The Time-Varying Impact of Fed's Rate Hikes on Yield and Volatility of Bitcoin

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Abstract. Covid-19 has had a significant impact on financial markets around the world, and various countries have adopted their methods to combat the impact of Covid-19 on equity markets. And because of Covid-19, the market share of the cryptocurrency market is increasing rapidly. This article focuses on how exchange rate changes caused by the Fed's interest rate hike affected the cryptocurrency market after the epidemic. The article uses ARMA-GARCH and VAR models to analyze the future change of the cryptocurrency market after 2022 and how an increase in interest rate affects cryptocurrency market volatility. Furthermore, the model predictions have not been found that the interest rate increase in early 2022 has produced volatility in the cryptocurrency market. Compared to traditional equity markets or real estate markets. Cryptocurrencies are not responsive to government intervention.

Keywords: Cryptocurrency · interest rate · equity market prediction

1 Introduction

Covid-19 was the worst disaster of the 20th century. Markets around the world were tested to the hilt. Stock markets, labor markets, and a host of other market conditions received a massive hit because of this disaster. However, with the advancement of technology, the world will not be as helpless as against other disasters such as plague and cholera. All governments immediately implemented many policies to organize the impact of the epidemic. The United States, for example, helped the financial markets recover by increasing the amount of money printed, issuing epidemic blessings, and quantitative easing. The U.S. response was so successful that we saw stock prices rebound quickly and reach new highs after the meltdown during the outbreak. Another interesting phenomenon is the considerable increase in cryptocurrency valuations during this period. That allowed many families to reduce their working hours during the epidemic, but they could still earn more income by investing in stocks and cryptocurrencies. However, the rapidly expanding stock values are increasing due to low-interest rates and money printing. However, the bubble in this can cause secondary damage to the market if it explodes. As 2022 begins, Covid-19 is drawing to a close. Moreover, the U.S. must do how to compensate for the side effects of the policies issued during Covid-19 through various policies.

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At the beginning of the epidemic, the U.S. influenced interest rates and market demand through monetary policy. When the federal government increases the money supply and lowers interest rates by printing large amounts of money, the currency's value decreases at that time. Moreover, lower interest rates reduce lending risk, allowing more investors to invest by borrowing money. When more money enters the market, this leads to a climbing demand for stocks, which leads to a rise in stock and cryptocurrency prices. With the end of Covid-19, the U.S. government increased the value of the U.S. dollar by increasing interest rates, which led to an increase in investment risk and cost for investors and reduced their enthusiasm for investing. The result of this was that the overall stock market declined significantly. The increase in interest rates has also led to several side effects, such as the appreciation of the dollar, capital outflows, and the flow of investments from the stock market to other markets, such as the relatively stable bond market. Even some real estate industries, such as real estate, can be affected by the interest rate. Glenn R. Mueller, in "The Effect of Interest-Rate Movements on Real Estate Investment Trusts," [2] mentioned that there is an inverse relationship between the interest rate and housing prices, and this inverse relationship is even more remarkable when housing prices are falling.

With interest rates dropping during the epidemic, investors will use this opportunity to discover many new investment markets. The cryptocurrency market has undoubtedly caught up with the wave since elevated or reduced interest rates can affect the financial value of many investment markets. So, whether the impact of interest rates on the cryptocurrency market, which has only emerged in recent years, will be the same as the traditional market is a question. Cryptocurrencies are coming to the forefront of more investors' minds with Covid-19. Unlike stocks, Christian [3] mentioned on her paper that cryptocurrencies do not have physical value in the sense of stocks, which results in cryptocurrencies having intrinsic value but not the properties of money. Cryptocurrencies are also not controlled by the Federal Reserve or the government, meaning they are a free investment zone. There are no middlemen to collect commissions directly from investors, and intermediaries do not control them. That also ensures the security of cryptocurrencies and the flow of information. These attributes different from the traditional market give investors a more excellent vision of this new market, and the demand for this market is rising rapidly during the epidemic. More and more brokerages are also offering the ability to trade cryptocurrencies. The market demand for cryptocurrencies and the share of the investment market are expanding rapidly at the same time. According to Statista statistics [4], the number of cryptocurrencies has rapidly increased from 2,817 in November 2019 to 10,397 in February 2022. The epidemic had undoubtedly brought about the massive growth in cryptocurrencies compared to previous years when they were rising by a few hundred per year. As the demand for cryptocurrencies rises, the price is also climbing rapidly. For example, Bitcoin climbed directly from a price of $8,147 on 4/10/19 to $61,283 on 12/3/2021. Such a colossal boost has led many investors to enter the cryptocurrency market. Cryptocurrencies are also gaining in stature, and many markets in Europe and the United States can even use cryptocurrencies as a payment option. That has also allowed cryptocurrencies to gain more of the attributes that trading currencies have. People also realize that cryptocurrencies are not just an investment product but even a currency that belongs to the future.

Conversely, many investors also believe that cryptocurrencies cannot create value. Because they do not represent any fundamental industry properties, their prices change dramatically due to market hype. Previously during the investment bonus period during the epidemic, the almost 0 interest rate on the dollar was considered the biggest hype news for the rise in cryptocurrency prices. As the epidemic ended and the dollar continued to raise interest rates, the price of cryptocurrencies stopped growing like crazy. The dollar's interest rate hike suppression of assets has on the surface, thrown a powerful punch at cryptocurrencies. Another possible reason is that investors realize through their growing knowledge of cryptocurrencies that the lack of intrinsic value attributes leaves them without any credibility to back them up. Also, the security and stability of cryptocurrencies are considered investment flaws in the cryptocurrency market. The market share held by Bitcoin is as high as 42% [5]. That results in a cryptocurrency market that does not have as much diversity as the stock market to ensure market stability. Harwick, Cameron [6] believes in his paper that cryptocurrency is an economic vehicle with stinging power. Trying to make cryptocurrencies disappear is a situation that can never occur. But because there are no financial institutions that can make cryptocurrencies stable, it is impossible for cryptocurrencies to replace centrally issued currencies.

As a fledgling market, the stability and intrinsic value of cryptocurrencies are often discussed, and changes in interest rates have been behind the rise and fall of cryptocurrencies. At the same time, the impact of interest rates on traditional markets has been widely discussed and directly demonstrated the connection. However, the cryptocurrency market is fundamentally different from the traditional stock and bond markets in many ways. Whether government changes to the economy affect the market value of cryptocurrencies and their value requires more data to support. This paper uses a VAR model to estimate the dynamic impact of exchange rate changes due to Fed rate hikes on bitcoin, coin, and Ethereum yields.

The rest of this paper is organized as follows: Part 2 is the research design, which includes data sources, unit root test, and model specification. Part 3 is data result analysis. Part3 includes.

2 Research Design

2.1 Data Source

In this paper, we obtain the daily price indices of Bitcoin [7], BNB [8], and Ethereum [9] to USD since January 1, 2022, from publicly available data already published by Yahoo Finance. Our main models and formulas are analyzed based on these four data. Then we will calculate the exchange rate, the logarithmic yield of the cryptocurrency price, and the original logarithmic series by Stata. We then import the data from Yahoo Finance for the conversion of USD to RMB on January 1, 2022.

2.2 Unit Root Test

To ensure that our data are in stable time order, the unit root test is the first item we need to do after obtaining the data.

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

x_t represent the value of the time series at time t. Δx_{t-i} represent different lag $t - i$ of time series. c_t is the coefficient at time t. e_t is an exogenous variable at time t.

In our Stata's equation, we will use the logarithmic rate of return, and the logarithmic original series as the variables in the equation. The null hypothesis is that the unit root is nonstable. So, if the β in the formula is equal to 1 we know that our formula is not smooth. The alternative hypothesis is when $\beta < 1$. Therefore, we can be sure that our data are smooth and comply with the time series rule when we reject the null hypothesis, and the alternative hypothesis holds. After we put in our variables which are the log-returns of the three cryptocurrencies plus the RMB to USD, and the log original series. We can directly observe whether the p-value will reject the null hypothesis by using the ADF test of Stata to determine whether our data satisfy the smoothness of the time series. If we get an unsteady result, we need to convert the unsteady variable into a steady logarithmic return by differencing it to help the subsequent calculation.

2.3 VAR Models Specification

This paper uses a VAR model for the cryptocurrency market to estimate the dynamic impact of exchange rate changes due to Fed rate hikes on bitcoin, coin, and Ethereum yields. VAR models can help us observe and predict multivariate and dynamic dependencies. Moreover, we can observe how much a unit shock causes other variables to change over time. This means that with VAR, we can know what effect a cryptocurrency coin will have on the price of other cryptocurrencies and make predictions.

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

Written as Matrix: If $Cov(\varepsilon_{1t},\ \varepsilon_{2t}) = \begin{cases} \sigma_{12}, \textit{if } t = s \\ 0, \textit{else} \end{cases}$ and $y_t \equiv \begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix}$, $\varepsilon_t \equiv \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$, then

$$y_t = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \gamma_{11} \\ \beta_{21} & \gamma_{21} \end{pmatrix} y_{t-1} + \cdots + \begin{pmatrix} \beta_{1p} & \gamma_{1p} \\ \beta_{2p} & \gamma_{2p} \end{pmatrix} y_{t-[} + \varepsilon_t \quad (3)$$

In VAR model β is the coefficient of the lags of y with order p. The formula is based on two-time series variables $\{y_{1t}, y_{2t}\}$. Variable we treated as two regression function's explained variables. The explanatory variable the p order lagged value of the two variables. Then a bivariate VAR(P) system will form. ε allows two functions exist. In our Stata formula, we will use BTC log yield, BNB log yield, ETH log yield, and RMB-USD log yield as the variable for Varsoc to recognize p. The VAR model does not only use the economy as the basis for its construction, so we can also conclude when we use some non-financial related variables. And a smaller p is better than a larger p, which will improve the efficiency of the model construction.

We can test whether the VAR holds by checking whether it obeys normal distribution. This ensures that our VAR system has a smooth process. Then, we will then examine how much a unit shock causes the other variables to change over time, using the impulse response function built up by the VAR.

2.4 Impulse Response Function

$$\frac{\partial y_{t+s}}{\partial \varepsilon_j} = \varphi_s \quad (4)$$

When the number of j variable's perturbation term ε_{jt} increase 1 unit at term t, the effect of the number of i variable at (t + s) taking the value $y_{i,t+s}$. Consider $\left(\frac{\partial y_{i,t+s}}{\partial \varepsilon_{jt}}\right)$ as a function of the time interval s. Is IRF.

2.5 ARMA-GARCH

The purpose of the ARCH model is to study the volatility patterns, such as risk premium, leverage, spillover effects, and other explanatory variables. So, the variance equation is what we need to focus on when studying volatility. In 1982 Engle pointed out that there is also a special kind of heteroskedasticity in time series data. We also became this case as Autoregressive conditional heteroskedasticity, also known as ARCH. Moreover, in our constructed model, we need ARCH to consider the volatility impact the exchange rate will have on our three cryptocurrencies.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_p \varepsilon_{t-p}^2 \quad (5)$$

Under the study of volatility please span, the conditional variance of the perturbation term ε is $\sigma_t^2 \equiv Var(\varepsilon_t | \varepsilon_{t-1}, \ldots)$, and in the case of ARCH σ_t^2 representation conditional variance changes over time. So due to the volatility focus phenomenon, we need to assume that σ_t^2 depends on the square of the previous period's perturbation term. So as ε_{t-p}^2 increase, σ_t^2 will become greater.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_p \varepsilon_{t-p}^2 + y_1 \sigma_{t-1}^2 + \cdots + y_p \sigma_{t-p}^2 \tag{6}$$

In the ARCH model if the p-value is large, so many parameters are added to the operation, which will lose the capacity of the sample. So, we need GARCH model to reduce the parameters to be estimated. So, we need to add the autoregressive part of σ_t^2 to the ARCH model. After we construct the model in Stata, we can check whether $\alpha andy$'s coefficient is significant.

3 Empirical Results and Analysis

3.1 ADF Test

After conducting the ADF test, since the p-values of the price of Bitcoin, Ethereum, BNB, and RMB-USD exchange rates are all above 0.1, we used VAR to obtain the log yield to ensure the stability of the logarithmic original series (Table 1).

3.2 VAR Identification

There are many ways to identify the stability of VAR models and lag order results. For example, FPE, AIC, HQIC, and SBIC. in this paper, we use LR as the primary method as a reference for testing. When we build the VAR model, we need to identify the variables under study and the maximum order of the lags.

Table 1. ADF test

Variables	t-statistic	p-value
Price		
Exchange rate	−1.697	0.7520
Btcoin	−0.599	0.9790
BNB	−1.110	0.9274
ETH	−0.014	0.9941
Yield		
Exchange rate	−7.260	0.0000***
Btcoin	−9.015	0.0000***
BNB	−8.827	0.0000***
ETH	−8.731	0.0000***

By the results of VAR prediction, we can find that when Lag is 10, LR at this time has a significant mark*. So, we need to use lag 10 as our 10 observations at the current time for the subsequent prediction (Table 2).

When we consider the stability of a VAR model, we need to analyze whether the effect of an impulse on the VAR model disappears as it moves through time. If the effect gradually disappears with time, then it proves that our VAR model is stable. And the VAR model containing the unit root is unstable. In this paper, we can determine from Fig. 2 that since all the eigenvalues are inside the unit circle, we can be sure that our VAR model is stable (Fig. 1).

Table 2. VAR model identification

Lag	LL	LR	df	p
0	1487.04			
1	1496.19	18.3	16	0.307
2	1500.47	8.5714	16	0.930
3	1511.81	22.678	16	0.123
4	1522.76	21.893	16	0.147
5	1526.75	7.9778	16	0.950
6	1537.01	20.527	16	0.197
7	1549.86	25.692	16	0.059
8	1558.82	17.933	16	0.328
9	1566.96	16.272	16	0.434
10	1581.65	29.37*	16	0.022
11	1592.49	21.68	16	0.154
12	1599.27	13.561	16	0.631

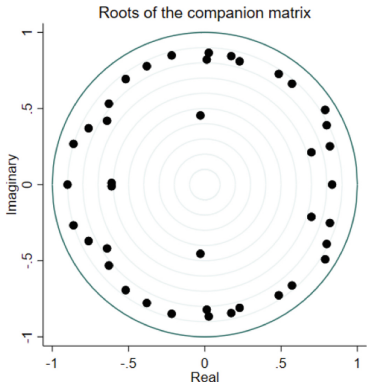

Fig. 1. VAR Stability

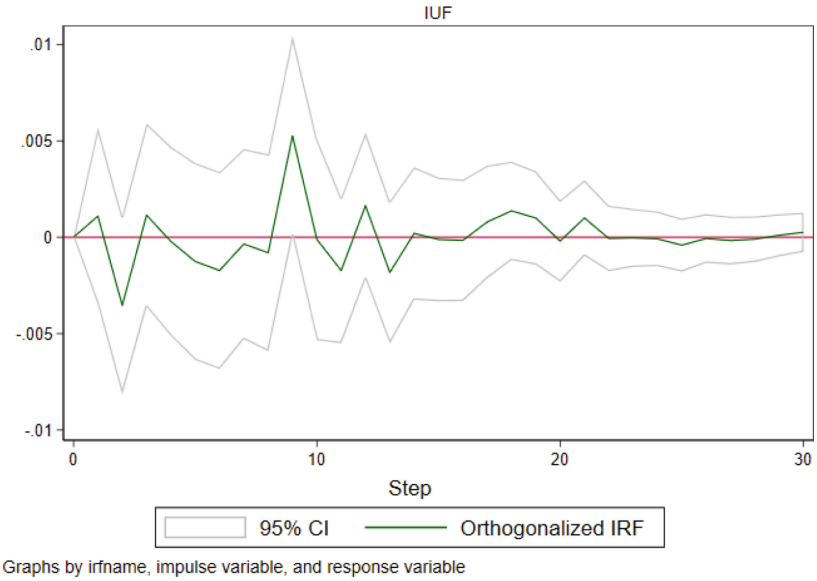

Fig. 2. BTC Impulse and response

3.3 Impulse Response

According to our impulse charts made for Bitcoin, Ethereum, and BNB, we can find that a change in the exchange rate during the gearing period will cause the electronic cryptocurrencies to emit similar changes in future periods. From the three impulse charts, we can see almost the same trend, all cryptocurrency prices fluctuate considerably in the 0–10 lag order, but the maximum oscillation is no more than 0.01. After ten steps, the oscillation calms down and converges sharply to 0. When the exchange rate changes by 1%, the cryptocurrency's yield produces a shock in the next fifteen steps, but the shock is always within or minus 0.5% of the expected magnitude. So, if we exclude the positive and negative offsetting cases where that effect exists, we can find that the appreciation of the US dollar due to the interest rate hike does not cause a relatively significant change in cryptocurrency market yields. In short, changes in interest rates do not affect long-term changes in the cryptocurrency market (Figs. 3 and 4).

3.4 ARMA Identification

In order to obtain the AR and MA's orders. We will use PACF and ACF to order the logarithmic yield series of Bitcoin, Ethereum, and BNB. The PAC Flag order chart for Bitcoin shows five significant values for orders equal to 9, 10, 14, 32, and 35. However, in BNB's PACF graph, we find five significant values for orders equal to 8, 9, 33, and 35. In the ACF graph, we only have a significant value of 9, so we will use nine as our order. In the Ethereum case, the PACF and ACF results have the same minimum value of order 3, so for the ETH, we will use the minimum value of 3 as our lag order to calculate (Figs. 5, 6, 7, 8, 9, and 10).

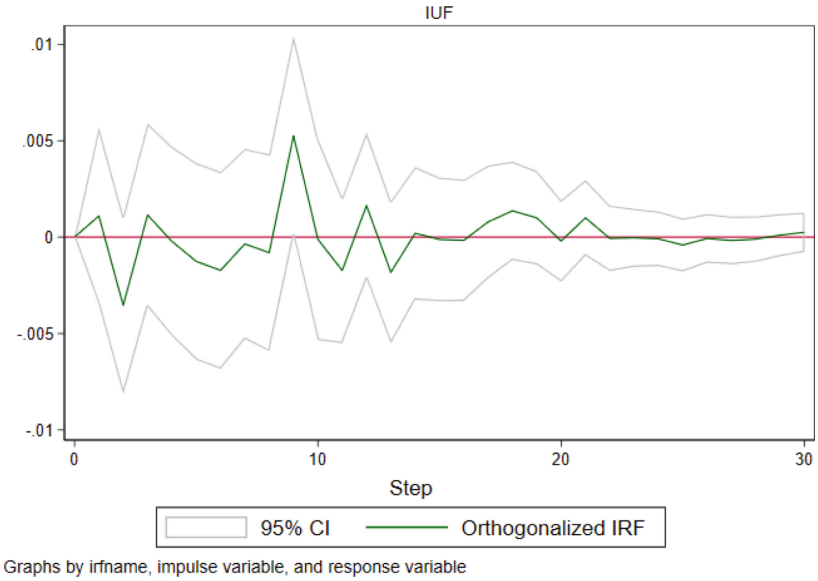

Fig. 3. BNB Impulse and response

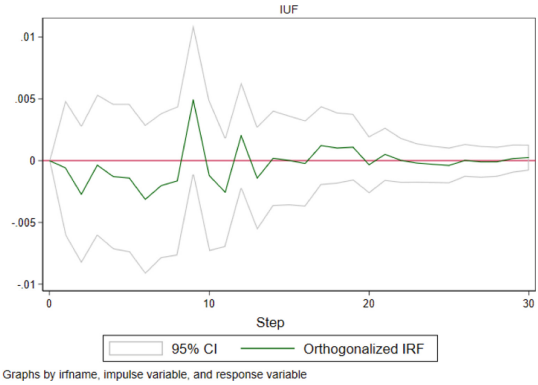

Fig. 4. ETH Impulse and response

3.5 ARMA-GARCH Analysis

Table 3 is obtained by setting the mean equation of the Grach model to the ARMA process and by introducing variance into the mean equation. Thus, we can observe the investor's measure of risk from the data, and we can observe both return and volatility. The data that we put into the arch model are the log returns of the three cryptocurrencies. In the ARMA-GARCH model, we will use the RMB-USD trading exchange rate as our explanatory variable. From the estimation results of the variance equation, the ARCH terms of bitcoin

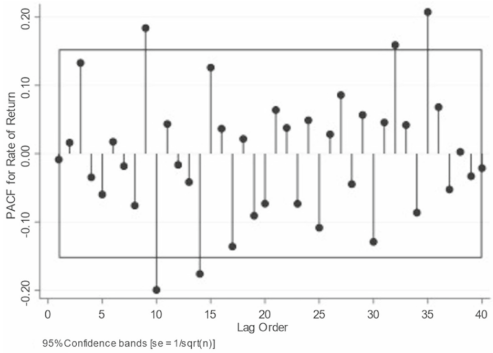

Fig. 5. PACF, BTC

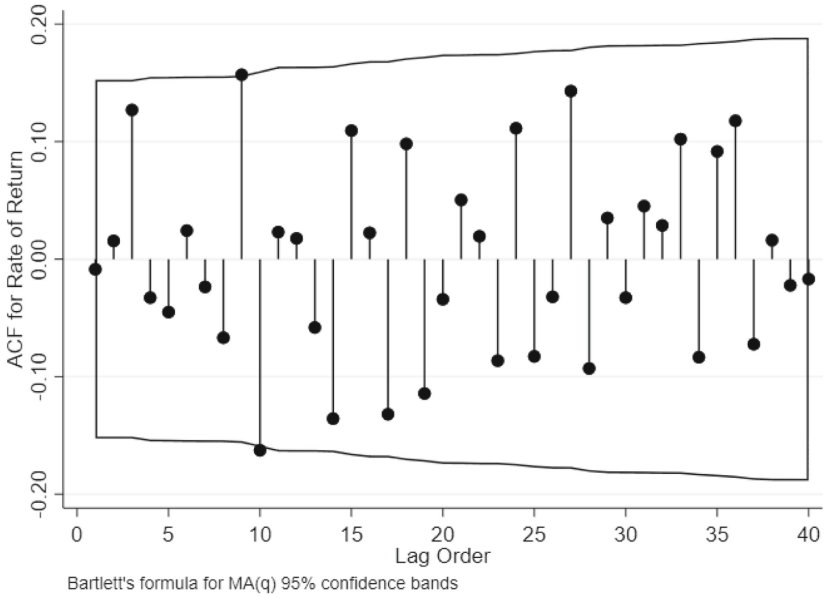

Fig. 6. ACF, BTC

return and Ethereum return are significant, indicating that there is significant conditional heteroskedasticity in the returns of these two cryptocurrencies, which can be modeled as GARCH, and the ARCH and GARCH effects of BNB are not significant and fit into the model. Moreover, by Variance, it can be shown that Bitcoin investors are more risk-averse because Bitcoin has the most considerable GARCH value. Based on arch and constant's significant marking * from Table 3 and impulse graph, we can conclude the

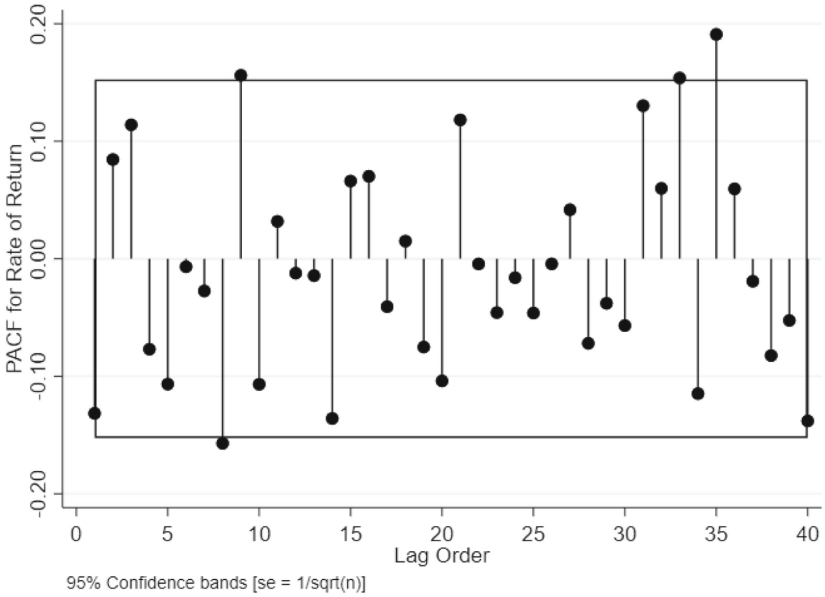

Fig. 7. PACF, BNB

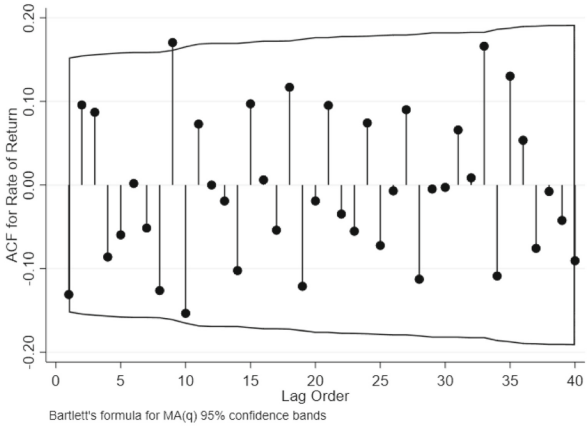

Fig. 8. ACF, BNB

following. According to the calculated valuation of exogenous variables, the floating exchange rate does not increase the daily volatility of cryptocurrency yields.

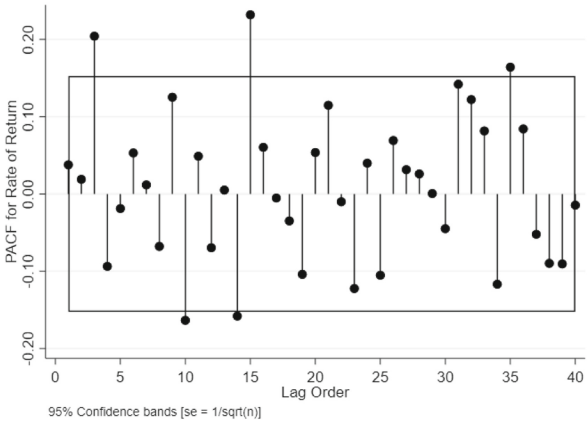

Fig. 9. PACF, ETH

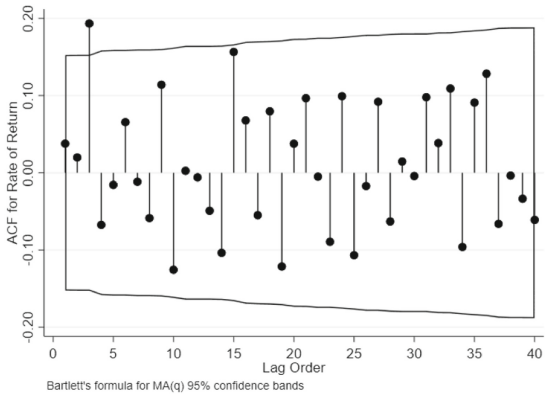

Fig. 10. ACF, ETH

Table 3. ARMA-GARCH estimation results, variance equation

Variables	(1)	(2)	(3)
	BTC	BNB	ETH
Exchange rate	1005.54	1177.144	1176.254
	(877.8451)	(775.1583)	(754.7588)
ARCH (−1)	0.0136**	0.1020	0.0181**
	(0.0695)	(0.1708)	(0.0768)
GARCH (−1)	0.3476	0.1355	0.2237
	(0.3498)	(0.3263)	(0.3432)
Constant	(−7.2579)	−6.9372	−6.7781
	(0.5726)	(0.4824)	(0.5080)

4 Discussion

We can find the results according to our estimation results by ARMA-GARCH combined with impulse responses. The market float of cryptocurrencies is not subject to interest rate de-variation as in Glenn R. Mueller's [1] analysis of fundamental economy markets. Whether it is negative investor sentiment due to higher interest rates or higher investment risk due to higher interest rates, these factors do not significantly affect the float of the cryptocurrency market. While the increase in interest rates may not yet have affected investors' positivity toward the cryptocurrency market, our conclusions' risk or predicted value has always remained very low. Based on Makarov, Igor, and Antoinette scholar's paper [10] we can find out that The United States plays an important dominant effect on the cryptocurrency market. So, what kind of government factors or changes in economic policies will affect cryptocurrencies as a market and for a highly globalized trading market, whether the economic policies of individual countries will influence the nature of the cryptocurrency market is something we need to continue to discuss. For governments and economic market rule makers, will such a market not easily influenced by government policies become a market full of the black market? For investors, the results of ARMA-GRACH will allow more people to invest in the cryptocurrency market as a short-term option to combat the impact of interest rate hikes.

5 Conclusion

The new market created through the epidemic's impact could be a dramatic change to the current investment system. The rise of new markets will undoubtedly steal market share and investment share from traditional markets. For example, many funds in the equity market have already started investing in the cryptocurrency market. Based on this paper's conclusion that from the basic finance theory, the Fed's rate hike may lead to the flow of funds from the stock market, foreign exchange market, and other financial markets, including the debt market. In terms of the estimation results from this paper, the cryptocurrency market is relatively independent and is not affected by the changes in exchange rates. This represents that the cryptocurrency market may not have as much influence on government decisions as other traditional markets. It is possible that the independent and highly globalized characteristics of the cryptocurrency market could serve as a benchmark and template for fully open markets and provide lessons for new markets in the future.

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