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The Time-Varying Impact of the Federal Reserve Rate Hike on Bitcoin

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Abstract

The Federal Reserve has raised interest rates four times in a row, twice by 75 basis points from June to July, totaling 150 basis points, since 2022 in an effort to reduce the rising inflation in the United States. This is the most important development since 1980. After the rate hike in July, the policy rates of the United States have reached a range from 2.25% to 2.50%, which is widely considered by dozens of people as a "neutral rate" level. Since the U.S. dollar is the dominant international currency and controls the world's financial, monetary, and trade settlement systems, the Fed's interest rate hike has an impact on the world financial market. Bitcoin has become a financial asset traded on a global scale and has gradually become popular in financial market transactions. With the Fed's rate hike, a considerable number of investors in the cryptocurrency market are very concerned about the impact of the Fed rate hike on Bitcoin, and then reassess the risks to ensure their own interests. This paper searches and obtains data on the Bitcoin price and USD/CNY exchange rate from June 1, 2021 to August 15 2022. This paper uses VAR and ARMA-GARCH models to study the impact of the USD-CNY exchange rate changes on the rate of return and volatility of Bitcoin.

Keywords: US; Federal Reserve Bank; rate hike; USD; CNY; ARMA-GARCH model

Introduction

In recent years, asset programs—the buying and selling of assets—have grown in importance as a weapon of the Federal Reserve [1]. A considerable number of experts and investors are concerned about whether the Fed's actions have an impact on the rate of return on assets. However, it is debatable whether the interest rates set by the central bank may affect economic investments [2]. It is commonly accepted by a number of researchers that the Federal Reserve has changed the rate several times. For example, The Federal Funds rate in the United States approached the zero lower limit in December 2008, because in comparison to earlier periods of financial turbulence, the financial crisis that started in late 2007 was global in scope, unprecedented in scope, and resulted in record low interest rates in the majority of advanced nations, and then the Fed then changed the rate by using an unconventional monetary policy [3]. The Fed usually raises interest rates to solve some significant practical problems, such as inflation. The Fed's mechanism for raising interest rates is explained as follows. The interest rate hike is to raise the U.S. federal funds rate, which means that banks and banks temporarily borrow money from each other in order to meet the temporary shortage of deposit reserves mandated by the central bank in the U.S. The hike of interest rate is to increase the overall interbank lending rate in the market and maintain it within a certain range. The federal funds rate is calculated by combining the major interbank offered rates in the market, and each bank can decide for itself the interest rate at which it lends or borrows funds. As the central bank, the Federal Reserve will not directly participate in the inter-bank lending business of these commercial banks like ordinary banks. It makes short-term fund owners feel that it is more cost-effective to give money to the Federal Reserve than to commercial banks. Soon the interbank lending market will face a situation where there is no money to borrow. Banks which are unable to pay the central bank for deposit reserve have to borrow money from

other banks, which can lead to an increase in the interest rate. At this time, it will be difficult for the Fed to reach the desired target of raising interest rates. Therefore, the Fed usually needs to use other methods to recover funds from the market first, so that commercial banks are generally short of money, so as to achieve the target of raising interest rates faster. The Federal Reserve is responsible for issuing currency. The Fed mainly purchases government-issued government bonds and other assets, lends to commercial banks with mortgages or sells these bonds. With the sale of bonds, the money of financial institutions is gradually pocketed by the Fed. Therefore, banks and other financial institutions have less money available for other investments and lending.

A considerable number of digital currencies, such as Bitcoin, have arisen during the past ten years. In terms of both price volatility and spectacular price development, Bitcoin stands out as the most notable of them [4]. In 2009, Satoshi Nakamoto invented Bitcoin, a digital money that has subsequently gained popularity owing to its decentralized nature and the technology that powers it. In a peer-to-peer system like Bitcoin, transactions happen without the involvement of a central party. The network's nodes validate the transactions, which are then added to the Blockchain for storage. A distributed database called the Blockchain maintains a permanent record of all network activity. Since Bitcoin became well-known, a number of technological businesses have become interested in it and have begun investigating its potential uses and advantages. Governments, investors, and regulators all need to understand Bitcoin volatility. There may be improved rules for this cryptocurrency's official usage in many economies throughout the world if the price and volatility of it are better understood. Understanding these features of Bitcoin may lower the risk associated with using and investing in this money [5]. It is commonly accepted by plenty of academic researchers that the price of Bitcoin is influenced by plenty of factors, such as COVID-19 and some monetary policies.

This paper focuses on the impact of the Federal Reserve rate hike on Bitcoin based on ARMA-GARCH model.

The remaining parts of this paper are arranged as follows: Part 2 is research design, including data sources, unit root test and model specification; Part 3 is empirical results and analysis, including model identification and estimation results; Part 4 is discussions which mainly focus on the similarities and differences between the conclusions of this paper and existing literatures, research implications, and some research findings for policy makers and investors; Part 5 is conclusions.

Research Design

Data Source

The data used in this research paper comes from Investing.com [6]. It is a website showing financial platform and news. Investing.com is one of the top three financial websites in the world, and it is founded in 2007 by Dror Efrat. It provides market conditions, information on stocks, futures, options, analytics, and commodities. This paper searches and obtains data on the Bitcoin price and USD/CNY exchange rate from June 1, 2021 to August 15, 2022 through this website to empirically analyze the impact of the Federal Reserve Bank rate hike on the Bitcoin price from June 1, 2021 to August 15, 2022. Data on the Bitcoin price and data on the USD/CNY exchange rate from June 1, 2021 to August 15, 2022 are merged in one file and then put into Stata.

Unit Root Test

It is essential to conduct a unit root test which is also known as a smoothness test on the model once it has been constructed. After checking the initial prices and yields, the result is that the model is not smooth. In order to make the model stationary, taking the logarithm of the data is necessary.

This part calculates the logarithm of the prices of Bitcoin and exchange rates, and the logarithm of yields of the prices of Bitcoin and exchange rates by using the following mathematical formulas.

$$logarithm\ of\ price = \ln(1 + price) \tag{1}$$

$$yield = \frac{the\ closing\ price\ of\ today - the\ closing\ price\ of\ yesterday}{the\ closing\ price\ of\ yesterday} \tag{2}$$

$$logarithm\ of\ yield = \ln(1 + yield) \tag{3}$$

This part checks the corresponding stationarity. It can be seen clearly from Table 1 that after entering the data into Stata and conducting the ADF test, the p-values for the log-yields are 0, which are less than 0.1, and we can thus obtain the information that the model is stable and practicable now.

Variables	*t-statistic*	*p-value*
Price		
Bitcoin	-1.7410	0.7326
USD-CNY	-1.0650	0.9347
Yield		
Bitcoin	-15.5880	0.000***
USD-CNY	-15.4890	0.000***

Table 1: ADF test.

VAR Model Specification

In time series research analysis, vector autoregressive (VAR) models are always applied such that researchers are able to check the dynamic correlations between interacting variables [7]. OLS might be beneficial to estimating the VAR system equation by equation, and OLS can provide a consistent and effective estimate of the VAR(p) if the errors are assumed to be normal [7]. If all variables are monolithic and non-stationary variables have a cointegration connection, the first difference method should be used to construct a VAR model and VECM model should be considered. This paper considers the logarithm of yields of bitcoin prices and exchange rates as two variables to construct VAR model. For instance, one 2-dimensional VAR (1) model is as follows [8].

$$y_{1,t} = c_1 + \emptyset_{11,1} y_{1,t-1} + \emptyset_{12,1} y_{2,t-1} + \varepsilon_{1,t} \quad (4)$$

$$y_{2,t} = c_2 + \emptyset_{21,1} y_{1,t-1} + \emptyset_{22,1} y_{2,t-1} + \varepsilon_{2,t} \quad (5)$$

where $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are white noise processes which might be contemporaneously correlated. The coefficient $\emptyset_{ii,l}$ captures the influence of the lth lag of variable y_i on itself, while the coefficient $\emptyset_{ij,l}$ captures the influence of the l th lag of variable y_j on y_i.

ARMA-GARCH Model Specification

Floating and volatility models are typically included in financial time series [9]. Moving average, ARIMA, and many other mean models have traditionally been used to model the floating component [9]. When financial time series contain stylized data, the volatility of the series will be modelled, and ARCH/GARCH modelling is a viable option [9].

The following mathematical formulas can be obtained [9].

$$\text{AR(m):} \quad \gamma_t = \mu + \emptyset_1 \gamma_{t-1} + \emptyset_2 \gamma_{t-2} + \cdots + \emptyset_m \gamma_{t-m} + u_t \quad (6)$$

$$\text{MA(n):} \quad \gamma_t = \mu + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \cdots + \theta_n u_{t-n} \quad (7)$$

Where $u_t (t = 1,2,3, \ldots)$ is a white noise disturbance term with $E(u_t) = 0$ and $var(u_t) = \sigma^2$.

$$\text{ARMA(m,n):} \quad \gamma_t = \mu + \emptyset_1 \gamma_{t-1} + \emptyset_2 \gamma_{t-2} + \cdots + \emptyset_m \gamma_{t-m} + +\theta_1 u_{t-1} + \theta_2 u_{t-2} + \cdots + \theta_n u_{t-n} + u_t \quad (8)$$

$$\text{GARCH(p,q):} \quad \sigma_t^2 = \delta + \sum_{i=1}^{p} \beta_i \, \sigma_{t-1}^2 + \sum_{j=1}^{q} \alpha_j \, \varepsilon_{t-j}^2 \quad (9)$$

Where δ is defined as the long-run volatility with the condition that $\delta > 0$, $\beta_i \geq 0$; $i = 1, \ldots, p$ and $\alpha_j \geq 0$; $j = 1, \ldots, q$. If $\beta_i + \alpha_j < 1$, then the GARCH (p, q) model is covariance stationary. The unconditional variance of the error terms is explained by a mathematical formula: $var(\varepsilon_t) = \frac{\delta}{1-\beta-\alpha}$.

According to the mathematical formula of the GARCH (p, q) model, the GARCH (1, 1) model can be demonstrated as $\sigma_t^2 = \delta + \beta\sigma_{t-1}^2 + \alpha\varepsilon_{t-1}^2$.

It is essential to add the exchange rate as an external explanatory variable in the variance equation.

Empirical Results and Analysis

VAR Model Identification

LL is the abbreviation of log-likelihood function and LR, similar to LL, is also the abbreviation of likelihood ratio test which means the likelihood ratio test for the joint significance of the last-order coefficients. When the LR statistic is less than the critical value, the lag order of the VAR model is moderate. When the LR statistic is greater than the critical value, it is considered that the lag order of the VAR model is not high enough, and more lag variables need to be added as explanatory variables. When the sample size is not sufficiently large compared to the number of estimated parameters, there will be a big difference between the finite sample distribution of LR and the asymptotic distribution of LR. The minimum values should be selected for FPE, AIC, HQIC and SBIC. Table 2 shows the above-mentioned statistics estimation results.

Lag	*LL*	*LR*	*df*	*p*	*FPE*	*AIC*	*HQIC*	*SBIC*
0	2875.72				5.0e-09	-13.4286	-13.4211	-13.4096
1	2888.03	24.619	4	0.000	4.9e-09*	-13.4674*	-13.445*	-13.4105*
2	2888.52	.96516	4	0.915	4.9e-09	-13.451	-13.4136	-13.3562
3	2888.72	.40838	4	0.982	5.0e-09	-13.4333	-13.3808	-13.3005
4	2891.58	5.7212	4	0.221	5.1e-09	-13.4279	-13.3605	-13.2572
5	2894.48	5.8075	4	0.214	5.1e-09	-13.4228	-13.3404	-13.2142
6	2895.72	2.4741	4	0.649	5.1e-09	-13.4099	-13.3125	-13.1633
7	2904.29	17.128	4	0.002	5.0e-09	-13.4312	-13.3189	-13.1467
8	2905.31	2.0495	4	0.727	5.1e-09	-13.4173	-13.29	-13.0949
9	2910.42	10.21*	4	0.037	5.1e-09	-13.4225	-13.2802	-13.0621
10	2912.96	5.0968	4	0.278	5.1e-09	-13.4157	-13.2584	-13.0174
11	2913.1	.26271	4	0.992	5.2e-09	-13.3976	-13.2253	-12.9614
12	2913.46	.73752	4	0.947	5.3e-09	-13.3807	-13.1934	-12.9065

Table 2: VAR model identification.

From Figure 1, it is obvious that all points are inside the circle, which can prove that the series is stationary.

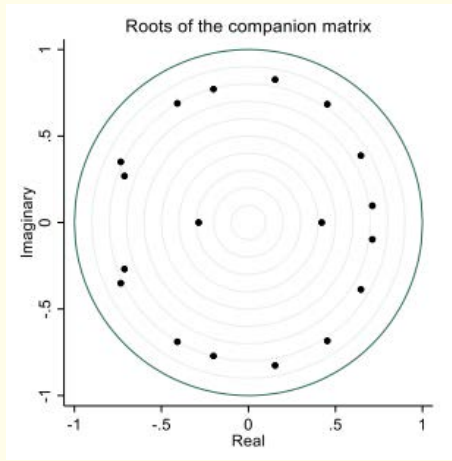

Figure 1: Unit root test.

Impulse and Response

From theoretical analysis, the Fed raising interest rates will result in a rise in demand for dollars in international hot money and the international financial market, and further deduce the dollar price and exchange rate, but this has two effects on the financial market. First and foremost, the U.S. dollar is one of the few currencies which can be directly traded with cryptocurrencies in fiat currency, which means that the U.S. dollar can be directly exchanged for cryptocurrencies. International financial markets have increased holdings of U.S. dollars, and this part of the extra funds may flow to the domestic stock market, bond market or other financial markets in the United States, and of course may also flow into the cryptocurrency market, leading to increased demand and prices. The above are the indirect effects of the exchange rate increase. A direct impact of an increase in the exchange rate on the financial market of other countries or the international financial market is that after the international hot money increases its holdings of dollars, funds from other countries or other markets may flow out, which in turn leads to lower demand and prices. Based on the above analysis, it is arduous to directly determine the net effect of the Fed rate hike on the cryptocurrency market.

According to the model results (Figure 2 and Figure 3), this paper demonstrates that: judging from the estimated results of the impulse response alone, it is difficult to judge the impact of the appreciation of the U.S. dollar triggered by the Fed's rate hike on Bitcoin's yield. The exchange rate shock of 1 unit at the time of t=0 has a positive effect on Bitcoin in the short term, but a large negative effect occurred at the time of t=6, which is about 0.15%. Accordingly, this paper continues to calculate the cumulative response function, which depicts the cumulative effect of a shock of 1 unit at the time of t=0 in the next 30 periods. It can be seen clearly from Figure 3 that the current exchange rate shock has a positive net impact on the yield of Bitcoin, with an effect slightly greater than 1%.

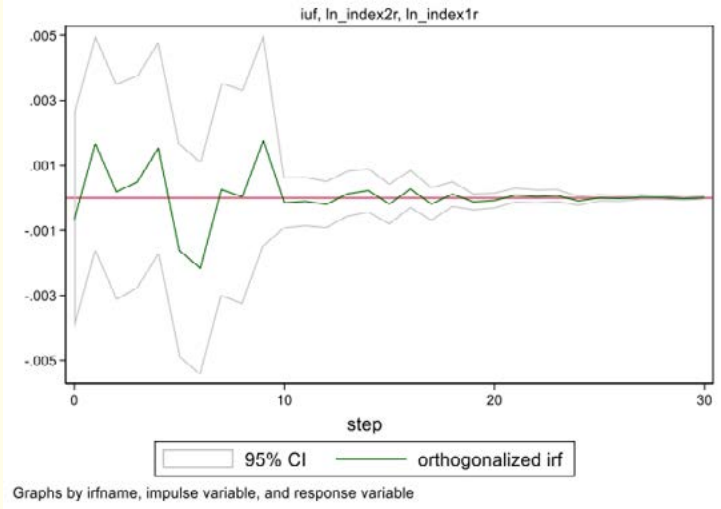

Figure 2: Impulse and response.

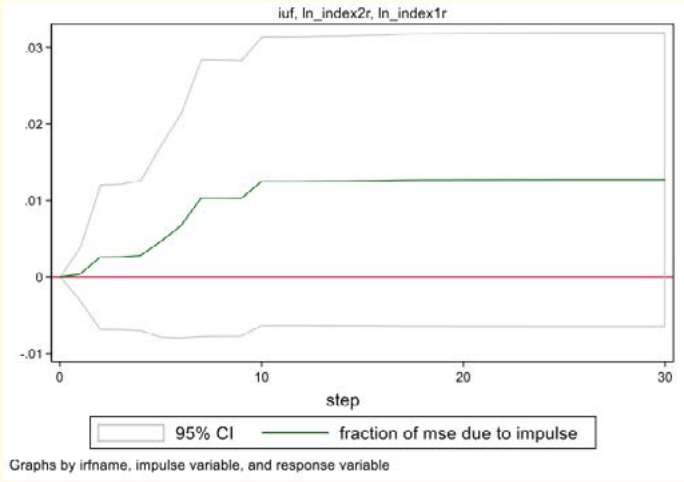

Figure 3: Cumulative response.

ARMA Model Identification

This paper orders logarithmic yield series of Bitcoin by using PACF and ACF (determine the order of the AR and the order of the MA), and presents the results in Figure 4. From the fixed order result of the two images in Figure 3, the first part beyond the x-axis is 9, so AR(P) is of order 9, MA(q) is also of order 9. i.e., the value of p and q is 9.

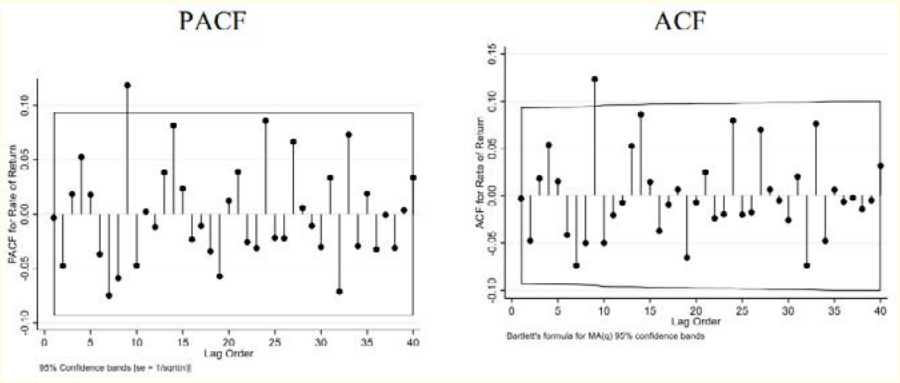

Figure 4: PACF and ACF.

Note: The Y-axis is the dependent variable, PACF, and ACF of the log of the rate of return on the price of Bitcoin, and the X-axis is the time lag order.

From the time series chart (Figure 5), the rate of return of Bitcoin has obvious clustering, but whether this effect is statistically significant still needs further empirical testing.

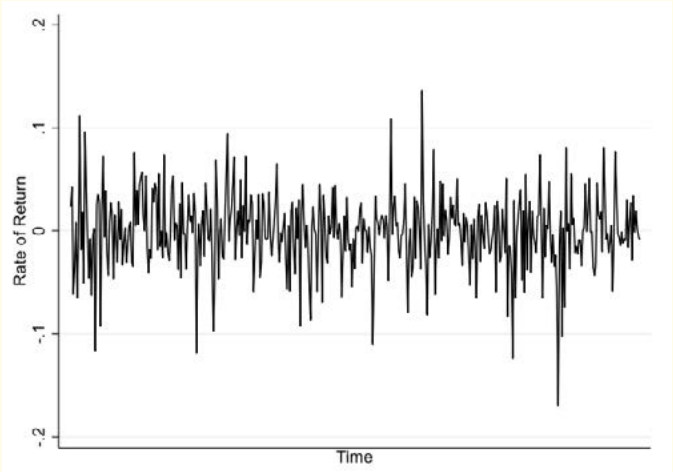

Figure 5: Yield trend.

ARMA-GARCHX Estimation Results

The exchange rate log return as an external explanatory variable is put in the variance equation. From the estimation results in Table 3, from the first column to the third column of the model, the ARCH term is not significant, while the GARCH term is significant which means that the rate of return of Bitcoin shows a statistically significant conditional heteroscedasticity, which satisfies the basic requirements of GARCH modeling.

From the estimation results of external explanatory variables, in the first column of the model, the logarithmic rate of return of the current exchange rate increases by 1 unit, and volatility of the Bitcoin increases by 210.9064 units, and the coefficient is significant at the level of 1%.

Furthermore, after adding the lagged term of the exchange rate logarithmic rate of return, the predicted coefficient for the most recent time is no longer significant, which indicates that the influence is lagged.

	(1)		*(2)*		*(3)*	
	Coefficient	***p>|Z|***	***Coefficient***	***p>|Z|***	***Coefficient***	***p>|Z|***
Mean equation						
AR, L9	-.3687	0.3170	-.3576	0.3420	-.3174	0.4240
MA, L9	.4801	0.1640	.4683	0.1850	.4314	0.2480
Constant	-.0005	0.7590	-.0006	0.7230	-.0008	0.6490
Variance equation						
Exchange rate						
L0	210.9064	0.0000	131.8810	0.9110	13.2325	0.9220
L1			148.5918	0.8860	33.2641	0.8140
L2					170.3945	0.0270
GARCH (1, 1)						
ARCH, L1	-.0066	0.1310	-.0067	0.1750	.0122	0.6050
GARCH, L1	.9877	0.0000	.9850	0.0000	.7840	0.0000
Constant	-10.7632	0.0000	-10.6176	0.0000	-8.3181	0.0000

Table 3: ARMA-GARCHX estimation results.

Discussion

This article studies the impact of the Fed's interest rate hike on the price of Bitcoin through data that is obtained from Investing.com on the USD/CNY exchange rate and the price of Bitcoin from June 1, 2021 to August 15, 2022. This research topic is relatively new in the existing academic literature. Other previous academic literature studies the price of Bitcoin and Fed rate hike as independent topics. The research interests of these academic papers mainly focus on the different reasons for Fed rate hike, the impact of Fed rate hike on other countries or other financial markets, and the use of machine learning methods to predict the price of Bitcoin. Some other research papers focus on the effect of Bitcoin price on the exchange rate. For instance, Bitcoin Sentiment Index and Bitcoin price have an unequal impact on the USD exchange rate [10]. This empirical study combines these two popular research fields to evaluate the impact of Fed rate hikes on Bitcoin from the perspectives of macro theory and the mathematical model. For policy makers, when dealing with various practical problems, not only macro factors such as inflation should be concerned, but also micro factors such as the impact of interest rate hikes on the cryptocurrency market should be carefully considered, and the interests of investors should not be undermined as much as possible. For cryptocurrency investors, under the condition of the Fed raising interest rates, investment behaviors should be more rational due to the complexity and uncertainty, and the impact of various factors should also be comprehensively considered.

Conclusion

To sum up, according to theoretical research, a rise in interest rates by the Fed would enhance demand for dollars in global hot money and the international financial market, which will further influence the price and exchange rate of the dollar. However, this will have two impacts on the financial market. The indirect effect is that a portion of the additional cash held by international financial mar-

kets may be transferred to the local financial markets in the United States, as well as, of course, to the cryptocurrency market, raising demand and prices. The immediate impact of a rising exchange rate is that after the increases of dollar holdings, funds from other markets may flow out, which in turn results in lower demand and prices. According to the data, it is difficult to pinpoint the overall impact of the Fed rate rise on the Bitcoin market. More empirical analysis and references are needed to further prove the conclusions.

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