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Did Fed's Rate Policy Benefit U.S. Company: Evidence from Tesla

Linxuan Li[1,a,*]

[1]*Wenzhou-Kean University, Wenzhou, 325060, China*
a. lilinx@kean.edu
**corresponding author*

Abstract: This paper studies the impact of the Federal Reserve's interest rate policy on American companies, taking Tesla as evidence. Data on the Tesla stock as well as the USD/RMB exchange rate for the previous year were gathered. The impact of a rising exchange rate on companies goes in two directions. On the one hand, the appreciation of the dollar means the depreciation of foreign operating income, and the depreciation of the domestic currency is bad for exports. On the other hand, it will affect how the stock market operates. An increase in dollar holdings in international financial markets would increase the demand for stocks, which would increase stock prices. The conclusion is that the Fed's interest rate policy to control inflation in the United States has, to some extent, come at the expense of stock market growth. The VAR model and ARMA-GARCH model were used to model and analyze the data, and forecast the trend of the company's stock price, then make recommendations for policymakers and investors. For policymakers, it is necessary to adjust the policy appropriately to minimize the volatility of stock market returns, and investors should turn to assets with lower risk instead of blindly investing.

Keywords: China, US, interest rate policy, exchange rate, VAR model, ARMA-GARCH model

1. Introduction

A country's economy is increasingly impacted by exchange rates as a result of the modern economy's fast globalization. Any nation's economy is impacted by exchange rate changes to varying degrees. Furthermore, the degree of openness a nation has to the outside world affects how exchange rate changes affect that nation's economy. Exchange rates have a growing impact on the stock market as countries' openness continues to develop. However, the impact on import and export trade is most immediate, with the import industry, which depends on foreign suppliers of raw materials, benefiting most from the appreciation of the native currency. On the contrary, the loss of competitiveness is causing the export business to lose money. But the opposite is true when the local currency declines. But both appreciation and depreciation have their advantages and disadvantages in terms of corporate performance and economic conditions. This article will discuss the impact of a rising exchange rate on companies.

From the theoretical analysis, the interest rate increase of the Federal Reserve will certainly causing the demand for dollars to rise in the international floating capital and the international financial market, and prompt a further rise in the exchange rate. However, the impact of exchange

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rate increase on the company has two directions: on the one hand, as a large multinational company operating in the world, the appreciation of the US dollar means that the operating income in foreign countries will depreciate, and the depreciation of domestic currency is not conducive to export. In this regard, a Fed rate hike could be a negative for Tesla. On the other hand, the international financial market holds more dollars, which may flow into the stock market or bond market, thereby increasing the demand for stocks and further driving up stock prices.

The remainder of this essay is structured as follows: The second part is literature review, including related studies on the causes and effects of the change in exchange rate and a summary of the literature review. Then the third part, with some data and images as the auxiliary, describes the method used in this paper. After that, the fourth part will analyze the ARMA-GARCH model with the relevant data obtained. The results of empirical analysis are used to demonstrate the impact of the interest rate policy issued by the Federal Reserve on American companies, and then the conclusions and forecasts are drawn after discussion.

2. Literature Review

The exchange rate is the measurement of the US dollars' worth in relation to other currencies. Interest rates are a key factor in determining the value of the dollar and have a big impact on stock prices. Exchange rates therefore have an impact on stock prices and can be used to forecast market behavior.

There is no appreciable link between the stock market and currency rate, according to Franck and Young's research [1]. Bhattacharya and Mukherjee studied the link between stock prices and the currency exchange financial sector in India and found no significant integration [2]. Ong and Izan used the nonlinear least squares method to find the relationship between stock prices and exchanges [3]. Between the US stock market and the currency, they discovered a very shaky link [3]. A substantial inverse relationship between dollar value and stock prices was discovered by Soenen and Henniger using monthly data for stock prices and effective exchange rates from 1980 to 1986 [4]. By taking into account how exchange rates affect US multinational corporations, Jorion is able to pinpoint major disparities between industries [5]. Exchange rate changes have a less impact on developed nations than they do on emerging or developing nations [5].

The evidence from Sweden provided by Nydahl demonstrates the enormous exchange rate risks that small open economies' sectors must deal with [6]. This study is additionally supported by Turkish Kiymaz evidence [7]. According to a study by Griffin and Stulz [8], stock markets in industrialized countries are less affected by weekly exchange rate movements. Turkish businesses were significantly impacted by exchange rate changes, according to Kiymaz [7]. Daniel Stavarek examined the relationship between stock prices and exchange rates from both long-term and short-term perspectives using the monthly data of four old and new EU member states [9]. Based on the data, he concluded that the long- and short-run link was stronger between 1993 and 2003 than it was between 1970 and 1992 [9].

The relationship between currencies and stocks may be different. The environment may change depending on factors like geography, the economy, relations with other nations, domestic circumstances, etc. Results that differ between nations may be caused by differences in trade volumes, rights and interests, economic ties, risk assessments, etc. Because the relationship between these two variables may be unidirectional, bidirectional, or multidirectional, the direction of their influence cannot be predicted. The Granger causality test was used by Bahmani-Oskooee and Sohrabian to determine the correlation between the exchange rate and stock market from 1973 to 1988 [10]. The short-term, bidirectional relationship between exchange rates and stock prices was examined, but the long-term relationship was not examined [10]. Granger et al. discovered a significant association between these two variables that, in some instances, has a one-way negative interaction and, in others, has a bidirectional relationship [11].

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Research on the effects of exchange rate changes have generally been in-depth, but there are very few studies on the effects of exchange rates on businesses, particularly domestic businesses in the United States. The future of domestic companies is hard to predict. Therefore, this paper hopes to further fill the research gap in this field and use empirical data to demonstrate the impact of interest rate policy on the current and long-term development of US domestic companies.

3. Method

3.1. Data Source

The data used in the study included daily observations of Tesla's share price and the dollar-yuan exchange rate (the central rate). All the data comes from the Choice Financial Terminal and Investing website. Data were collected from June 1, 2021, to August 11, 2022, with 303 observations, all series converted to natural logarithmic series.

3.2. ADF Test

To complete the model construction, firstly a unit root test (smoothness test) on the model is needed to perform, where the original hypothesis is that the model is not smooth. After putting the data into Stata and performing the ADF test, Table 1 shows that the p-value for the log returns is 0, which is less than 0.1, and null hypothesis can be rejected original hypothesis.

Table 1: ADF test.

Variables		t-statistic	p-value
Price			
	Tesla	0.3100	0.6200
	Exchange rate	0.4684	0.9369
Yield			
	Tesla	0.0000	0.0000***
	Exchange rate	0.0000	0.0000***

3.3. VAR Model

One technique to anticipate these variables is to arrange them as a system so that the forecasts are self-consistent. This allows for the simultaneous forecasting of several economic variables. Such a strategy is the "Vector Autoregression" Sims promotes.

Consider two time series variables $\{y_{1t}, y_{2t}\}$, as the explanatory variables for the two regression models, respectively; The P-order lag value of the two variables, which together make up a bivariate VAR(P) system, serves as the explanatory variable:

$$\begin{cases} y_{1t} = \beta_{10} + \beta_{11} y_{1,t-1} + \ldots + \beta_{1p} y_{1,t-p} + \gamma_{11} y_{2,t-1} + \ldots + \gamma_{1p} y_{2,t-p} + \varepsilon_{1t} \\ y_{2t} = \beta_{20} + \beta_{21} y_{1,t-1} + \ldots + \beta_{2p} y_{1,t-p} + \gamma_{21} y_{2,t-1} + \ldots + \gamma_{2p} y_{2,t-p} + \varepsilon_{2t} \end{cases} \quad (1)$$

Among them, $\{\varepsilon_{1t}\}$ and $\{\varepsilon_{2t}\}$ are white noise process (so there is no autocorrelation), but allows two equations of the disturbance between the same period "relevance" (contemporaneous correlation) :

$$\mathrm{Cov}(\varepsilon_{1t}, \varepsilon_{2t}) = \begin{cases} \sigma_{12}, \text{if } t=s \\ 0, other \end{cases} \quad (2)$$

Notice that the explanatory variables in the above two equations are the same. Write the two equations together:

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

Consolidate the related coefficients into a matrix, write the current variables as column vectors, and then:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \gamma_{11} \\ \beta_{21} & \gamma_{21} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \end{pmatrix} + \ldots + \begin{pmatrix} \beta_{1p} & \gamma_{1p} \\ \beta_{2p} & \gamma_{2p} \end{pmatrix} \begin{pmatrix} y_{1,t-p} \\ y_{2,t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \tag{4}$$

Let $y_t = \begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix}, \varepsilon_t = \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$, so

$$y_t = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \gamma_{11} \\ \beta_{21} & \gamma_{21} \end{pmatrix} y_{t-1} + \ldots + \begin{pmatrix} \beta_{1p} & \gamma_{1p} \\ \beta_{2p} & \gamma_{2p} \end{pmatrix} y_{t-p} + \varepsilon_t \tag{5}$$

Define the corresponding coefficient matrix as $\Gamma_0, \Gamma_1, \ldots, \Gamma_p$ can be obtained:

$$y_t = \Gamma_0 + \Gamma_1 y_{t-1} + \ldots + \Gamma_p y_{t-p} + \varepsilon_t \tag{6}$$

$\{\varepsilon_t\}$ is a generalization of the vector white noise process, which is a one-dimensional white noise process.

In the process of VAR modeling, it is necessary to determine the number of variables (N) with mutual influence and how many lag variables are needed to explain clearly the endogenous variables (K) with mutual influence. If K is too small, it will lead to the autocorrelation problem of the error term, which may lead to a large error in the model parameter estimation. The model's degrees of freedom will be lowered if k is set too high, which will directly impact how well the model parameter estimator works. Using the LR likelihood technique, the maximum lag order k is determined:

$$LR = -2(LogL_k - LogL_{k+1}) \tag{7}$$

$$LR \sim \chi^2_{(N^2)}$$

The lag order of the VAR model is regarded as mild when the LR statistic is lower than the critical value. The crucial threshold is exceeded when the LR statistic, it is considered that the lag order of the VAR model is not high enough, and more lagged variables should be added as explanatory variables. The finite sample distribution of LR will diverge significantly from the asymptotic distribution of LR if the sample size is insufficient compared to the number of calculated parameters. In this paper, data on Tesla stock and the exchange rate between US dollar and RMB are used to construct the VAR system.

3.4. ARMA-GARCH Model

Introduction of ARMA(p,q) model

$$x_t = \phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i} + a_t - \sum_{i=1}^{q} \theta_i a_{t-i} \tag{8}$$

Where the $\{a_t\}$ is the white noise sequence, and are both non-negative integers, as are P and G. Both the AR and MA models are variations on the ARMA model (p, q). From equation above, it

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shows that, $\phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i}$ represents the AR(p) model, which uses the historical returns of semiconductor stocks to forecast the future; while $a_t - \sum_{i=1}^{p} \theta_i a_{t-i}$ which uses past volatility to estimate the future and the last part of the model.

Introduction of ARMA (p, q) model

The model GARCH (p, q) is set as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_q \varepsilon_{t-q}^2 + \gamma_1 \sigma_{t-1}^2 + \ldots + \gamma_p \sigma_{t-p}^2 \quad (9)$$

In equation above, the term $\alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_q \varepsilon_{t-q}^2$ is ARCH part, σ_t^2 is the conditional variance of the disturbance term ε_t, the subscript t indicates that variance changes over time. σ_t^2 is based on the disturbance term's square over the preceding p periods. The GARCH model is constructed using the ARCH model. with the addition of autoregression σ_t^2. The term $\gamma_1 \sigma_{t-1}^2 + \ldots + \gamma_p \sigma_{t-p}^2$ is GARCH part.

The most used GARCH model is GARCH (1,1). The GARCH model is made to have fewer parameters. In certain ways, the ARCH model of infinite order and GARCH (1,1) are analogous. The higher-order ARCH(p) model can frequently be reduced to GARCH if σ_{t-1}^2 is considered the explanatory variable (1,1).

4. Empirical Results and Analysis

4.1. Data Source

In this section of this paper, first, it is necessary to use Varsoc to determine the order, construct the VAR model, and draw the pulse diagram, and the results are as follows:

Table 2: VAR model identification.

Lag	LL	LR	df	p	FPE	AIC	HQIC
0	1877.35				8.3e-09	-12.9335	-12.9233*
1	1882.84	10.969	4	0.027	8.2e-09*	-12.9437*	-12.9133
2	1884.96	4.2459	4	0.374	8.3e-09	-12.9308	-12.8801
3	1885.52	1.1311	4	0.889	8.5e-09	-12.9071	-12.8361
4	1887.02	2.9941	4	0.559	8.7e-09	-12.8898	-12.7985
5	1892.21	10.385	4	0.034	8.6e-09	-12.898	-12.7865
6	1894.49	4.5422	4	0.338	8.7e-09	-12.8861	-12.7543
7	1901.42	13.868*	4	0.008	8.5e-09	-12.9063	-12.7542
8	1904.55	6.2602	4	0.181	8.6e-09	-12.9003	-12.728
9	1908.68	8.2572	4	0.083	8.6e-09	-12.9012	-12.7086
10	1911.43	5.5081	4	0.239	8.6e-09	-12.8926	-12.6797
11	1912.45	2.0386	4	0.729	8.8e-09	-12.8721	-12.6389
12	1914.71	4.508	4	0.342	8.9e-09	-12.86	-12.6065

Through this table, the order is determined by LR criterion, and the order is 7.

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4.2. Var Model

The pulse plot is drawn after the VAR is used to determine the order. Test whether VAR system is a stationary process: whenever all eigenvalues are contained within the unit circle, it is a stationary process. As can be seen from the following figure1, all points are in the circle, so it is stationary.

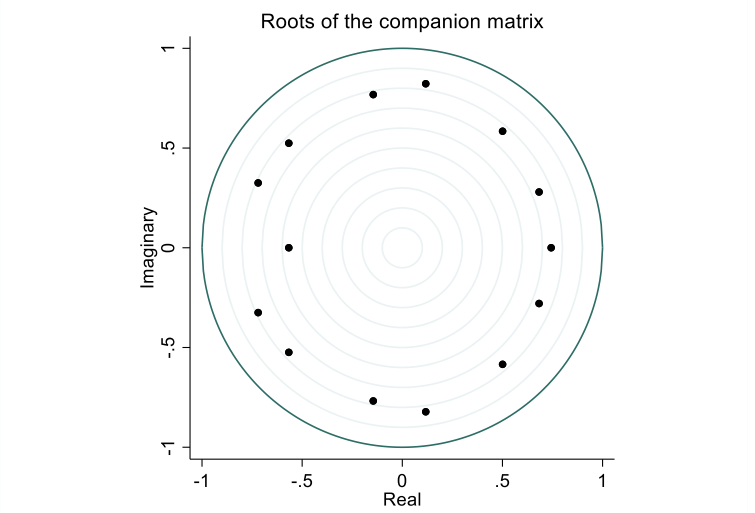

Figure 1: Unit circle test.

Then the impulse function of 30 periods is calculated to obtain the impulse response diagram Figure 2.

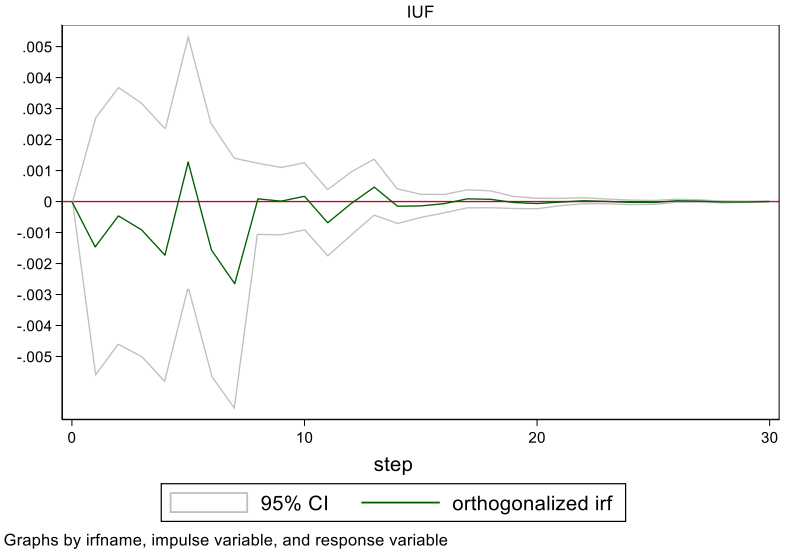

Figure 2: Unit circle test.

From the theoretical analysis, the interest rate increase of the Federal Reserve will certainly lead to an increase in the demand for dollars in the international floating capital and the international financial market, and further lead to the increase of the exchange rate. However, the impact of the exchange rate increase on the company has two directions: Firstly, with reference to the producer theory in microeconomics, this paper assumes that there is rigidity in the product price of enterprises

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in a short period, that is, it is difficult to adjust. As a large multinational company operating worldwide, Tesla's main revenue and financial reports are calculated in U.S. dollars. A stronger dollar means lower earnings from operations abroad and a weaker currency hurts export. In this regard, a Fed rate hike could be a negative for Tesla. In addition, an increase in interest rates means that the savings rate will inevitably increase and national consumption will inevitably be depressed, which is also one of the negative factors for Tesla.

However, on the other hand, the international financial market holds more dollars, which may flow into the stock market or bond market, thereby increasing the demand for stocks and further driving up stock prices every year.

Based on the above theoretical analysis, it is difficult to directly judge whether net capital inflow or foreign currency depreciation is the dominant influence on Tesla stock price under the background of an interest rate hike by the Federal Reserve.

Starting from the model results, this paper finds that the net effect of the dollar appreciation caused by the Federal Reserve's interest rate increase on Tesla is negative. Specifically, the maximum negative effect of the 1% increase in the exchange rate return in the period t=0 on Tesla's earnings occurs in the 7th period, and the magnitude is about 0.25%. Although a small number of periods have positive effects, the value is small, and some of these periods are also small, the overall still show negative effects.

In the case of Tesla, the reduction in foreign income and the dampening effect of consumption are significantly greater than the gains from net capital inflows.

Thus, it can be seen that the interest rate policy adopted by the Federal Reserve to control inflation in the United States is to some extent at the expense of stock market growth.

In addition, it is important to note that Tesla shares could face continued downside risk if the exchange rate continues to rise.

4.3. ARMA-GARCH Model

The results of using PACF and ACF to order Tesla's logarithmic return series are displayed in the following figure. As seen by the fixed order outcome in Figure 3, the first part outside the X-axis is 7, so AR(p) is of order 7, and MA(q) is of order 18. So p and q are equal to 7.

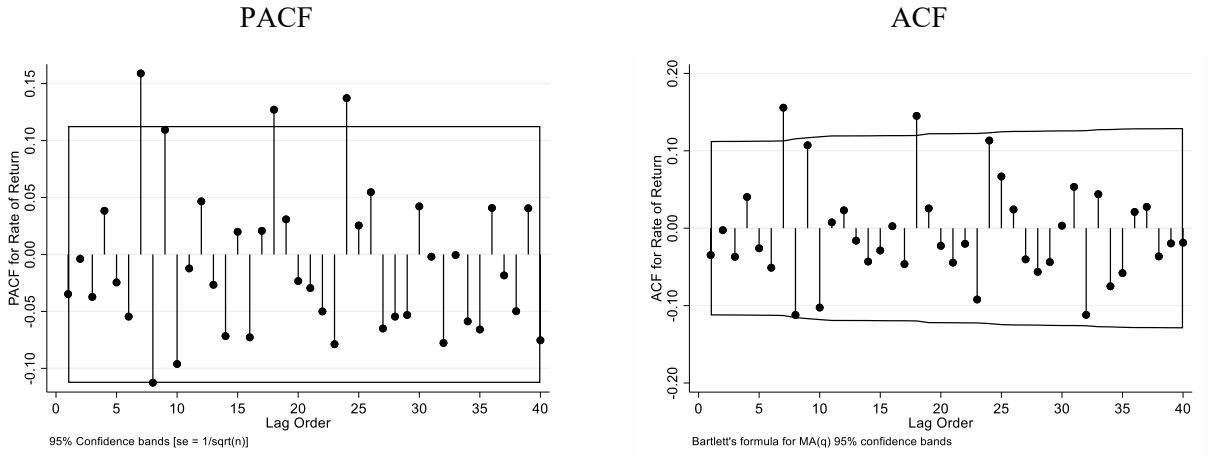

Figure 3: PACF and ACF.

From the time series diagram in Figure 4, the volatility of Tesla stock returns has increased significantly over time.

In addition, volatility has an obvious aggregation effect, but whether it is statistically significant needs to be further empirically tested.

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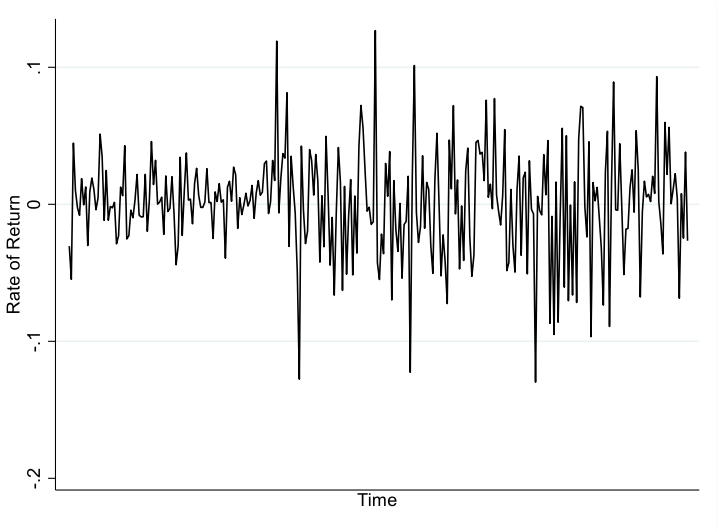

Figure 4: Yield.

4.4. Estimation Results

According to the estimation results of the ARMA-GarchX model, after controlling the autocorrelation of the mean equation with the ARMA model in this paper, the Tesla return rate still shows a statistically significant ARCH effect and GARCH effect, that is, the return rate has conditional heteroscedastic property, which can be used for GARCH modeling.

According to the findings of external explanatory variable estimation, changes in exchange rates have a sizable positive effect on Tesla's volatility. Specifically, when the logarithmic return rate of exchange rate rises by 1 unit, the volatility of Tesla's return increases by 342.5874 units, and the coefficient is significant at the 1% level.

Table 3: ARMA-GARCHX estimation results.

	Coefficient	Std. err	p>|Z|
Mean equation			
AR, L7	-0.2076	0.4362	0.6340
MA, L7	0.3442	0.4149	0.4070
Constant	0.0019	0.0024	0.4270
Variance equation			
Exchange rate	342.5874	71.4166	0.0000***
ARCH, L1	0.0543	0.0196	0.0060***
GARCH, L1	0.9197	0.0262	0.0000***
Constant	-10.5289	0.4138	0.0000***

5. Discussion

The existing literature is based on theoretical analysis, and it is difficult to directly judge whether net capital inflow or foreign currency depreciation is the dominant influence on Tesla stock price under the background of interest rate hike by the Federal Reserve. Based on the results of the ARMA-GARCH model, this paper finds that the net effect of the dollar appreciation caused by the Fed's interest rate hike on Tesla is negative. For Tesla, the reduction in foreign income and the dampening effect of consumption are significantly greater than the gains from net capital inflows. The interest

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rate policy adopted by the Federal Reserve to control inflation in the United States is to some extent at the expense of the growth of the stock market. And through the time series diagram, it is found that as time goes by, the volatility of Tesla stock returns increases significantly. If the exchange rate continues to rise, Tesla shares could face continued downside risk. Other companies, including those in the United States, are also at risk.

Therefore, for policymakers, it is necessary to adjust the policy appropriately to minimize the volatility of stock market returns, not to ignore the stock market just to control the inflation of the country. It is important that there have a stock market because when stocks are issued, a lot of capital flows into it and into the companies that issue them. This encourages capital concentration and significantly speeds up the growth of the commodity economy. The stock market offers a fundamental setting for the circulation and transfer of stocks, while also serving as a catalyst for stock purchases and a security for the issue of the primary stock market. It significantly affects the market as a whole.

For investors, Investment in developing economies may be hampered by the volatility of financial market pricing and returns. A high premium will be demanded by investors if there is excessive volatility, which will result in a high cost of capital that is harmful to economic progress. The rising volatility of the stock market indicates that the risk of stock investment is rising. Investors should turn to assets with lower risk instead of blindly investing. Volatility in the stock market has a variety of detrimental repercussions, including a negative impact on the financial system's efficiency and the state of the economy.

6. Conclusion

The research object of this paper is the impact of the interest rate policy issued by the Federal Reserve on American companies, taking Tesla as evidence. And the development direction and development of American companies put forward forecasts and suggestions. This paper mainly uses the ARMA-GARCH model to analyze and integrate relevant data, and by examining the change and volatility of Tesla stock returns to represent the impact on American companies.

The impact of exchange rate increase on companies has two directions. On the one hand, the appreciation of the dollar means the depreciation of operating income in foreign countries, and the depreciation of the domestic currency is bad for exports. When interest rates increase, the savings rate will inevitably increase, and national consumption will be more or less restrained. On the other hand, it will have an impact on the stock market. The increase of dollar holdings in the international financial market will increase the demand for stocks so that the stock price will rise. According to the analysis results of the data model in this paper, the overall impact of the dollar appreciation caused by the Fed's interest rate hike on Tesla is negative. One can draw the conclusion that the Federal Reserve's interest rate policy, which it implemented to curb American inflation, has harmed the stock market's expansion in some way.

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