The Yield and Volatility of Cryptocurrency in the Uncertain Market: Evidence from Ethereum

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Abstract. With the advent of 2022, the impact of the COVID-19 pandemic has weakened, the US labor market has recovered, and inflation has been severe, creating the conditions for the Fed to tighten its policies. At the same time, cryptocurrencies as a hot topic in recent years; ETH is one of the most popular cryptocurrencies in the market; this article aims to assess the impact of the Fed's raised interest rates on the yield and volatility of cryptocurrency Ethereum (ETH) based on data on the ETH price and the US dollar/CNY exchange rate since 2022. And further, simulate the impact on the overall cryptocurrency market. This paper constructs VAR and ARMA-GARCH models to analyze ETH returns and volatility variations. The results of these models suggest that the exchange rate rise triggered by the Fed's rate hike has had a negative impact on ETH yields and increased the volatility of its returns. Further, this article recommends that investors should adjust their portfolios according to their risk appetite in an uncertain market environment.

Keywords: Fed Rate Hike, Ethereum, Cryptocurrency, US exchange rate.

1. Introduction

As the Fed reacted to the COVID-19 pandemic that lasted for several years, the Fed implemented several rate cuts and printed more dollars. These measures led to a sustained increase in inflation in the United States in various categories and reached a nearly 25-year high of 7.5% in January 2022[1,2]. In addition, after the epidemic finally subsided, the US unemployment rate fell sharply to 4% in January 2022, returning to normal levels before the epidemic [3]. With the gradual improvement of the economy, the conditions for interest rate hikes are becoming more and more mature. In order to control and reduce the inflation rate, the Fed implemented several rate hikes in 2022, and the total rate hike by August 2022 is even at an all-time high. Under the influence of the interest rate hike policy, the global economic system will be affected to varying degrees. First, from the perspective of the exchange rate, the reduction in the liquidity of the US dollar will lead to an increase in the value of the US dollar. The demand for the US dollar in the global market will increase, which in turn will lead to the continuous strengthening of the US dollar exchange rate and the depreciation of other currencies. In traditional financial derivatives markets such as the stock market, interest rate hikes will lead to higher dollar financing costs, which will affect the liquidity of the US stock market and fall. After that, the rate hike will attract a large amount of capital backflow, which will cause the US stock market to rebound [4]. Overall, the Fed's rate hike will increase overall uncertainty in financial markets over time.

Cryptocurrencies have been a popular investment option in recent years, boasting the advantages of no inflation, inability to reuse, counterfeiting, and fast transaction speed [5]. Its price has also risen rapidly in recent years while fluctuating sharply, attracting more attention and research from investors. As a new type of decentralized currency, cryptocurrencies should theoretically be independent of traditional financial markets and the influence of conventional currencies. It is mainly affected by the supply and demand relationship of its market. Some studies argue that in addition to the supply and demand of cryptocurrencies themselves, the strength of the entire cryptocurrency market, trading volume, and the attractiveness of a particular currency (Google search frequency) will also have a positive impact on the price of cryptocurrencies [6]. In general, some investors and researchers believe that changes in the macro market have little impact on the price of cryptocurrencies.

However, the reality is that cryptocurrencies showed a jumping trend after the Fed took steps to raise interest rates [7]. Meanwhile, a study of a mainstream cryptocurrency, Bitcoin, by Denton Jack and Daren Fonda in May 2022 noted that “fed funds rates have delayed, threshold, higher order, and spillover effects on Bitcoins [8].” These findings reveal that the price of cryptocurrencies is influenced by macro markets and traditional financial products.

Combining these findings, there are complex and delicate relationships between macroeconomics, traditional currencies, and the prices of cryptocurrencies, especially at different times, such as during covid-19 and the conventional period. Therefore, this article attempts to narrow down the variables while controlling a specific period (the 2022 Fed continuous rate hike cycle) and a single cryptocurrency (Ethereum). Examine the relationship between fed rate hikes and Ethereum yields and volatility. Based on the theory, the increase in international floating capital and financial market demand for the dollar caused by the Fed's interest rate hike will further lead to an increase in the US dollar exchange rate. Here this article uses the exchange rate of the US dollar against the CNY to concretize and stimulate the impact of the rate hike on the price of Ethereum.

This article examines Ethereum prices. The analysis has two factors: yield and volatility. The study focused on the yield of ETH and the extent to which it is affected by the US exchange rate against the CNY. And in a way, it represents the relationship between the yield of the entire cryptocurrency market and the US interest rate. Firstly, this paper examines the stability of the logarithmic origin series and logarithmic yield sequences of ETH and exchange rates. Next, this article constructs a VAR model for the logarithmic yield series of Ethereum and exchange rates, creating a system that contains the Price of Ethereum (the exchange rate of USD/CNY). VAR systems can be used to focus simultaneously on the prediction and dynamic dependencies of multiple variables. At the same time, a pulse plot of the pulse variable function is plotted for the two variables, visually showing the size of the change in Ethereum logarithmic yield over time caused by the effect of the logarithmic yield of one unit exchange rate. In the last part of the paper. Using the conditional heteroscedasticity in the yield sequence, the ARMA-GARCH model of the Ethereum logarithmic yield and the exchange rate logarithmic yield is constructed. The aim is to study yields and volatility to indicate the risk of Ethereum.

The rest of this paper is organized as follows: Part 2 is the research design, which includes the data source, unit root test, and model specification; Part 3 is the empirical results of the model. Constitutes the main conclusion of this article. Part 4 is a discussion focusing on the similarities and differences between the findings of this article and the existing conclusions, as well as suggestions for investors and possible subsequent research directions. Part 5 is a brief conclusion of the research.

2. Research Design

2.1 Data Source

The data on the price of Ethereum and the exchange rate of the US dollar and RMB used in this article are from investing.com. One of the top three global financial websites in the world [9]. It records the prices of many types of financial derivatives, including stocks, options, exchange rates, and cryptocurrencies. Historical data used in this paper is from January 1, 2022, to August 4, 2022, and the daily closing price is selected for analysis.

This article matches the daily price and exchange rate of ETH based on the date. This analysis does not account for the change in the price of Ethereum on non-trading days because exchange rates only fluctuate during trading days. The remainder of the data is paired by date. In this case, the analysis can accurately estimate Ethereum's yield and analyze how yields and fluctuations are affected by exchange rate changes. After that, this paper logarithmically processes the data series of Ethereum and exchange rates and derives the logarithmic yield. The use of these logarithmic data will facilitate the subsequent construction of VAR and ARMA-GARCH models. In the course of this study, Stata is the primary tool for processing and analyzing data to conclude.

2.2 Unit Root Test

The occurrence of unit roots indicates non-stationary time series, which leads to pseudo-regression in regression analysis. The unit root test is a specific steady-state test method provided for the presence of unit roots in macroeconomic data series as well as monetary and financial data series. Non-stationary time series make it difficult for the model to reflect the past and future of the time series, requiring additional processing. Therefore, testing the unit root to ensure stationarity is a necessary prerequisite for time series analysis. Here the paper uses an ADF-test as the unit root test.

The formula of time series x_t used for the unit root test can be written as:

$$x_t = c_t + \beta x_{t-1} + \sum_{i=1}^{p-1} \phi_i \Delta x_{t-i} + e_t \tag{1}$$

The null hypothesis of the test is that the coefficient H_0: $\beta = 1$, which indicates that the series has a unit root and is not stationary, while the alternative hypothesis is that H_1: $\beta < 1$, indicating the series has no unit root and is stationary.

Table 1 shows the result of the ADF-test of the logarithm origin series and the logarithm yield series:

Table 1. ADF test

Variables	t-statistic	p-value
	Price	
Ethereum	-1.749	0.7287
Exchange rate	-1.874	0.6683
	Yield	
Ethereum	-8.837	0.0000***
Exchange rate	-8.514	0.0000***

The logarithmic origin series of Ethereum and the exchange rate perform poorly in the stationarity test, as seen by the results of the ADF test, and both are not significantly stationary even within the 90% confidence range. The logarithmic yield series for both, though, can be trusted within a 99% confidence interval. This article is able to develop the following model using the test research.

2.3 AR Model Specification

Sims (1980) first suggested the vector autoregressive (VAR) model, which has proven to be the most effective, adaptable, and simple model for the analysis of multi-time series (MTS) data [10]. A VAR model is used to explain the relationship between various time series. By allowing for multivariate time series, VAR models generalize the single-variable autoregressive model. VAR models combine several variables into a single system and forecast it in order to get several forecasts that are all consistent with one another.

The process of building a model can be explained by the example of forming a bivariate VAR (p) system:

Suppose there are two-time series variables (γ_{1t}, γ_{2t}) as the interpreted variable of the two regression equations, the explanatory variable is the p-order lag value of both variables:

$$\begin{cases} \gamma_{1t} = \beta_{10} + \beta_{11}\gamma_{1,t-1} + \cdots + \beta_{1p}\gamma_{1,t-p} + \gamma_{11}\gamma_{2,t-1} + \cdots + \gamma_{1p}\gamma_{2,t-p} + \varepsilon_{1t} \\ \gamma_{2t} = \beta_{20} + \beta_{21}\gamma_{1,t-1} + \cdots + \beta_{2p}\gamma_{1,t-p} + \gamma_{21}\gamma_{2,t-1} + \cdots + \gamma_{2p}\gamma_{2,t-p} + \varepsilon_{2t} \end{cases} \tag{2}$$

As these two functions have the same explanatory variable p, these equations can be written together, then write the contemporaneous vector as a column vector, and combine the corresponding coefficients as the matrix.

$$\begin{pmatrix}\gamma_{1t}\\ \gamma_{2t}\end{pmatrix} = \begin{pmatrix}\beta_{10}\\ \beta_{20}\end{pmatrix} + \begin{pmatrix}\beta_{10} & \gamma_{11}\\ \beta_{10} & \gamma_{21}\end{pmatrix}\begin{pmatrix}\gamma_{1,t-1}\\ \gamma_{2,t-1}\end{pmatrix} + \cdots + \begin{pmatrix}\beta_{1p} & \gamma_{1p}\\ \beta_{2p} & \gamma_{2p}\end{pmatrix}\begin{pmatrix}\gamma_{1,t-p}\\ \gamma_{2,t-p}\end{pmatrix} + \begin{pmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{pmatrix} \tag{3}$$

Define the same coefficient matrix as $\Gamma_0, \Gamma_1, \ldots, \Gamma_p$ then:

$$\gamma_t = \Gamma_0 + \Gamma_1\gamma_{t-1} + \cdots + \Gamma_p\gamma_{t-p} + \varepsilon_t \tag{4}$$

In this case, the two variables (ETH logarithm yield and exchange rate logarithm yield) and the error term matrix are:

$$\gamma_t = \begin{bmatrix}\gamma_{1t}\\ \gamma_{2t}\end{bmatrix}, \varepsilon_t = \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix} \tag{5}$$

After building the VAR model, this article will calculate the impulse response function for the variables in the model and plot the impulse response graph. Impulse response plots visualize the magnitude of changes in time caused by the impact of one unit over time in other variables.

The equation of the impulse response function (IRF) is:

$$\frac{\partial\gamma_{t+s}}{\partial\varepsilon_{t'}} = \Psi_s \tag{6}$$

The equation represents that when the variable j increases by 1 unit in the perturbation term in the t period (the other variables and other perturbation terms are unchanged), the effect on the value of the variable i in the t + s period.

2.4 ARMA-GARCH Model Specification

2.4.1 ARMA Model Specification

The Autoregressive–Moving-Average (ARMA) model is formed of two parts, an Autoregressive (AR) model and a Moving-Average (MA) model. The ARMA model predicts the future with both past realizations and past perturbations and can help in understanding and forecasting the future values in a time series [11].

An AR (*p*) model can be expressed as:

$$y_t = \phi_0 + \sum_{i=1}^{p}\varphi_i y_{t-i} + \varepsilon_t \tag{7}$$

A MA (*q*) model can be expressed as:

$$y_t = \phi_0 + \sum_{i=1}^{p}\varphi_i y_{t-i} + \sum_{k=0}^{l}\omega_k x_{t-i} + \varepsilon_t \tag{8}$$

Together, the AR (*p*) model and the MA (*q*) model can form an ARMA (*p*,*q*) model, which can be expressed as:

$$y_t = \phi_0 + \sum_{i=1}^{p}\varphi_i y_{t-i} + \varepsilon_t - \sum_{i=0}^{q}\omega_k x_{t-i} \tag{9}$$

2.4.2 ARCH Model Specification

Robert Engle proposed the Autoregressive Conditional Heteroskedasticity (ARCH) model in 1982 [12]; The model addressed the issue of time series volatility and improved the realism of time series analysis. In order to access patterns of volatility, such as aggregation, risk premium, leverage (asymmetric effect), spillover effects, or the addition of other explanatory variables, the ARCH model, which can forecast the conditional variance of return series, is typically utilized. [13]. This paper focuses on the equation of variance and studies volatility using the ARCH model. The standard equation of an ARCH model would be expressed as:

$$\sigma^2{}_t = \alpha_0 + \alpha_1 \varepsilon^2{}_{t-1} + \cdots + \alpha_p \varepsilon^2{}_{t-p} \tag{10}$$

α_0 is a constant and σ_t, ε_t each refers to the forecast variance and actual variance in period t.

2.4.3 GARCH Model Specification

The GARCH model is an improvement on the ARCH model proposed by Bollerslev in 1986 [14]. The GARCH model lowers the number of parameters that must be estimated and improves the precision of conditional variance forecasts. The GARCH model adds the autoregressive part of $\sigma^2{}_t$ to the ARCH model.

GARCH (p, q) model specification is:

$$\sigma^2{}_t = \alpha_0 + \alpha_1 \varepsilon^2{}_{t-1} + \cdots + \alpha_p \varepsilon^2{}_{t-p} + \gamma_1 \sigma^2{}_{t-1} + \cdots + \gamma_p \sigma^2{}_{t-p} \tag{11}$$

2.4.4 ARMA-GARCH Model Specification

As this article focus on both the yield and volatility of Ethereum, an ARMA-GARCH model is built to analyze the value and the risk of Ethereum at the same time. The ARMA part concentrated on the value and the GARCH part concentrated on the risk. Together, the ARMA-GARCH model plays a crucial role in generating the conclusions of this article.

3. Empirical Results

3.1 VAR Order Selection

In order to construct a VAR (*p*) model that accommodates the logarithmic yield of the Ethereum and exchange rate, this article first uses VARSOC selection-order criteria in Stata to determine an appropriate order *p*. The results in Table 2 indicate the feasibility of building a 12 orders VAR model.

Table 2. VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	811.535				2.3e-08*	-11.9049*	-11.8875*	-11.8621*
1	812.522	1.9746	4	0.740	2.4e-08	-11.8606	-11.8084	-11.7321
2	813.589	2.1338	4	0.711	2.5e-08	-11.8175	-11.7305	-11.6033
3	814.636	2.0941	4	0.718	2.6e-08	-11.7741	-11.6522	-11.4742
4	816.617	3.9613	4	0.411	2.7e-08	-11.7444	-11.5877	-11.3589
5	818.639	4.0431	4	0.400	2.8e-08	-11.7153	-11.5238	-11.2441
6	819.825	2.3731	4	0.668	2.9e-08	-11.6739	-11.4476	-11.1171
7	823.084	6.5174	4	0.164	3.0e-08	-11.663	-11.401	-11.0205
8	825.716	5.2655	4	0.261	3.0e-08	-11.6429	-11.347	-10.9147
9	827.517	3.6012	4	0.463	3.1e-08	-11.6105	-11.2798	-10.7967
10	831.423	7.8127	4	0.099	3.1e-08	-11.6092	-11.2436	-10.7097
11	833.657	4.4679	4	0.346	3.2e-08	-11.5832	-11.1829	-10.598
12	838.814	10.312*	4	0.035	3.2e-08	-11.6002	-11.165	-10.5294

After building VAR (12), it is necessary to check the eigenvalue stability condition; this article uses Stata for verification and draws a unit circle to visualize the result. VAR is considered to be stable if all dots representing the eigenvalues lie within the unit circle. Figure 1 shows the unit circle and the plots. All plots lie within the circle, furtherly confirming the stability of the VAR system.

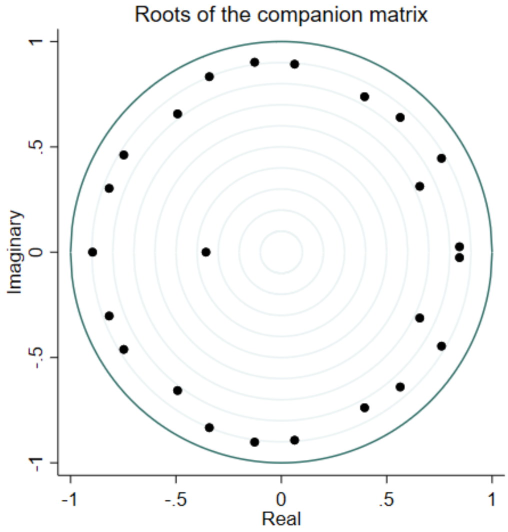

Fig 1. VAR stability

3.2 Impulse Response Graph and Forecast

Figure 2 shows the impulse response graph of the model. Results can be derived from the figure as; The appreciation of the dollar triggered by the Fed's interest rate hike has shown a negative net effect on Ethereum. Specifically, 1 unit increase in the logarithmic yield of the exchange rate in the t = 0 period will cause the Ethereum yield to decrease by 2%. And then, the effect will oscillate around 0 for the subsequent periods.

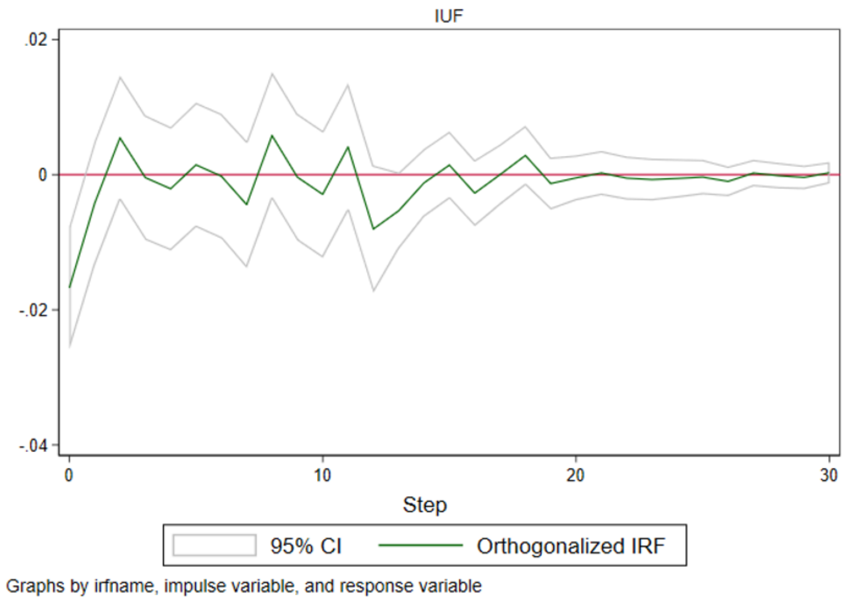

Fig 2. Impulse and response

Also, this article forecasts the Ethereum yield based on the result from the VAR model. The chart of the forecast result is shown in Figure3. From the estimated results of the forecast chart, although the net effect of the exchange rate increase on Ethereum is negative, if you take into account the autocorrelation of Ethereum's yield and make a forecast, it can still be found that its yield is positive in the short term in the future.

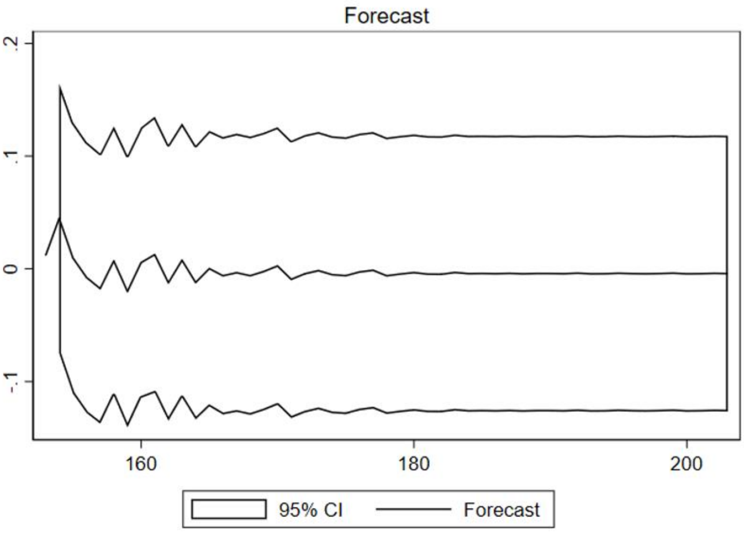

Fig 3. Forecast

3.3 ARMA Order Selection

In order to build an ARMA-GARCH model, this article first finds the appropriate lag order for the AR and MA parts. This article uses the partial autocorrelation plot (PACF plot) and the autocorrelation plot (ACF plot) to decide the lag order for AR and MA. Figure 4 is drawn Stata shows the PACF and ACF plot of the logarithmic yield of the Ethereum.

The points beyond the black rectangles in Figure 4 represent the benchmark of statistically significant terms. Both PACF and ACF plots indicate that lag 5 and 7 terms could have a significant impact on the logarithmic yield of the Ethereum. The result also shows lag 5 and 7 terms are feasible choices for both the Autoregression and the Moving Average model. To make the results of the ARMA model more accurate and more informative, lag 5 is selected here as the order of the ARMA model.

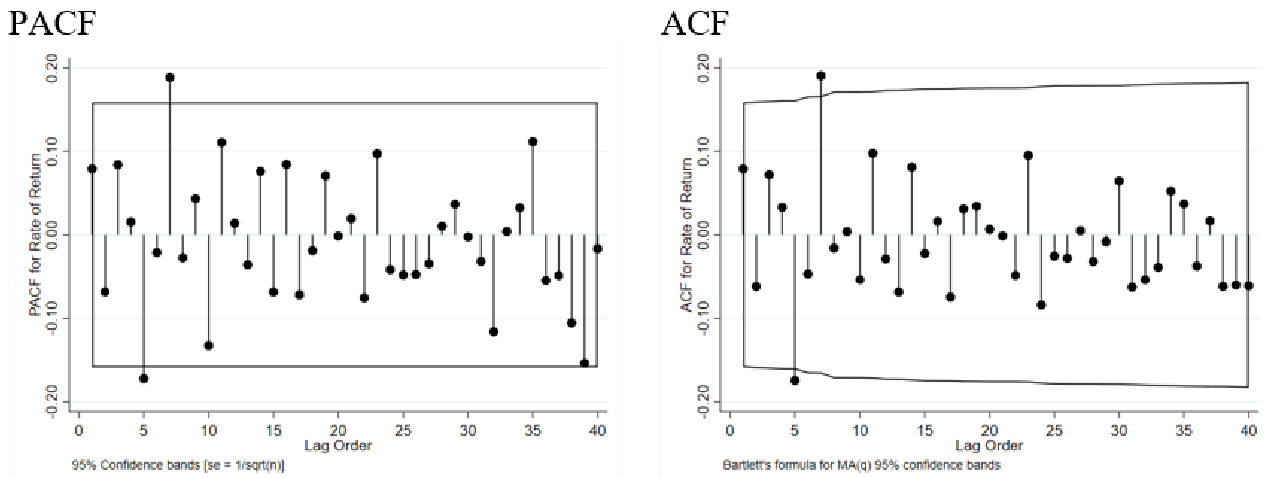

Fig 4. PACF and ACF

3.4 ARMA-GARCH Results

This article uses an ARMA (5,5) – GARCH (1,1) model with an exogenous lag term of the logarithmic yield of the exchange rate. The results of this model complement and refine the conclusions from VAR. The estimation result is shown in Table 3.

Table 3. ARMA-GARCH estimation results

	Coefficient	Std. err	Z	P>|z|
		Mean equation		
AR (-1)	0.0227	0.0952	0.24	0.811
MA (-1)	-0.2013	0.0930	-2.16	0.031
Constant	-0.0047	0.0040	-1.17	0.243
		Variance Equation		
Exchange rate	13.4326	7.3765	1.82	0.069
ARCH(-1)	0.0543	0.0172	3.14	0.002
GARCH (-1)	-0.9667	0.0416	-23.20	0.000
Constant	-4.9974	0.0886	-56.40	0.000

From the estimated results of the variance equation, both the ARCH term and the GARCH term are significant, indicating that the Ethereum yield has a statistically significant conditional heteroscedasticity, which can be modeled by GARCH. Additionally, according to the anticipated coefficient from the exchange rate's logarithmic yield, the yield will grow by 1 unit, and the volatility of the Ethereum yield will rise by 13.4326 units, significant increases at the level of 10%.

Combined with the results of the former discussion, this article argues that the exchange rate increase caused by the Fed's interest rate hike not only has a negative impact on Ethereum yields but also increases the volatility of its earnings.

4. Discussion

From a theoretical analysis, it is impossible to directly determine the net effect of the Fed's interest rate hike on Ethereum. The Fed's interest rate hike will undoubtedly lead to an increase in the demand for international floating funds and the US dollar in the global financial market, and further lead to a rise in the exchange rate. But the impact of exchange rate increases on other markets has two directions. The indirect effect is that International financial markets hold more of the dollar, and this excess money may flow to the stock market, bond market, or other financial markets in the United States, and of course, may also flow into the cryptocurrency market, resulting in higher demand and prices. The direct effects of exchange rate increases in other countries' financial markets or international financial markets are that when international floating capital increases its holdings of the United States dollar, funds from other countries or other markets may flow out, resulting in lower demand and prices. However, the results from this article suggest that the appreciation of the dollar triggered by the Fed's interest rate hike has shown a negative net effect on Ethereum and increased the volatility of Ethereum's earnings. This result is unexpectedly similar to the results of a study conducted by Khaled Mokni, and Ahdi Noomen Ajmi in 2021 [15], namely that the US dollar and cryptocurrencies are moving in a direction with a significant two-way negative causal relationship. However, the difference is that in the results of this article, it can also be found that the long-term impact of exchange rate changes is not large, and the forecast can still find that the Ethereum yield is positive in the short term. This may prove that even though the exchange rate change would increase the volatility of Ethereum. The investors may still choose to invest in cryptocurrencies like Ethereum when Fed’s decision to implement a hike. For further research, the research direction can focus on the changes in the price of Ethereum that may result from changes in the Fed interest rate hike other than those that cause changes in the US dollar exchange rate. Or it could focus on taking more cryptocurrency into account and analyzing the Fed's interest rate hike.

5. Conclusion

In the context of the continuous sharp interest rate hike of the Federal Reserve and the continuous heating up of cryptocurrency. This article examines how Fed rate hikes affect Ethereum's yields and volatility. To visualize the impact of the Fed's rate hikes, this article uses changes in the exchange rate of the US dollar from the beginning of 2022 to August to reflect the move to raise interest rates. And targeted study of Ethereum's return rate and volatility changes. The results of the study show that, first, the exchange rate increase caused by the Fed's interest rate hike has a negative impact on Ethereum yields in the short term, and each unit of exchange rate logarithmic yield increases will affect the Ethereum yield reduction by about 2%, but the long-term impact is not significant. Second, the rise in exchange rates also increases the volatility of Ethereum yields and investment risks.

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