Dynamic Changes in US Technical Company under Uncertain Market

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Abstract. Since the outbreak of the COVID-19 epidemic, great changes have taken place in the world's economic situation. The interest rate increase by the Federal Reserve has become one of the most influential actions. Researchers have found that the Fed's interest rate hike not only has an impact on the American financial market but also on the world economic situation to a certain extent. Therefore, this paper collects the share price of US dollar and the exchange rate between US dollar and RMB since June, 2021, and uses VAR model and ARMA-GARCH model to model and analyze the data, to examine how the Fed's interest rate hike will affect the dollar's value and Apple's share price, and to predict the future exchange rate and the development trend of Apple's share price in the case of the Fed's interest rate increase, so as to further study the dynamic changes of American technology companies in the uncertain market.

Keywords: Federal Reserve; Exchange rate; Apple's share price; ARMA-GARCH model; Fed Hikes Rates.

1. Introduction

Due to the fluctuation of global economic market, tightening monetary and fiscal policies has to be adopted by the U.S. government [1]. Looking back at the history of the Fed's interest rate hike, as early as the 1970s and 1980s, due to the long-term stagflation, the US monetary policy was in a period of drastic changes, and the Fed implemented a firm monetary tightening policy. From the end of this crisis to the 1990s, the economic market of the United States has been self-adjusting by inflation and contraction. However, from the late 1990s to the 21st century, the global financial market was in constant turmoil, and the Federal Reserve actively cut interest rates in all previous crises. In 2015, monetary policy became normal after global financial crisis and the Great Recession. According to incomplete statistics, since the 1980s, the Federal Reserve has raised interest rates six times. Many reasons are full of complexity, such as high inflation, supply chain break, economic downturn, high stock prices, and other factors [2]. However, just as the global financial market was stabilizing, the arrival of the COVID-19 epidemic forced the production and life of most countries in the world to come to a standstill, thus the economic market suffered a severe blow. After continuously providing subsidies and benefits to the people and trying to save the unemployment rate, the asset-liability ratio of the Federal Reserve and the federal fiscal deficit reached a record high. Under such circumstances, the Federal Reserve had to make a tight fiscal policy of raising interest rates according to its economic situation.

The Federal Reserve operates as the nation's central bank, and its purpose is only to stimulate the local economy of the United States and ensure market employment [3]. But in fact, why does the Fed's interest rate hike affect American domestic companies and even the international economic market? There have been many previous studies discussing that the US dollar, as the largest currency in the world, its instability will definitely bring an impact on the international economic market, and the Fed's interest rate hike will make the exchange rate unstable. However, previous studies are all based on the financial market and social situation of that year, and may no longer be used in the current international financial market. Therefore, this paper aims to select the data from the middle of 2021 to the present after the outbreak of the COVID-19 epidemic and answer this question from two aspects. It will analyze the exchange rate and Apple, the representative company of American science and technology, respectively, to get the impact of the Fed's interest rate increase and make predictions and suggestions on the future development trend combined with the data.

The remainder of this essay is structured as follows: The next part is a literature review, including collecting the possible economic consequences of exchange rate changes and the potential gains and losses of multinational companies under exchange rate uncertainty. In the next part, the daily closing price of Apple and the daily exchange rate of USD against RMB from June 2021 to date will be collected from "choice Financial Terminal" and the unit root test and two different model settings will be conducted to select the most appropriate model, so as to observe the earnings and volatility of Apple's stock price under the condition of unstable exchange rate through daily data changes. After that, the fourth section will use the relevant data obtained for VAR and ARMA-GARCH model analysis. The results of the empirical analysis are used to demonstrate that the exchange rate change caused by the Federal Reserve's interest rate increase will lead to various changes in Apple's stock price. Finally, it draws a conclusion and makes a forecast, and gives feasible and innovative suggestions for the future development of multinational companies under the fluctuation of exchange rates.

2. Literature Review

Bo Guangsen believes that due to the action that increasing rates from Federal Reserve, China's exchange rate will decline dramatically, and this will also have an impact on the stock market and overall price level and proposes that the Securities and Futures Commission and the People's Bank of China both do their responsibilities fully, improve the regulatory system and strengthen the market at the same time The stability of the market, enhance the concept of investors' long-term investment [4]. Bowman, Londono, and Spariza used both event analysis and VAR model when studying the impact mechanism of the Federal Reserve's unconventional monetary policy on emerging countries. The empirical results show that when the United States implements an unconventional monetary policy, affected by the implementation of the policy, the bond yields of these emerging countries also decrease while the bond yields of these emerging countries decrease. Moreover, the more emerging countries with imperfect financial systems, the more and faster their bond yields decrease speed [5]. By examining the spillover effect of US monetary policy on Latin American countries, Soyoung discovered that the impact of US monetary policy on those nations was substantial. [6]. Mackowiak focuses on the relationship between U.S. monetary policy and the inflation and output levels of emerging economies, concluding that both variables are affected by material shifts in U.S. monetary policy, while the main way that U.S. monetary policy affects emerging economies is through international trade [7]. He Guohua and Peng Yi found that China's RMB exchange rate and inflation index are most affected by the macro-control policies of the United States when using the SVAR model for empirical research. However, there are certain differences in the research conclusions of many scholars on whether these two indicators have a positive impact or a negative impact [8]. Hausman and Wongswan conducted a thorough analysis of the effects of U.S. monetary policy actions on the stock index, short-term yield, medium- and long-term interest rates, and exchange rates of 49 different nations. The findings of the study demonstrate that changes in U.S. monetary policy have clear spillover effects on the stock index, interest rates, and currency rates of 49 other nations. The study also indicated that the diverse exchange rate systems of other nations, particularly the spillover effect of countries with fixed exchange rate systems, have a major impact on how the U.S. monetary policy affects asset values. The percentage of the market value of national equities owned by American investors serves as a major barrier to the stock market's ability to absorb the effects of U.S. monetary policy [9]. The FGLS method was utilized by Liu Xiaolan, Professor Lai Mingyong, and others to investigate how the American monetary policy of spillover effect affected China's industrial sector by applying FGLS method. The conclusion shows that the Federal Reserve's quantitative easing measures will impact China's industrial industry trade through RMB and commodity price index, and the impact is more significant. The Federal Reserve's quantitative easing policy has a positive interaction effect on China's industrial industry exports through the actual output of American industry [10]. Li Quanhai thinks that the Federal Reserve's quantitative easing policy

has led to a corresponding drop in the US dollar and a corresponding rise in the RMB, which has worsened China's terms of trade and has played a certain role in restraining China's exports. However, both advantages and disadvantages of such a role are: on the one hand, it is beneficial to easing Sino-US trade frictions, reducing enterprise import costs, and accelerating the transformation of export structure; from another aspect, it will reduce the rate of export growth, obstruct the rise of foreign investment, and worsen domestic employment pressure [11]. Yu Le, Peng Hui, and others, through the SVAR model, have conducted an empirical study on the four channels of the U.S. quantitative easing policy: the price channels that have spillover effects on commodities, the international heavy commodity price channels, the foreign direct investment channels, and the U.S. export channels. The empirical results show that the U.S. quantitative easing policy promotes imports and exports [12]. According to Susan Sun, a qualitative study shows that RMB is the primary factor influencing the growth of China's imports and exports, and a change in the RMB exchange rate is certain to have a significant impact on the bilateral trade relations between China and the United States. During the period when the Federal Reserve carried out quantitative easing monetary policy, the US dollar depreciated significantly, causing the RMB to rise accordingly, the terms of trade to deteriorate, and the export growth to be restrained. The pressure on export businesses has increased due to the growth in export costs, which is not good for the expansion of China's export commerce [13].

This paper takes the exchange rate of USD/RMB and daily closing price of Apple stock as two research variables and uses VAR and ARMA-GARCHX models to explore how the exchange rate changes cause the stock volatility of US technology companies under the influence of the Federal Reserve's interest rate increase, so as to provide credible data forecast and development or transformation ideas for companies affected by the exchange rate changes in this economic environment.

3. Methodology

3.1 Data Sources

The entire set of data used in this essay was taken from Choice Financial Terminal [14], which finds and sorts out the daily exchange rate between USD and RMB and the daily closing price of Apple's stock price from June 2021 to August 2022 in this software. Then merge the two data and import them into "Stata" for further operation and modeling.

3.2 Unit Root Test

Table 1. ADF Test

	Variables	t-statistic	p-value
Price			
	Apple	-2.282	0.4437
	Exchange rate	-1.033	0.9395
Yield			
	Apple	-12.923	0.0000***
	Exchange rate	-13.397	0.0000***

After the data is imported into the Stata, the first thing that needs to be done is data processing, i.e. unit root inspection. Whether a unit root exists or not determines whether these two pieces of data can apply time series algorithms. If a unit root exists, the time series will be non-stationary and must first be transformed into a stationary one. The unit root test method used in this study employs the ADF test, whose initial presumption is that the sequence is unstable and which should be approved when the value is greater than 0.1. The first step is to test the stationarity of the logarithmic series of Apple's stock price and exchange rate. The logarithmic price formula is ln(1+p). By applying code to Stata, the values of the Test Statistic and p-value of Apple's stock price and exchange rate can be obtained. As can be seen from Table 1, both p-values are greater than 0.1, which indicates that both

logarithmic series are unstable. Similarly, the second step needs to test the stability of the yield of the rival of Apple's stock price and exchange rate. Using the running codes, it can be recognized that the value of p-value, which is 0.000, indicates that the two logarithmic yield series are stable and extremely significant.

3.3 VAR Model Setting

In this paper, the first model selected is "Vector Autoregression" (abbreviated as "VAR"). VAR, which is an econometric model, is frequently used to calculate the dynamic connection between two joint endogenous variables. The VAR model extends the univariate autoregressive model to the "vector" autoregressive model [15], formed of multivariate time series variables, by treating each endogenous variable in the system as a function of the lag value of all endogenous variables in the system. This is what VAR (1) looks like.

$$y_{1,t} = c_1 + A_{1,1}y_{1,t-1} + A_{1,2}y_{2,t-1} + e_{1,t} \quad (1)$$

$$y_{2,t} = c_2 + A_{2,1}y_{1,t-1} + A_{2,2}y_{2,t-1} + e_{2,t} \quad (2)$$

In addition, in the VAR model, there are three main features worth mentioning: First, the VAR model is not based on economic and financial theory, so other explanatory variables can be added arbitrarily, such as GDP, CPI, and so on. Secondly, the VAR model is more tolerant to the parameters. If all the variables are stationary, they can be estimated directly by OLS. Thirdly, the VAR model has a considerable number of parameters to be estimated, i.e., Kn^2 . Finally, after constructing VAR, this part can test whether the residuals have autocorrelation and obey normal distribution. At the same time, it is also possible to test whether the VAR system is a stationary process through images. If all points are inside the circle, it is a stationary process.

3.4 ARMA-GARCHX Model Setting

The ARMA-GARCHX model is another model studied and tested. The model can be regarded as a combination of two models: ARMA and GARCHX. The autoregressive moving average model, or ARMA model. This approach fits a broad range of real-world issues and is a typical approach to studying the rational spectrum of stationary stochastic processes. Secondly, this model can also be regarded as a mixture of AR model and MA model. On the other way, a statistical technique for processing time series is the AR model, which predicts the performance of $x_t$in the current period by using the same variable such as the previous periods of x , i.e., $x_1$to x_{t-1}, and assumes that they have a linear relationship. In a nutshell, it is to use the autocorrelation rule of time series to predict, i.e., to predict the future with the realized value of the past [16]. Unlike the AR model, the MA model uses past disturbances to predict the future. For example, the model of MA (1) is as follows: where x_t is the weighted average of two perturbations at and a_{t-1}, and a_t is a white noise sequence [17]. The ARMA model performs better in terms of spectrum estimation and spectral resolution when compared to the AR model approach and the MA model method, although parameter estimation is more time-consuming. The following is the appearance of ARMA model, in which the second term and the last term are the expressions of AR model and MA model respectively, similar to MA model, in which a_t is a white noise sequence, it can be concluded that both AR model and MA model are special cases of ARMA model [18].

$$x_l = \emptyset_0 + \emptyset_1 x_{l-1} + \cdots + \emptyset_p x_{l-p} + a_l \quad (3)$$

$$x_l = C_0 + a_l - \emptyset_1 x_{l-1} - \cdots - \emptyset_p x_{l-p} \quad (4)$$

$$x_l = \emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{l-i} + a_l - \sum_{i=1}^{q} \theta_i a_{l-i} \quad (5)$$

$$h_t = k + \sum_{i=1}^{q} G_i h_{t-i} + \sum_{i=1}^{p} A_i {\epsilon^2}_{t-i} \quad (6)$$

A type of often employed stochastic time series model known as the GARCH model accurately fits and forecasts short-term financial data. The GARCH model's prediction can more accurately capture the structure and traits of time series when compared to the actual value and the expected value of the return rate. It must be acknowledged that GARCH (1,1) is somewhat akin to an infinite

order ARCH model, which can adequately capture a wide range of financial time series data and is highly successful in forecasting the unconditional volatility of the market. The benefits of the GARCH model are: The heteroscedastic sequence fitting model with the best results so far is the GARCH model. Disadvantages include: The application scope of GARCH model is restricted by the parameters; The responses to positive and negative perturbations are symmetrical, which inevitably affects the prediction accuracy [19].

Generally speaking, the purpose of using the ARMA-GARCH model is to forecast the return rate and volatility simultaneously. The model setting is to set the mean value equation of the GARCH model as the ARMA process.

4. Empirical Results and Analysis

4.1 VAR Ranking

After determining the VAR model, the next thing to do is to determine the order of VAR. In this paper, using the LR likelihood method is needed when determining the maximum lag order k, "LR" means the likelihood ratio test, which is to test the joint significance of the last order coefficients. When the crucial value is reached but the LR statistic is not, the lagging order of VAR model is considered to be moderate. On the contract, it is considered that the lagging order of VAR model is not high enough and more lagging variables need to be added as explanatory variables. By running the code, varsoc is used to rank the logarithmic yield series of Apple's yield and exchange rate. The total number of lags is 12. Table 2 lists the important values of each LAG, such as LL, LR, p-value, etc., and can infer the degree of stability and significance. It can be seen in Figure 1 that when all points (eigenvalues) fall inside the unit circle, it is a stationary process, and it shows that this order is feasible. In the model of this paper, when lag=5 (i.e. the order equals 5).

Table 2 VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	2097.14				1.9e-09	-14.3996	-14.3894	-14.3743*
1	2106.25	18.222	4	0.001***	1.8e-09	-14.4347	-14.4043*	-14.3589
2	2110.77	9.0425	4	0.060*	1.8e-09	-14.4383	-14.3877	-14.312
3	2113.52	5.4958	4	0.240	1.9e-09	-14.4297	-14.3589	-14.2529
4	2118.07	9.1014	4	0.059*	1.8e-09	-14.4334	-14.3424	-14.2062
5	2123.2	10.265*	4	0.036**	1.8e-09*	-14.4412*	-14.33	-14.1635
6	2125.83	5.256	4	0.262	1.9e-09	-14.4318	-14.3003	-14.1036
7	2129.46	7.2704	4	0.122	1.9e-09	-14.4293	-14.2776	-14.0506
8	2134.04	9.1581	4	0.057*	1.8e-09	-14.4333	-14.2613	-14.0041
9	2137.25	6.4192	4	0.170	1.9e-09	-14.4278	-14.2357	-13.9482
10	2138.73	2.9509	4	0.566	1.9e-09	-14.4105	-14.1981	-13.8803
11	2142.68	7.9173	4	0.095*	1.9e-09	-14.4102	-14.1776	-13.8295
12	2145.87	6.3669	4	0.173	1.9e-09	-14.4046	-14.1517	-13.7734

All points fall within the unit circle, thus determining the order of the corresponding VAR model for apple and the exchange rate yield is 5.

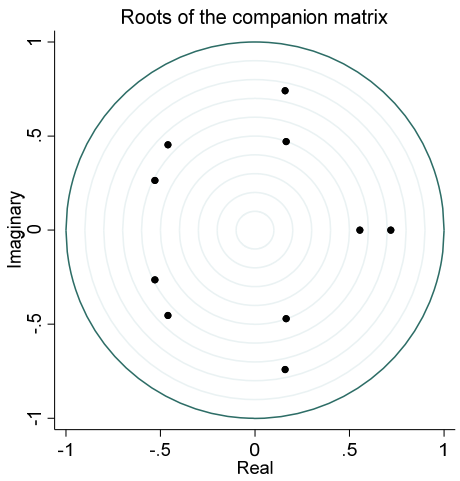


Figure 1 Unit Circle test
Photo credit: Original

4.2 Impulse Response

From the theoretical analysis, the Fed's hike in interest rates will inevitably result in a rise in demand for USD and other forms of hot foreign currency, and further lead to an increase in the exchange rate. However, the influence of higher exchange rates on Apple may have the following economic consequences:

First, with reference to the microeconomic producer theory, this paper assumes that the firm's product price is rigid in the short term (this is a weak assumption), i.e. Apple is difficult to adjust the product price according to the exchange rate in the short term (recall that the devaluation of the ruble around 2015 led Apple's stores in Russia to close down instead of adjusting the price). As a large multinational company, Apple's major revenue and financial report are all in USD. The appreciation of the US dollar means that the operating income of enterprises abroad will depreciate. Starting from this aspect, the Federal Reserve's interest rate increase may be bad for Apple. In addition, higher interest rates will definitely boost domestic savings and curb consumption. This is also one of the negative factors.

Second, the international financial market holds more US dollars, which may flow into the stock market or the bond market, increasing the demand for stocks. That is, there is a net inflow of capital into the US stock market, which may in turn drive up the US stock price.

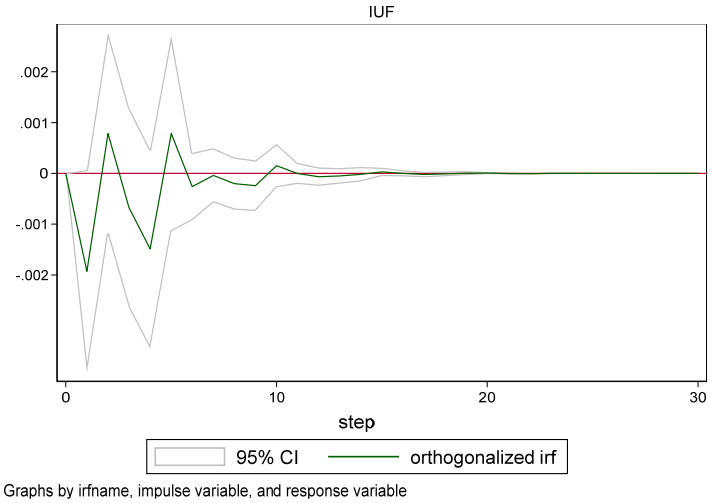


Figure 2. Impulse and response
Photo credit: Original

The purpose of the impulse response function is to examine how much other variables change over time as a result of an impact in one unit. In this paper, the 30-period pulse function is first calculated by Stata (Figure 2). Secondly, the result is obtained by substituting the pulse variable and the response variable. Judging from the estimation result of impulse response, the net impact of the appreciation of US dollar on the yield of Apple stock is negative. Specifically, the impact of a unit's exchange rate shock at t=0 on Apple's yield at t=0 was negative, slightly less than 0.2%. The second highest value of negative effect appeared in the period of t=4, about 0.15%. Although there was a small amount of positive effect, the values were small, all less than 0.1%

4.3 ARMA Identification

When determining the order of ARMA model, this paper needs to use PACF and ACF to rank the logarithmic yield series of apples to determine the order of AR part and MA part (Figure 3). PACF is a useful tool for ranking AR models. The effective way to introduce PACF is to increase (p) in AR and observe whether the results are significant until they are not significant. In this paper, the PACF image can be obtained by running the following code. It can be found that when lag=11, 23, 34, the PACF Rate of Return increases dramatically, while when t=8, 28, 40, the value of the vertical axis reaches the low point repeatedly. For MA(q) model, ACF is the most useful tool to determine the value of q. For time series x_l with autocorrelation function ρ_l, if ρ_q is not equal to 0, but $\rho_l = 0$ for $l > q$, then x_l obeys a MA(q) model. Simply put, by observing the two graphs of PACF and ACF, when the value of the vertical axis exceeds the range of rectangle, this lag is determined as the order of ARMA (p, q). In this paper, it can be seen that in PACF and ACF, when lag=4, the value of the vertical axis exceeds the critical value, so the module ARMA (8,8) is chosen in this paper.

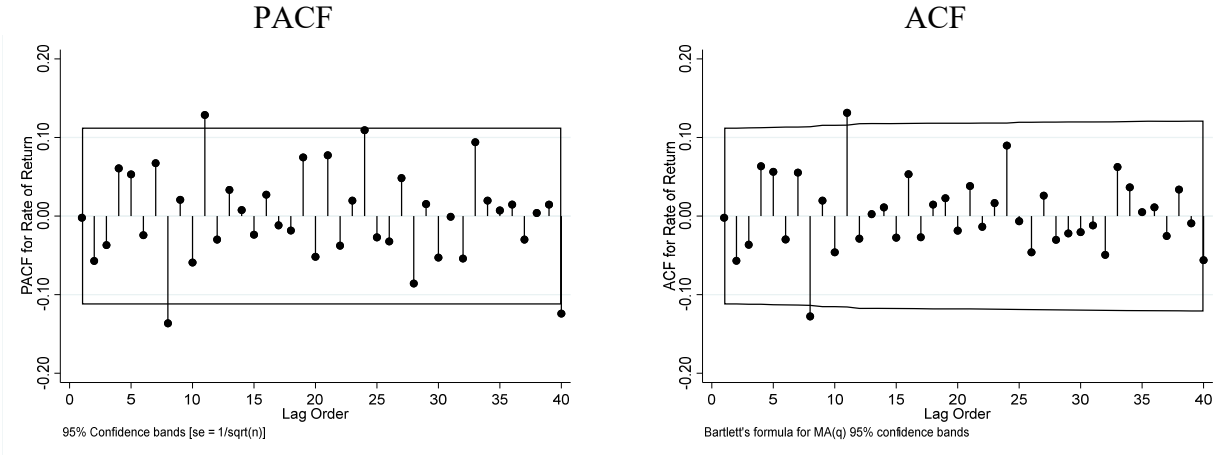


Figure 3. PACF and ACF

Photo credit: Original

4.4 ARMA-GARCHX Estimation Results

In the ARMA-GARCH model, as mentioned above, the GARCH model is mixed into the ARMA model, and the logarithmic rate of return of exchange rate is put into GARCHX as an explanatory variable. By running code, the time series diagram of "Yield Trend" is shown in Figure 4. It can be concluded in the image that Apple's stock return rate has obvious aggregation, but whether this property is statistically significant remains to be tested.

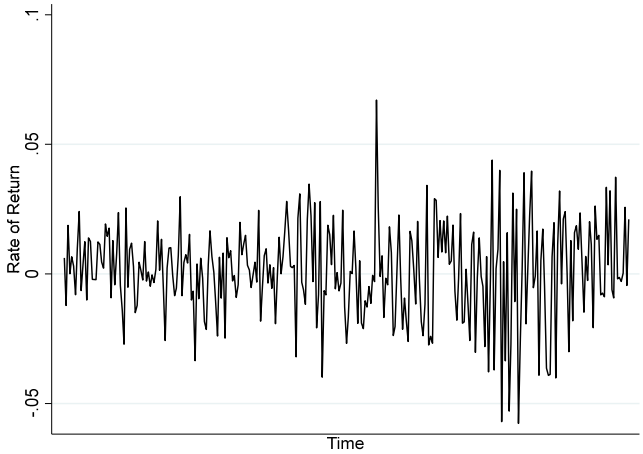


Figure 4. Yield Trend

Photo credit: Original

Next, put the determined order of AR and MA and increment into ARMA-GARCH code to run, and get the following estimation results. According to the estimation results of ARMA-GARCHX model, GARCH terms of the three models are all significant, which indicates that there is statistically significant conditional heteroscedasticity in apple stock return rate, so GARCH model can be established (please see Table 3). In the model of column (1), the current exchange rate's logarithmic rate of return is introduced as an external explanatory variable. The results demonstrate that the exchange rate change has a favorable effect on the stock return of Apple, with a coefficient of 391.8055, which is significant at the level of 1%. After adding the lag value of exchange rate return in columns (2) and (3), it is found that the logarithmic return rate of the current exchange rate is still significant, but the lag term is not significant, which indicates that there is no lag effect of exchange rate on apple volatility.

Table 3. ARMA-GARCH estimation results

Variables	(1)		(2)		(2)	
	Coef.	p>|Z|	Coef.	p>|Z|	Coef.	p>|Z|
Mean equation						
AR, L8	-0.1988	0.606	-0.1965	0.605	-0.1951	0.627
MA, L8	0.0653	0.867	0.0592	0.878	0.0617	0.880
Constant	0.0013	0.105	0.0013	0.111	0.0013	0.108
Variance equation						
Exchange rate						
L0	391.8055	0.000	397.9378	0.000	388.6347	0.000
L1			-25.5384	0.889	39.6961	0.858
L2					-92.9584	0.329
GARCH (1, 1)						
ARCH (-1)	0.0376	0.340	0.0348	0.372	0.0344	0.386
GARCH (-1)	0.8238	0.000	0.8260	0.000	0.8141	0.000
Constant	-10.5818	0.000	-10.5880	0.000	-10.5160	0.000

5. Discussion

Compared with the existing academic research, it is not difficult to find that the main findings of this paper have two similarities with the previous research. First, both domestic and foreign economies are impacted by changes in exchange rates. They will certainly affect not only domestic industries but also import and export trade and multinational companies. Second, changes in exchange rates will unavoidably have some detrimental effects on economic expansion. Previous studies have

shown a correlation between foreign investment and the real effective exchange rate of a type of currency, and the fluctuation of effective exchange rate of currency has a negative effect on foreign investment [20]. According to the model data in this paper's findings, under the change of exchange rate, the decrease of foreign income and the inhibitory effect of consumption are the two major negative factors that inhibit the growth of the stock price of Apple, which is consistent with the former research conclusion.

The significance of this paper lies in taking Apple as a typical case, which provides other companies with a way out of the dilemma in the current economic environment and future development ideas. Given the current social situation, after the epidemic, the fiscal deficits of many countries in Europe and the United States increased sharply. Under the government's tight fiscal policy and foreign exchange fluctuation, all companies and industries are facing a crisis. Therefore, this paper takes Apple, a technology company, as an example and uses VAR model and ARMA-GARCH model as the practical basis to obtain the impact of exchange rate changes on Apple's stock price from a realistic perspective and make a reasonable forecast. Future research can pay more attention to the development of other types of companies under the fluctuation of exchange rate, make the development trend forecast and put forward relevant suggestions, and make valuable research for different industries. According to the results of this study, investors can be advised to avoid making huge investments during this period, regardless of whether the impact of exchange rate fluctuations is more beneficial than harmful or if the negative impact accounts for the majority. During this period, for example, it is usually difficult to judge whether net capital inflows or consumption inhibition, or the impact of foreign currency devaluation on the company's share price is dominant. Any action is considered to be high-risk.

6. Conclusion

Under the impact of the COVID-19 epidemic, the world economic situation is in a state of turmoil. In order to cope with the trend of economic stagnation and even retrogression, every country and economy has to implement a series of fiscal and monetary policies to make its economy recover while stabilizing the people. Among them, the Federal Reserve's interest rate hike means that after the United States implemented social welfare and subsidies to save the unemployment rate and other unfavorable factors, the national debt ratio and fiscal deficit of the United States reached a record high, so the government had to implement a tight fiscal policy, and the Federal Reserve raised interest rates to save the domestic economy. This article focuses on how the exchange rate changes caused by the Federal Reserve's interest rate hike have affected the share prices and yields of multinational companies, Apple. Through the impulse response used in this paper, it is found that the net effect of US dollar appreciation on the return rate of Apple stock is negative. The results of time series chart and VAR, ARMA-GARCHX model suggest that for Apple, the reduction of foreign income and the inhibition effect of consumption are significantly greater than the gains from net capital inflow. The Federal Reserve's interest rate strategy, which was implemented to curb American inflation, can be considered to some extent as harming the development of the stock market.

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