCH model is used because heteroscedasticity (ARCH) on the four variables are observed. The model is selected using the order of ARIMA as its basis. Variables shown in table 5 are considered significantly significant to bitcoin if the p-value is less than 0.05.

Table 5. GARCH (1,1) with Bitcoin as an Explanatory Variable

Variables	Mean Equation	Variance Equation
Ln. Gold	-3.09e05	0.001769 (0.006976)***
Ln. Stock	-0.000347	-0.000643 (0.010466)***
Ln. USD-IDR	0.000512**	-0.000671 (0.000177)***
Ar (10)	-0.001359***	
Ar (19)	-0.001802**	
l.arch α		132.2105*** 0.299874***
l.garch β		0.001111*** 0.129266***
Constant		0.001155*** 0.144754***

*Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.*

The aforementioned table shows the regression results with the GARCH model using the mean equation, where it shows how gold, stock, and USD-IDR exchange rates affect bitcoin returns. Additionally, the variance equation results show how the gold, stock, and USD-IDR exchange rates affect the volatility of bitcoin.

In the results of GARCH with the mean equation, one can see that the coefficients of gold and stock are not statistically significant when viewed from the probability value. The results imply that gold and stock variables do not affect bitcoin returns, while the USD-IDR exchange rates coefficient is statistically significant. Meaning, bitcoin returns are influenced by the USD-IDR exchange rate variable. GARCH results with variance equation show that bitcoin volatility is not influenced by variable gold, stock, and USD-IDR exchange. In the variance equation, the ARCH(1) and GARCH(1) coefficients are statistically significant after judging by their probability values. The estimates imply that the bitcoin variable is volatile in the observed period, influenced by the residual square of the previous period ARCH(1) and the residual variance of the previous period GARCH(1).

Here are the regression results generated using the GARCH mean equation model and variance equation as follows:

GARCH model with explanatory variables and mean equations.

$$\Delta \ln price_t = 0.001155 + (-0.001359 lnprice_{t-1}) + (-0.001802 lnprice_{t-2}) + (-3.09e05 Gold_{t-1}) + (-0.000347 Stock_{t-1}) + 0.000512 USDIDR_{t-1} + \varepsilon_t$$

GARCH model with explanatory variables and variance equations.

$$\sigma_t^2 = \exp(0.144754 + (-0.006976 Gold_{t-1}) + (-0.010466 Stock_{t-1}) + (-0.000177 USDIDR_{t-1}) + 0.299874 \varepsilon_{t-1}^2 + 0.12966 \sigma_{t-1}^2$$

Following the GARCH model, our second model is the exponential GARCH model (EGARCH), which invests returns on bitcoin, gold, stock, and the USD-IDR exchange rates and is asymmetrically influenced by good and bad news or known as leverage effects.

Table 6. EGARCH (1,1) with Bitcoin as an Explanatory Variable

Variables	Mean Equation	Variance Equation
Ln. Gold	0.002690***	0.000438 (0.023938) *
Ln. Stock	0.002408***	6.73E-05 (0.060974) ***
Ln. USD-IDR	-6.53e-06	-0.000251 (0.003367)
Ar(10)	0.006024***	
Ar(19)	-0.000414	
l.earch α		7.052215*** 0.267238***
l.earch_a γ		6.857885*** (0.005777)
l.egarch		0.494357*** 0.903741
Constant		-3.119747*** -0.121764***

*Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.*

The table above shows regression results with the exponential GARCH model using mean equations and variance equations. The result of the exponential GARCH with mean equation shows that the coefficients of gold and stock are statistically significant when judging from their probability values, while the USD-IDR exchange is statistically insignificant. Further, the exponential GARCH with variance equation has estimated that gold is not statistically significant, which means that gold can be used as a hedging instrument because it is not affected by positive or negative shocks. The exponential GARCH model has also estimated that stocks have a statistically significant negative coefficient value, which means that it is asymmetrically affected by adverse shocks. Then, the USD-IDR exchange rate was estimated as being statistically insignificant to bitcoin returns, meaning that it is not being affected by positive or negative shocks. On the contrary, according to the GARCH variance equation, the USD-IDR exchange rate affects the volatility of bitcoin negatively, which indicates that an increase in USD-IDR volatility lowers the variance of bitcoin's returns. Thus, in line with Dyhrberg's (2016) finding, the estimation shows that bitcoin is a relatively safe asset in the market during the period of observation.

Here are the regression results generated using the GARCH exponential mean equation model and variance equation:

Exponential GARCH model with explanatory variable and mean equation.

$$\Delta \ln price\ BTC_t = (-3.119747) + 7.052215 lnpriceBTC_{t-1} + 0.002690 Gold_{t-1} + 0.002408 Stock_{t-1} + (-6.53e-06 USDIDR_{t-1}) + 6.857885 e_{t-1} + 0.494357 e_{t-2} + \varepsilon_t$$

Exponential GARCH model with explanatory variable and variance equation.

$$\ln(\sigma_t^2) = -0.121764 + 0.267238 + (-0.005777) + 0.903741 + (0.000438 Gold_{t-1}) + (6.73e-05 Stock_{t-1}) + (-0.000251 USDIDR_{t-1}) + V_t$$

CONCLUSION

Based on the results of hypothesis tests and analysis done, this study has found that the gold price does not affect bitcoin returns. The results of this study are in line with Warsito's (2020) research, stating that gold price does not affect bitcoin returns. Similarly, in line with Warsito's (2020) research, this study found that stock price does not significantly affect bitcoin returns. On the contrary, the analysis found that the USD-IDR exchange rate affects bitcoin returns, which echoed Dyhrberg's (2016) findings on correlation between the USD-GBP exchange rate.

Moreover, this study has found that bitcoin could not be used as a hedging instrument, which was not in line with Dyhrberg's (2016) study. Dyhrberg (2016) argued that positive and negative shocks do not affect the return of bitcoin and gold asymmetrically, which made it an effective instrument for hedging. Dyhrberg (2016) was not found in this study because bitcoin price is affected by asymmetric shocks. However, similar to Dyhrberg (2016), this study found that bitcoin is a safe investment asset because the USD-IDR exchange rates volatility negatively influences bitcoin returns. Thus, making bitcoin a relatively safe investment asset.

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