



The Fed's Rate Hikes, USD-RMB Exchange Rate, and Dynamic Changes in Stock Market

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Abstract. Growing inflation causes US Federal Reserve increasing interest rates, however, it brings a problem for the stock market. This paper focuses on how increasing interest rates affect the Chinese and USA stock market by using VAR and ARMS-GARCH models. This paper selected daily closing prices from Yahoo Finance and Choice, which includes the National Association of Securities Dealers Automated Quotation (Nasdaq), Standard and Poor's 500 (S&P 500), Dow Jones Industrial Average (DJI), and China Concepts Stock (CCS). When the interest increases, us dollars are appreciated, and the China Yuan (RMB) depreciated. As a result, the United States import from China greater than export, which rises the trade deficit. It causes RMB outflow to the US market. It also harms US companies, which was proven by the model. The author suggests that the government should think about more aspects before making the suggestions. For the Chinese company, it is a great chance for companies whose business is exported to the US. In conclusion, the volatility of US dollars and the RMB exchange rate affect the stock market. US market return rate suffered a great impact, compared with China Concept Stock.

Keywords: Inflation · OLS model · interest rate

1 Introduction

Successively growing inflation is an issue in the United States. In the past 60 years, the average inflation is around 3.8% [1]. In May 2022, the United States inflation has reached 8.5% [2], which means customers will purchase fewer products due to the rising price of goods and services. This phenomenon pushed the Federal Reserve increasing interest to inhibit the growth of inflation. Therefore, the purpose of the paper is to find out how increasing interest affects the Chinese and American stock markets.

Federal Reserve is the United States central bank, founded in 1913, and takes charge of monetary policy. Monetary policy consists of maximum employment, stable prices, and moderate long-term interest rates, including maintaining inflation on average of 2.5%. The Federal Reserve decreased the basis points have been dropped by 150 basis points in 2020 due to the COVID-19 pandemic. Until 2022, Federal Reserve started to increase the basis points from March 2022 to 150. The latest increasing interest happened

on June 22, which is 75 basis points. It is the biggest since 1994 [3]. Keeping high inflation harms the economy. According to an article written by Darla Moore School of Business, high inflation will cause a recession and a rising unemployment rate, which is like the period in the early 1980s in the United States [4].

If the interest increases, then export will increase, and capital outflow will occur. At the same time, changes in interest rates will affect the exchange rate between the China Yuan (RMB) and the US dollar. When the Federal Reserve increases interest, dollars will appreciate and RMB will depreciate. From the global market perspective, the action caused Chinese companies to prefer to export to import. It is beneficial to Chinese companies. According to statistics, from 2020 to 2021, China's export to the United States rose from 432,683.4 million to 504,935.4 million [5]. On the other hand, the decision was adverse to the stock market. For example, capital outflow in China will increase, which means holding RMB is decreasing.

Most published papers mentioned the consequences of increasing interest rates in different aspects. For example, G Ciminelli discussed that US capital outflow exists but with a small amount [6]. Also, increasing interest is beneficial to the housing market [7]. When the author tested S&P500's 11 GIDS, the article concludes that interest rates have a negative relationship with stocks [8].

This paper uses time series models to analyze the impact of the USD-RMB exchange rate caused by the Fed's interest rate hikes on the yield and volatility of China's and American stock markets. The chosen variable is the National Association of Securities Dealers Automated Quotation (Nasdaq), Standard and Poor's 500 (S&P 500), Dow Jones Industrial Average (DJI), and China Concepts Stock (CCS). Then, the independent value is the exchange rate between dollars and RMB. The daily statistic was selected from January 2022 to June 2022. Nasdaq was founded in 1971, and Nasdaq Composite reflects the changes in the stock market index that companies listed on Nasdaq. It is the first stock market that can transact electrically in the world [9]. Next, S&P 500 is a stock market index with 65 years of history, including five hundred big companies that are listed in the United States [10]. Furthermore, DJI represents the 30 companies, such as Goldman Sachs Group Inc., listed in the United States stock market [11]. CCS is a group of Chinese companies listed on the United States stock market. The exchange rate is a ratio of one currency to another. In other words, it expresses one currency to another currency [12].

In the following sections of the paper, the author separated the paper into research design, empirical results, decision, and conclusion. The research design is going to explain the method and procedure that the paper used. Empirical results are the consequence of the model. The decision part elucidated the suggestions for researchers. The last part will summarize the main idea of the paper.

2 Research Design

2.1 Data Sources

Data were downloaded from two websites. Nasdaq, S&P 500, and DJI are collected from Yahoo Finance. CCS and exchange rate are selected from CHOICE. CHOICE is a finance APP in China. In the system, investors have access to view the latest stock market

information and stock data, including The United States' inflation increases severely, especially in 2022. The data was selected daily, which was from January 2022 to June 2022, then chosen the closed prices for each index to do the VAR and ARMA-GARCH. VAR gets the results of lags, then tests the stationarity for the data. ARMA-GARCH testify the hypothesis. In the following sections, this tester should test the logarithm's stationarity index will be applied to the model.

2.2 ADF-Test

Before creating the model, this tester should make sure of the stationarity. If the data is not stationarity, it is difficult for testers to get results. The Augmented Dickey-Fuller test is capable to test the stationarity for a series of data. The model separates two scenarios, prices, and yields. The first step of the test is in (1). The tester should set a hypothesis, which is all the closing prices are stationarity. If the hypothesis failed, the alternative hypothesis, which is the yield of data is stationarity. The second step will use the formula in (2). It is the ADF test to make sure the data stationarity.

The model is as followed:

$$y_t = \varnothing + \theta x_t + z_t \tag{1}$$

$$x_t = c_t + \beta x_{t-1} + \sum_{i=1}^{p-1} \varnothing \Delta x_{t-i} + e_t \tag{2}$$

Table 1 shows the result of the ADF test. P-value plays an important role in the analysis, which is called the possible value. When the possibility value is small, the original hypothesis will be refuted. When the p-value is smaller than the 0.01, it is most stationarity. If the p-value is greater than 0.1, it is less stationarity. In Table 1, choosing closed prices to test the stationarity conclude that they are nonstationary because all the p-value are large in the above range. However, the yield sections are more stationarity than the price segment because their p-values are zero. As a result, the data in the following sections will use logarithmic yield data in the model.

2.3 Model Specification: VAR

“A Vector autoregressive (VAR) model is useful when one is interested in predicting multiple time series variables using a single model” [13]. The prediction makes variables mutually consistent with each other, which is called multivariate time series. In (3) and (4), y_{1t} and y_{2t} are time series. β is the coefficient matrices, and \mathcal{E} indicates the noise that is called the vector white noise process. One of its advantages is applying more than one variable. The model serves as the OLS model if variables are stationarity, which means the p-value is small. In this case, the index's yield data will be used.

The model is as followed:

$$y_{1t} = \beta_{10} + \beta_{11}y_{t-1} + \dots + (\beta_{1p}\gamma_{1p})y_{t-p} + \varepsilon_{1t} \tag{3}$$

$$y_{2t} = \beta_{20} + \beta_{21}y_{t-1} + \dots + (\beta_{2p}\gamma_{2p})y_{t-p} + \varepsilon_{2t} \tag{4}$$

Table 1. ADF test

Variables	t-statistic	p-value
Price		
Exchange rate	-1.7480	0.7295
Nasdaq	-2.6150	0.2730
S&P 500	-0.2060	0.2795
DJI	-2.8570	0.1768
CCS	-2.9030	0.1611
Yield		
Exchange rate	-6.9180	0.0000***
Nasdaq	-7.3530	0.0000***
S&P 500	-7.6320	0.0000***
DJI	-0.4340	0.0000***
CCS	-7.4910	0.0000***

The impulse responses examine how one independent variable impacts other dependent variables within a period. In (5), how do the changes of \mathcal{E} affect the various $(t + s)$. In other words, when the one variable with t period increases by one unit on ε_t , how does that influence all variables with $(t + s)$ periods. The left of the formula, $(\partial y(t + s))/(\partial \varepsilon_t)$, is called IRF. The model is as followed:

$$\frac{\partial y_{t+s}}{\partial \varepsilon_t} = \varphi_s \tag{5}$$

2.4 Model Specification: ARMA-GARCH

ARMA stands for Autoregressive Moving Average. The purpose of the model is to use past error items to predict the future [14]. In (6), α_{t-i} is the lag error term. The combination of the AR model and MA model is a special case of ARMA.

GARCH has additional terms compared with the ARCH model, which is $\alpha_q \varepsilon_{t-q}^2 + \gamma_1 \sigma_{t-p}^2$ in (7). In the ARCH model, when the p-value is larger and growth parameters, which destroy the sample volume. Alpha is the excess return and \mathcal{E} is the distributor. To reduce the parameters, GRAPH was created in 1986 by Bollerslev [15]. This model can decrease the parameters and make the prediction more accurate. A commonly used GARCH model is (1,1), which is written as $\sigma^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2$. PACF and ACF are the graphs that serve for ARMA ordering.

The model is as followed:

$$x_t = \varnothing_0 + \sum_{i=1}^p \varnothing_i x_{t-i} + \alpha_t - \sum_{i=1}^q \theta_i \alpha_{t-i} \tag{6}$$

$$\sigma^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \tag{7}$$

3 Empirical Results

3.1 VAR Order Identification

The VAR’s purpose is to examine dynamic correlations amount multiple variables. As a result, Table 2 shows the VAR has 12 lags. Furthermore, the data indicate that HQIC and SBIC are smaller when the lag is smaller. For example, when the lag is less than one, its HQIC and SBIC are the smallest amounts of the data. To do a deeper analysis, the tester should ensure the stationarity of the data. Figure 1 shows the stationarity of the data because all the points are in the circle.

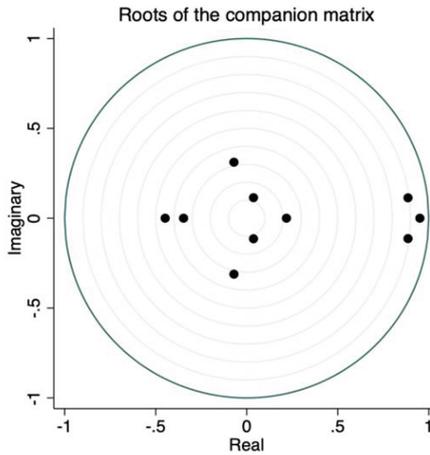


Fig. 1. VAR stability

Table 2. VAR Model Identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1579.5				7.6e−21	−32.1327	−32.0794*	−32.0008*
1	1608	56.992	25	0.000	7.1e−21*	31.2041*	−31.844	−31.4128
2	1619.87	23.74	25	0.534	9.3e−21	−31.9361	−31.3493	−30.4854
3	1638.85	37.955	25	0.047	1.1e−20	−31.8132	−30.9597	−29.703
4	1654.08	30.473	25	0.207	1.3e−20	−31.6139	−30.4937	−28.8443
5	1676.12	44.067	25	0.011	1.5e−20	−31.5534	−30.1664	−28.1244
6	1705.3	58.361	25	0.000	1.4e−20	−31.6387	−29.985	−27.5502
7	1721.65	32.699	25	0.139	1.8e−20	−31.4622	−29.5417	−26.7143
8	1740.82	38.343	25	0.043	2.2e−20	−31.3422	−29.1561	−25.9359
9	1761.89	42.142	25	0.017	2.7e−20	−31.263	−28.8092	−25.1963
10	1788.13	52.487	25	0.001	3.1e−20	−31.2884	−28.5678	−24.5622
11	1825.2	74.136	25	0.000	3.0e−20	−31.5347	−28.5474	−24.1491
12	1863.84	77.277*	25	0.000	3.0e−20	−31.813	−28.599	−23.768

3.2 Impulse and Response

According to Fig. 2, the return decreases when the US dollar increases appreciated. However, the affection still has differences from the unalike stock index. First, Nasdaq has more than three thousand listing companies, so diversification can help the stock overcome the crisis. The chart for Nasdaq rate return fluctuates slightly. On other hand, S&P500 and DJI suffer a huge loss. According to the figures, the rate of return of two stock indexes dropped, but the phenomenon was only sustained in a short term. Finally, the event impacts the return negatively for CCS. On the other hand, the figure proves the hypothesis. The RMB depreciation did not affect the CCS performance, even though the rate of return increased. In contrast, the situation harms local companies in the United States. The results of the S&P 500 and DJI confirm the idea.

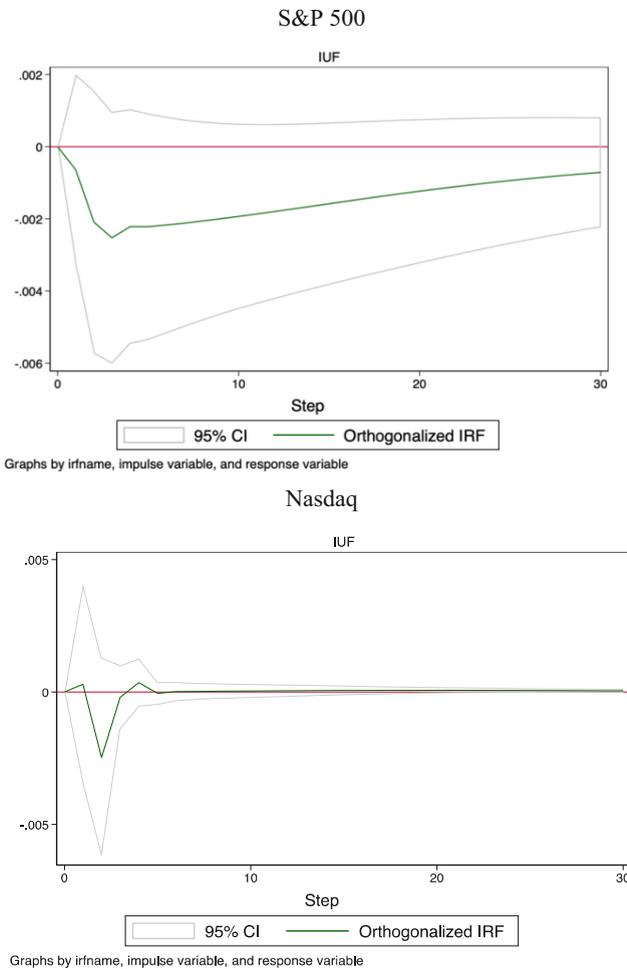


Fig. 2. Impulse and response

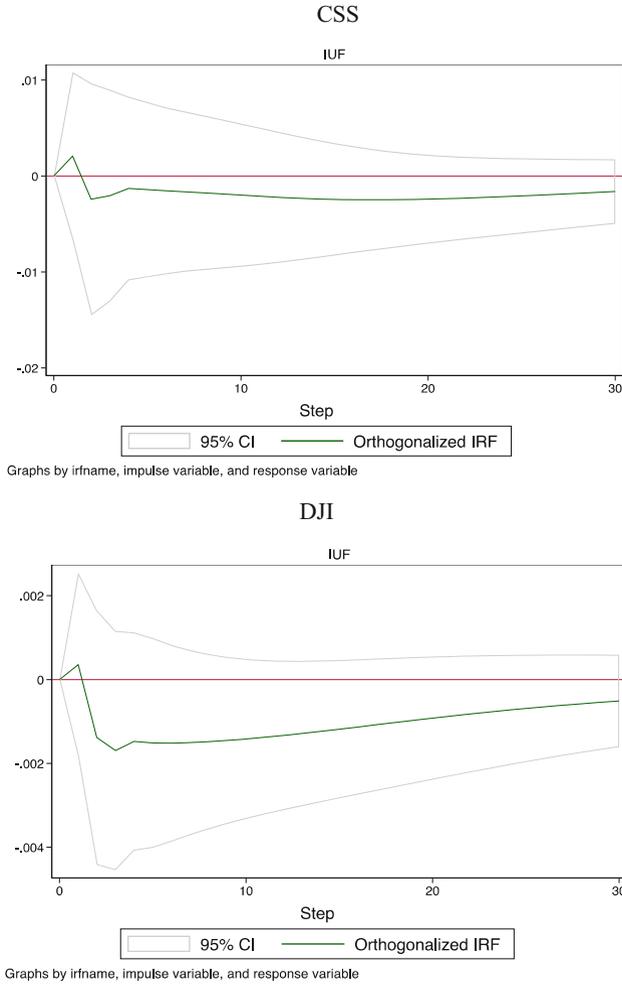


Fig. 2. (continued)

3.3 ARMA Identification

Figure 3 shows Nasdaq's PACF and ACF. The 95% confidence interval is the range of y value between 0.19 to -0.19 . For PACF, lag 7, lag 15, lag 33, and lag 37 are out of the 95% confidence interval. However, all other lag orders are in the 95% confidence interval.

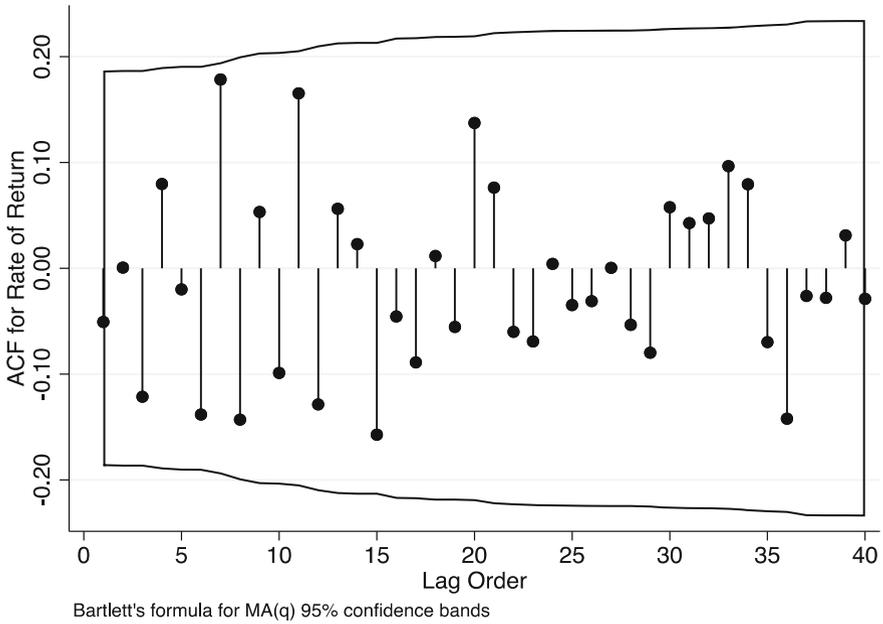
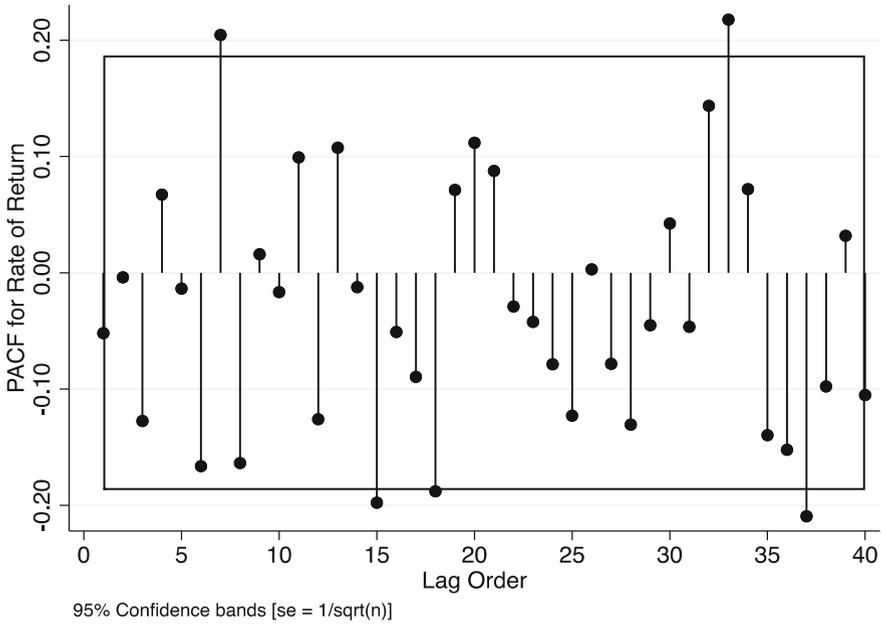


Fig. 3. PACF and ACF, Nasdaq

Next, Fig. 4 demonstrates S&P 500 PACF and ACF. In this case, the 95% confidence interval is the y-value from 0.19 to -0.19 . Lag 34, lag 36, lag 37, and lag 38 leave the

range of the interval. Similarly, S&P 500's lags are all in the 95% confidence interval, like Nasdaq.

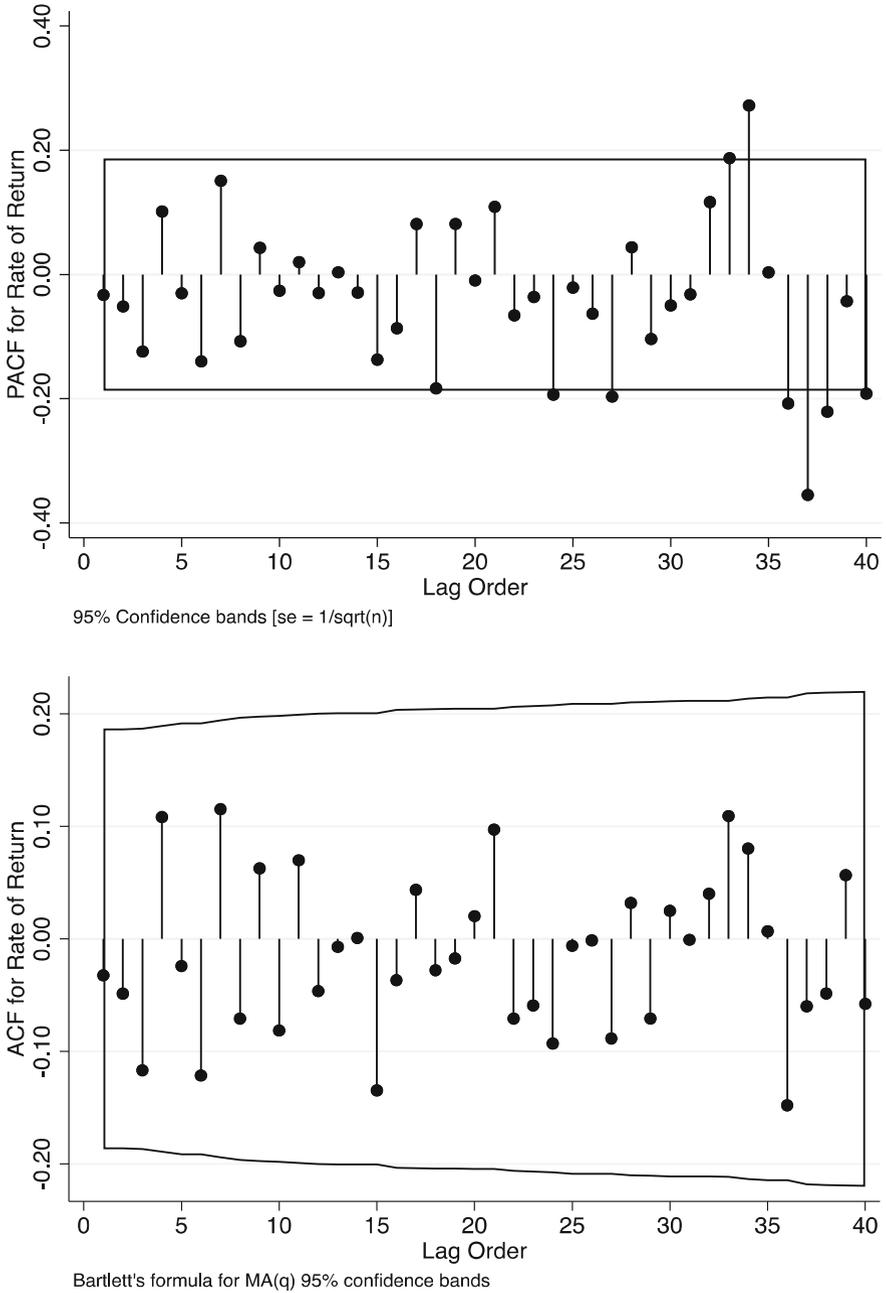
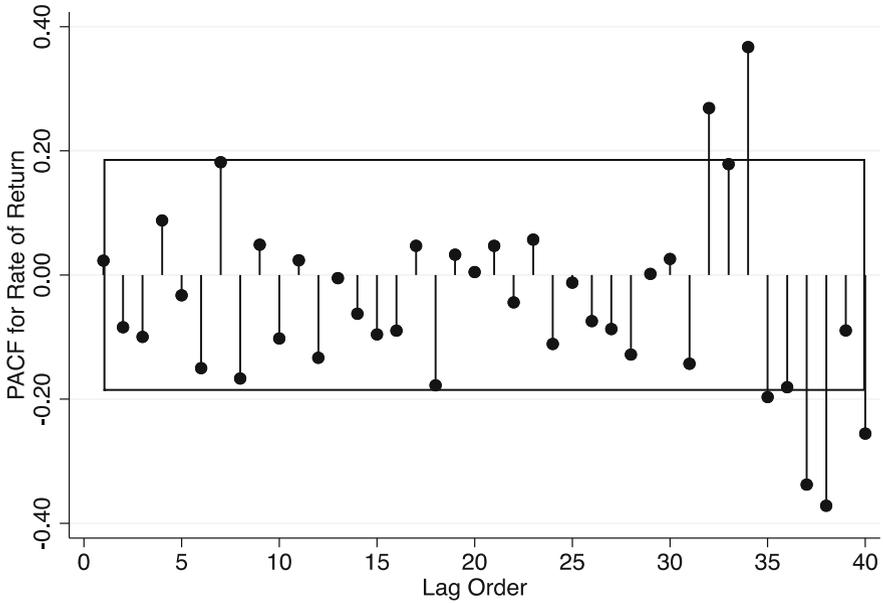
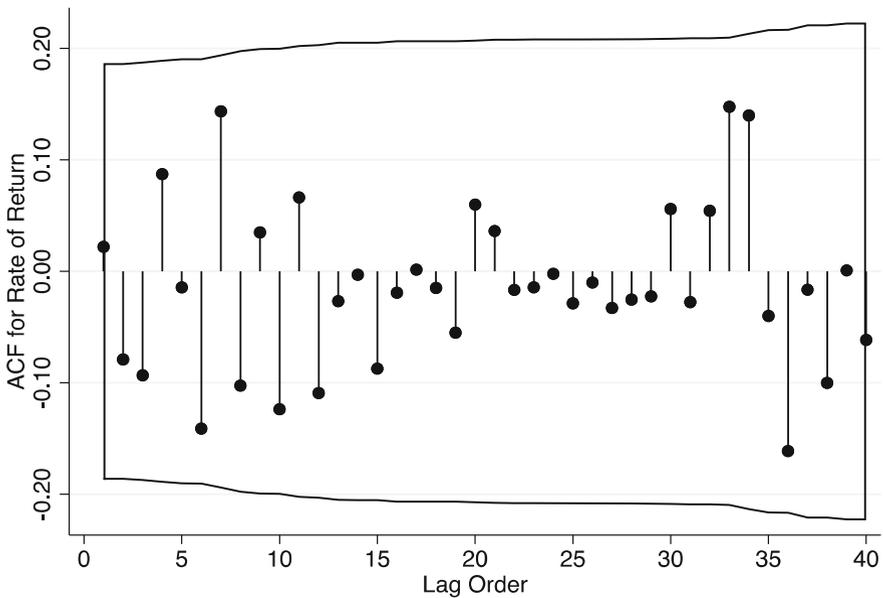


Fig. 4. PACF and ACF, S&P 500

Then, Fig. 5 below displays DJI's PACF and ACF. Its 95% confidence interval is the same as S&P 500 and Nasdaq. In the PACF figure, lag 32, lag34, lag 35, lag 37, lag 38,



95% Confidence bands [se = 1/sqrt(n)]



Bartlett's formula for MA(q) 95% confidence bands

Fig. 5. PACF and ACF, DJI

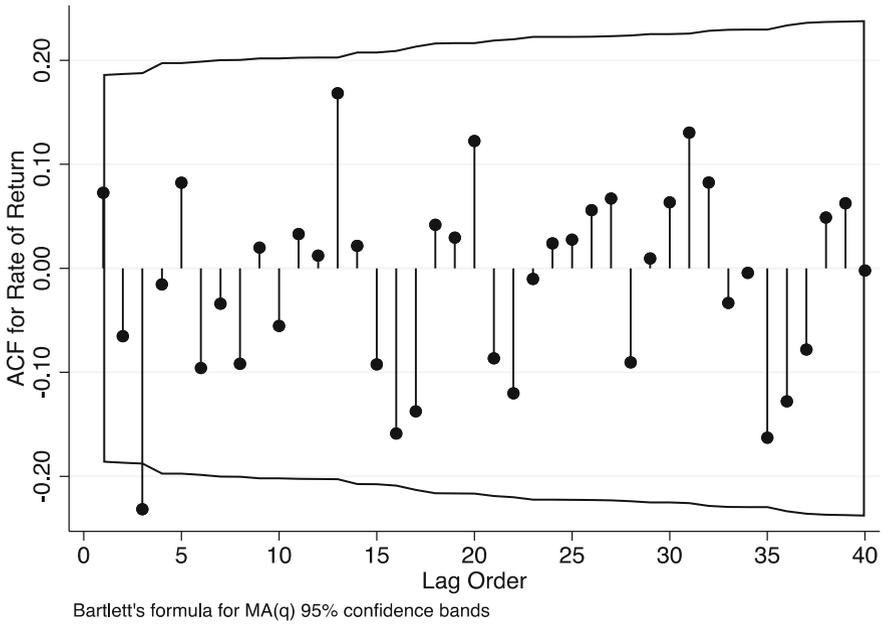
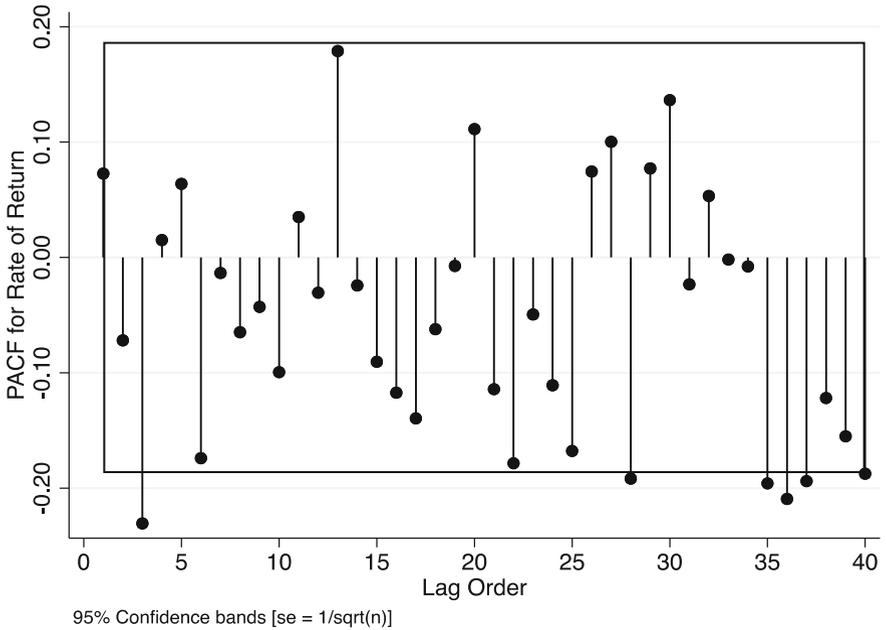


Fig. 6. PACF and ACF, CCS

Table 3. ARMA-GARCH estimation results

Variables	CCS	S&P500	DJI	Nasdaq
Exchange rate	-130.0965 (152.6041)	213.9702*** (62.6785)	3.9058 (6.9040)	198.7218** (63.3814)
ARCH (-1)	0.2834 (0.1737)	-0.0451 (.1153)	0.1061** (.0508)	-0.0803 (0.1253)
GARCH (-1)	0.5671** (0.1927)	0.7842*** (0.1771)	-1.1139*** (.1036)	0.8588*** (0.1099)
Constant	-7.9751*** (0.6637)	-10.0324*** (0.6767)	-8.2102*** (.0594)	-9.4909*** (0.7171)

and lag 40 are not in the interval. In contrast, all lags are in the 95% confidence interval in the figure of ACF.

Finally, Fig. 6 shows the CCS’s PACF and ACF. The 95% confidence interval should use the y value as standard, which should be 0.19 to -0.19. As a result, lag 3, lag 28, lag 35, lag 36, and lag 37 are out of the boundary. At this time, lag 3 is out of the 95% confidence interval in the figure of PACF.

3.4 Arma-Garch

According to Table 3, the exchange rate change makes statistical significance for S&P500 and Nasdaq. Value differences are the reason why they have statistical significance or not. The value of S&P500 and Nasdaq are 34 billion and 88 billion [16]. Compared with DJI, the stock indexes are 400 million. CCS listed in the United States are 281 companies. It is obvious that the value gap. The exchange rate rose one percent, the S&P 500’s rate of return volatility increased by 213 units, and the Nasdaq’s rate of return volatility increased by 198 units. At the same time, the S&P 500 and Nasdaq’s coefficients’ significance increased by 1% and 5%.

4 Discussion

In general, the paper focuses on the stock market index that can represent the stock market. The test model is different from other dissertations. The paper applies ADF-Test, VAR, and ARMA-GARCH to verify the influence that increasing interest rates. It is a unique method to give the conclusion from those models. The paper pays attention to the main indexes on the stock market, which can express the trend and influence of the stock market.

From a decision-maker aspect, the paper should give the idea that increasing interest rates may solve the problem of inflation. At the same time, the citizens bear the risk for the government. The stock market was hit by the decision. Government should think about more aspects. When they notice that the decision may harm the citizens, they should

carry out policies to help local companies. Moreover, the trade deficit will increase, which means the import is greater than the export, and the United States' investment has a net flow phenomenon. Growth import means the country relies on imports. Also, the government should think of an alternative method to solve the high inflation issue.

From the investors' aspect, it is a great chance to earn money for Chinese companies whose businesses are relevant to export. They should take the opportunity to set up the output for export. Investors should identify which type of stock market should be invested in. When investors meet a situation, like an increasing interest rate, it is appropriate to use the model above to help investors do the right decisions. However, it is necessary to give serious consideration to investing for avoiding being hotheaded. Investors should be skilled to pass judgment on how long the occurrence is.

5 Conclusion

As a result, the volatility of US dollars and RMB exchange rate affect the stock market. The increasing interest rate makes dollars more valuable, but it harms the stock market. As mentioned before, the stock index, such as DJI and S&P 500 have lost because of the change in interest rate. However, CCS did not influence this event.

In addition, the exchange rate affects S&P 500 and Nasdaq, but CCS and DJI have fewer influences. First, the stock index contains different fields and sizes of companies. S&P 500 includes 500 American companies, which are 70% of the whole stock market. Nasdaq performance by 2500 national and international common stocks that are listed on the Nasdaq stock exchange. Nasdaq is known as the electric stock exchange, so 50% of the stocks are in the Technology industry, which caused Nasdaq to have less variety. Those companies are the leading enterprise in different industries. Second, the stock selection has different standards from the different indexes. Being the stock in Nasdaq has a lower standard. The only standard is the company should list on the Nasdaq stock exchange. DJI's stock was selected strictly, which are 30 companies are qualified. To sum up, the reason why the exchange rate makes an impact on Nasdaq and S&P 500 is: that Nasdaq mixes stocks and basic standards, and S&P 500 are all American stocks.

Whatever China and the United States, the government and citizens face different problems. In the aspect of America, Chinese imports will be greater than export, which enlarge the gap of trade deficit. Although dollars appreciate, it is not advantageous to citizens. On the other hand, the China Yuan depreciation did not hamper economic development. Instead, export increased, which was proven by the impulse response.

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