

# Oil Price Volatility and Boeing Stock Dynamics During the Russia-Ukraine Conflict

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**Abstract.** In the background of the Conflict between Russia and Ukraine, the volatility of global oil prices has also led to a fluctuation in the stock prices of many oil-related industries, including the aerospace industry, for example, Boeing company. This paper focuses on the analysis of the dynamic changes in Boeing company's stock price and its stock returns during the Russia-Ukraine conflict. And according to the empirical results, this paper concludes that oil price fluctuations only have a negative impact on Boeing company's stock in the short term and almost no impact in the long run. At the end of this paper, we propose how policymakers and investors should face this phenomenon, and suggest how Boeing should innovate in the future.

**Keywords:** Russia-Ukraine conflict; Oil price fluctuation; Boeing stock price; Volatility of stock returns-; short- and long-term impact.

## 1. Introduction

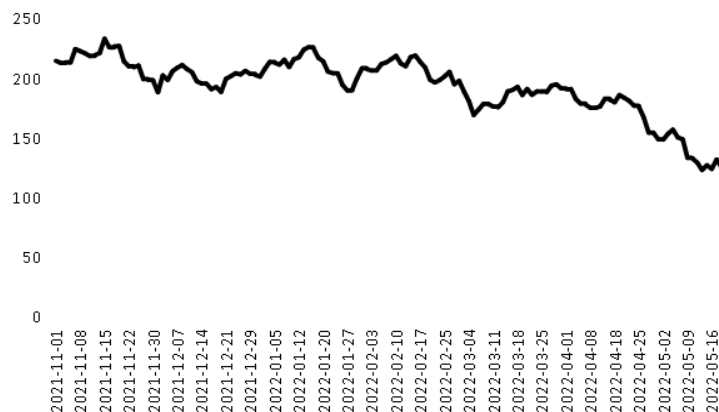
Since the beginning of the year, the Russia-Ukraine Conflict has been in the limelight. From January 10, 2022, to February 23, 2022, Russia held talks with the United States and NATO on security guarantees, during which time the price of oil rose sharply. On February 24, the Russo-Ukrainian war broke out in full swing. On February 26, CNN (Cable News Network) reported that the European Union, the United States, and their Allies had agreed to remove some Russian banks from the SWIFT (Society for Worldwide Interbank Financial Telecommunications) system. IMF (International Monetary Fund) Managing Director Kristalina Georgieva said on March 6 that global economic growth is expected to be lowered and global trade has shrunk markedly due to the Russia-Ukraine Conflict. With the conflict between Russia and Ukraine, international oil prices are facing huge fluctuation

Russia is one of the world's largest producers and exporters of crude oil. According to the BP Statistical Review of World Energy (2021) [1], by the end of 2020, Russia's proven oil reserves reached 107.8 billion barrels, accounting for 6.2% of the world's total proven oil reserves, and Russia's total oil production reached 524 million tons, second only to the United States (713 million tons) in 2020. However, with the escalating conflict between Russia and Ukraine, western countries put pressure on Russia in finance, energy, and other fields. Until April 2022, the EU has imposed five rounds of sanctions on Russia. The fifth round of sanctions includes provisions prohibiting the sale, supply, transfer, or export of specific refining products and technologies to Russia. The US, UK, Canada, and Australia have even banned imports of Russian oil, natural gas, and other energy sources. At the same time, under the pressure from the government and public opinion, major international energy enterprises have to take measures to interrupt project cooperation with Russia. For example, ExxonMobil and BP have announced withdrawal from cooperation with Relevant energy enterprises in Russia. This series of measures not only restricted Russia's oil trade but also caused turbulence in the international oil trade market.

Oil prices remain high amid the Russia-Ukraine conflict. Before the outbreak of the Russia-Ukraine conflict, the global economy was gradually recovering from the COVID-19 epidemic, and international oil prices were already high due to a series of policies and demands. However, with the escalation of the conflict between Russia and Ukraine, international oil prices continue to rise. The

announcement of a series of sanctions on Russia's oil trade has been a major reason for higher oil prices as public anxiety about the oil supply continues to rise. The public's concern is not unfounded. In the post-pandemic era, oil demand is on the rise in all industries, especially the global aerospace industry. In 2020, the EU imported about 2.7 million barrels of Russian crude oil per day, accounting for 23% of its total crude oil consumption. After the implementation of sanctions against Russia, it is difficult to find an alternative source from the already tight international crude oil market in the short term, so the international crude oil supply is even tighter. In 2022, the frequent conflicts in the Middle East and the escalating conflicts between Russia and Ukraine will increase the uncertainty of the international crude oil supply [2]. Since February 2022, the Russia-Ukraine conflict has pushed Brent crude oil futures above \$100 per barrel for the first time in seven years. Oil prices fluctuated above \$100 a barrel amid slow-moving talks between Russia and Ukraine and the spread of fighting. Against such a backdrop, we still need to consider whether the increased volatility of high oil prices is good or not for the global economy [3].

The Boeing Company, one of the world's largest manufacturers of civilian and military aircraft, has also suffered a lot from fluctuating oil prices. On the one hand, there are reports that Boeing has put 141 aircraft orders on hold and is not expected to deliver them due to the Conflict with Ukraine, international sanctions against Russia, and other contract issues. On the other hand, Boeing's stock price has also been fluctuating due to the price of oil. As you can see from the chart below, Boeing's stock price has fluctuated from November 2021 to mid-May. We wondered how Boeing's stock price fluctuated, whether it correlated with oil price fluctuations in the international market, and how closely the two correlated. Therefore, we carry out research and analysis based on the above purposes.



**Fig. 1** Boeing's stock price trend

Most studies have focused on the impact of the Russia-Ukraine conflict on the international oil market as a whole, but few have studied the impact of high oil price fluctuations on a single company. For example, a study combined historical events and the Russia-Ukraine conflict to analyze the evolution of the international oil trade pattern and proposed how a country, such as China, should respond to the change in the international oil trade pattern [4]. Even more, research has focused on changes in the overall energy landscape, including oil and gas, as a result of the Russia-Ukraine conflict [5]. what's more, some studies have analyzed the impact on world finance from inflation, exchange rate, oil futures and other aspects based on the rise of oil price in the past [6]. Similarly, VAR model and GARCH - BEKK model were also used to analyze the one-way spillover effect of the interaction between international financial factors and international oil price on the stock market [7]. We hope to find a specific company as an example to illustrate the impact of oil price fluctuations on real businesses. At the same time, we also found that oil price fluctuations have a profound impact on the aerospace industry. Based on the general background that the Conflict between Russia and Ukraine affected the fluctuation of international oil prices, this paper will study the change in Boeing Company's stock price during the conflict between Russia and Ukraine and analyze the reasons behind the change.

The following parts of this paper are composed as follows: Section 2 is research and analysis, which includes research background, analyzed data, model specifications, and model introduction. Section 3 presents our empirical results and analysis, including the estimation results of VAR, ARMA, and ARMA-GARCH models. The fourth part is our discussion about the results of the model. Section 5 is the conclusion.

## 2. Research Design

### 2.1 Data

The prices of Boeing company’s stock and international oil future used in this essay are found in the CSMAR. We select these two closed prices daily from three months before the Russia-Ukraine conflict to the present. Data from CSMAR is high-quality and has been used in a massive number of articles. So, it is accurate and trustworthy. Then, we use these data to calculate the yields of Boeing company and oil future. In the following analysis of this article, all the data is transformed into a logarithm. For example, the price of Boeing company’s stock is logarithmic.

### 2.2 ADF-test

If the data is not stationary, it is very difficult to reflect on their past and future prices in building models. In order to test the stationarity of these two prices, unit root test needs to be done. The null hypothesis is that the data is non-stationary which is assumed as  $\beta=1$  and the alternative hypothesis is  $\beta<1$ . The ADF-test is the key to unit root test to show whether the time series data is stationary. The t-statistic is set as follows:

$$t = \frac{\hat{\beta}-1}{\text{the standard deviation of } \hat{\beta}} \tag{1}$$

If the p-value in the ADF-test is less than 0.01, the time series can be seen as stationary. Therefore, these logarithmic yields are all qualified and introduced into the VAR model which needs all data in it to be stationary.

As shown in Table 1, these two logarithmic prices are all non-stationary. Because the p-values of them are all larger than 0.1. But these two logarithmic yields of Boeing company’s stock and international oil future are stationary, whose p-values are all 0.0000 which are less than 0.01 which mean we should refuse the original hypothesis.

**Table 1.** ADF test

Variables	t-statistic	p-value
Price		
Boeing	-0.855	0.9608
Crude oil	-2.961	0.1435
Yield		
Boeing	-6.937	0.0000***
Crude oil	-9.085	0.0000***

### 2.3 VAR model

In order to predict the change in Boeing company’s stock price and international oil future price, we construct this model. And we put these two prices together as a single system to make the predictions mutually consistent. This model can also help us to find the dynamic dependence between each other. The model is set as follows:

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

In this model,  $\{\varepsilon_t\}$  is an extension of the one-dimensional white noise process which is called the ‘vector white noise process’,  $y_t = \{y_{1t} \ y_{2t}\}$  is a vector of two-time series and  $p$  is the time lag.

After obtaining the estimated results from VAR model, it’s very necessary to test whether there is an autocorrelation existing in the residual and whether it obeys normal distribution.

The impulse response function aims to find when one unit changes how much it causes other variables to change with time.

$$\frac{dy_{t+s}}{d\varepsilon_t} = \Psi_s \quad (3)$$

This model shows that when the disturbing term  $\varepsilon_t$  at  $t$ -the period increases by one unit while other variables and disturbance terms in other periods stay unchanged, the figure of  $y_{t+s}$  will be changed to what with the effect of  $\varepsilon_t$ .

Then, we can use variance decomposition to find how much each of the other variables contributed to the change in one variable. For example, how much of the change in variable  $y_1$  is explained by  $y_2$ , how much by  $y_3$ .

## 2.4 ARMA-GARCH

We now construct an ARMA model first to observe the Boeing company’s stock return volatility. In order to construct an ARMA model, it’s important to find the order of AR model and MA model.

AR model use  $y_t$  which is the time series and its autocorrelation to predict the future, which means using the past realization to predict the future yield. The model is set as follows:

$$y_t = \varphi_0 + \sum_{i=1}^p \varphi_i y_{t-i} + a_t \quad (4)$$

Then we can use the partial autocorrelation function to fix the order for the AR model.

To find the significant impact of external disturbances on the stock yield, we build MA model. The model is set as follows:

$$y_t = c_0 + a_t - \sum_{i=1}^q \theta_i a_{t-i} \quad (5)$$

Then we can use the autocorrelation function to find the order of MA model. So, the ARMA ( $p, q$ ) model is set as follows:

$$y_t = \varphi_0 + a_t + \sum_{i=1}^p \varphi_i y_{t-i} + \sum_{i=1}^q \theta_i a_{t-i} \quad (6)$$

In (4), (5), and (6),  $y_t$  is the logarithmic yield of Boeing company’s stock at the  $t$ -th period and  $y_{t-i}$  represents the yield in the past period.  $\{a_t\}$  is the series of white noise whose expected number is 0 and variance is  $\sigma_a^2$ . This model can help us predict the future yield by using past volatility.  $p$  is the order of AR model and  $q$  is the order of MA model.

To observe the change in the Boeing company’s stock return, we build the GARCH model. The model is set as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^m \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^s \gamma_j \sigma_{t-j}^2 \quad (7)$$

In (7),  $\varepsilon_t$  is the disturbance term in  $t$ -th period which represents a sequence of random variables whose conditional variance is  $\sigma_t^2$ .  $\sum_{i=1}^m \alpha_i \varepsilon_{t-1}^2$  is a part of ARCH, so ARCH is a basis of GARCH model.

After finishing these, we construct the ARMA-GARCH model to predict the yield and the volatility of Boeing company’s stock. What we should do next is just to set the equation of GARCH model as ARMA process.

### 3. Empirical Results

#### 3.1 VAR estimation results

Table 2 shows that LR reaches the minimum at lag=5, so we determine 5 as the order of the VAR model.

**Table 2.** VAR model identification

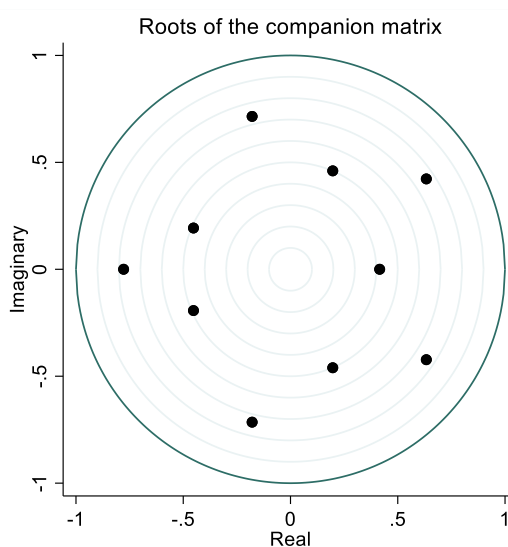
Lag	LL	LR	df	p
0	517.588			
1	517.943	.70834	4	0.950
2	521.774	7.6634	4	0.105
3	523.687	3.8257	4	0.430
4	527.014	6.6529	4	0.155
5	531.994	9.9601*	4	0.041
6	535.352	6.7166	4	0.152
7	537.154	3.6039	4	0.462
8	538	1.6926	4	0.792
9	539.002	2.0044	4	0.735
10	542.301	6.5963	4	0.159
11	543.901	3.1999	4	0.525
12	544.056	.3116	4	0.989

It's very important to test the stationary of the parameters to make sure that they can be estimated accurately. The model is set as follows:

$$VAR(k): y_t = c + Ay_{t-1} + U_t \tag{7}$$

If all of the roots of the characteristic equation  $|A - \lambda I| = 0$  are located in the unit circle, the VAR system can be seen as stationary

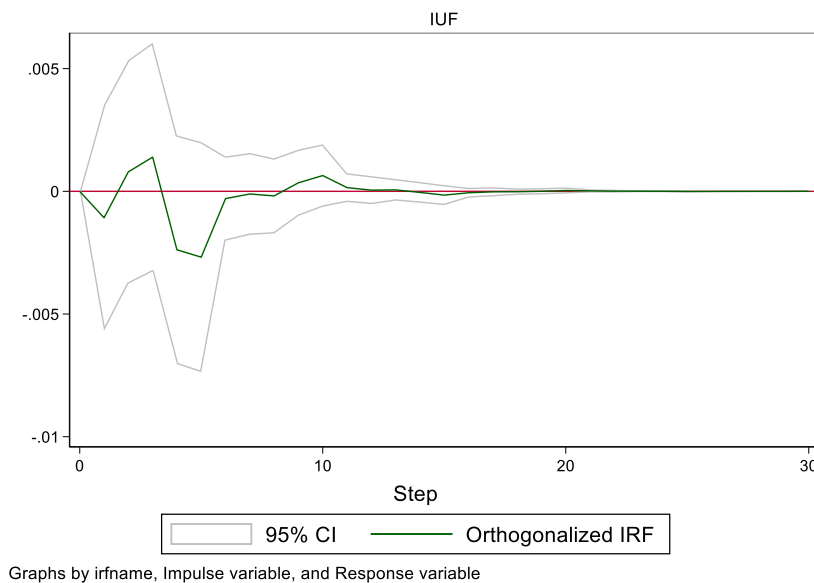
As we can see in Figure 1, the roots of the companion matrix are all in the unit circle, so the VAR system in this paper is stationary.



**Fig. 2** VAR system's stability

After proving the VAR system is stable, we use the impulse response function to find how much a unit of the impact causes other variables to change over time. We use the logarithmic yield of the international oil future as the impulse variable and the logarithmic yield of Boeing company's stock

as the response variable. Figure 2 shows when the international oil future’s yield changes, and how does the yield of Boeing’s stock changes.



**Fig. 3** Impulse and response

Note: The Y-axis is the change in the yield of Boeing company caused by the change in the oil future, and the X-axis shows the different periods.

We can see from Figure 2 that the yield fluctuates greatly and then stay stable at 0 which means the change in the oil future’s yield can affect the yield of Boeing’s stock in the first 6 terms. As time goes on, the effect of oil on the Boeing yield decreases gradually and it disappeared around 10 terms. Figure 2, shows that the international oil future price had a limited impact on Boeing’s stock yield.

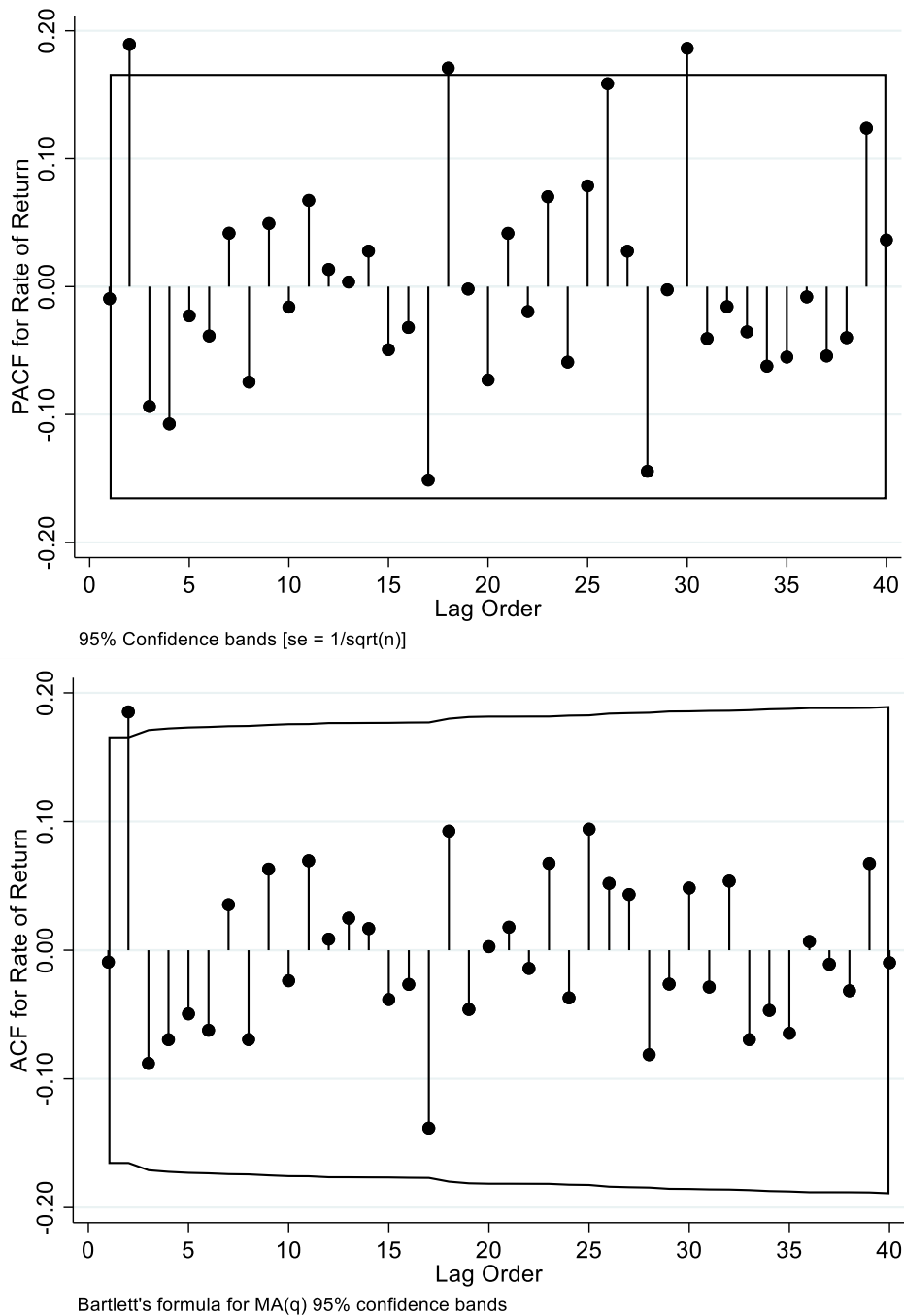
### 3.2 The order of ARMA

Then we use the autocorrelation function (ACF) and the partial autocorrelation function (PACF) to test the orders of the AR model and MA model respectively. We can use ACF and PACF to calculate the log returns of Boeing company and use the order of AR and MA models to determine the order of ARMA. And Table 2 and Figure 3 show the results of ACF and PACF.

**Table 3.** AR identification

Lag	LL	LR	df	p
0	267.649			
1	267.649	5.4e-06	1	0.998
2	270.063	4.8281*	1	0.028
3	270.532	.93912	1	0.333
4	271.35	1.6346	1	0.201
5	271.406	.1116	1	0.738
6	271.718	.62498	1	0.429
7	271.957	.47715	1	0.490
8	272.291	.66815	1	0.414
9	272.458	.33492	1	0.563
10	272.474	.03155	1	0.859
11	272.727	.5066	1	0.477
12	272.737	.01968	1	0.888

Note: we can see in this table LR reaches the minimum at lag=2



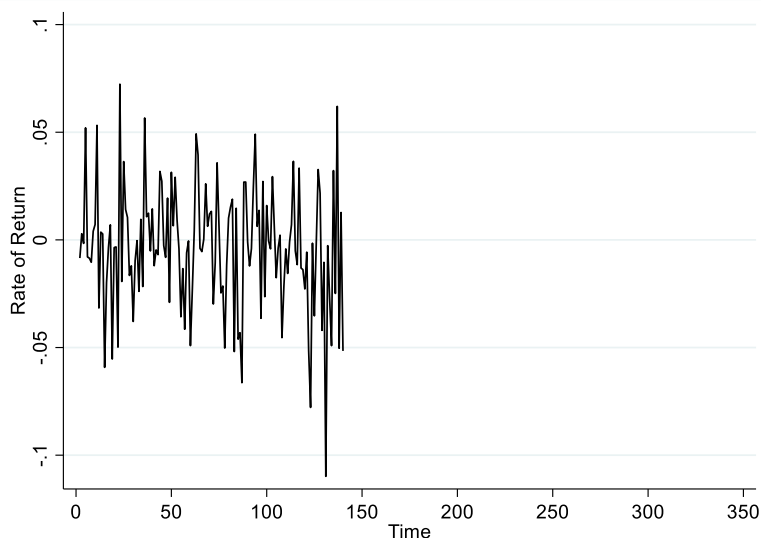
**Fig. 4** ARMA order identification, PACF, and ACF

Note: The former picture shows the order of the AR model. We can see the second point is beyond the range so we can construct AR (2) model. The later picture shows the order of MA model. The second point is also beyond the restricted domain, so we build a MA (2) model.

So, we can construct ARMA (2,2) model to predict the trend of Boeing company's stock price in the future.

### 3.3 Result of the ARMA-GARCH

Then we use the autocorrelation function (ACF) and the partial autocorrelation function (PACF) to test the orders of the AR model and MA model respectively. We can use ACF and PACF to calculate the log returns of Boeing company and use the order of AR and MA models to determine the order of ARMA. And Table 2 and Figure 3 show the results of ACF and PACF.



**Fig. 5** Rate of return

From this picture, we can see sometimes the rate of return fluctuates greatly and sometimes it relatively stays stable which is called volatility clustering [8].

Table 3 is the estimation result of the variance equation. From the ARMA-GARCH estimation results, the estimated coefficient of ARCH term is not significant, but that of GARCH term is significant. Therefore, Boeing's return rate has significant conditional heteroscedasticity, which can be used for GARCH modeling. In addition, from the perspective of the estimated coefficient of return on international futures crude oil, only the estimated coefficient in column (2) period  $t=-1$  is significantly positive, while other models have no significant positive coefficients. Therefore, it can be seen from the model estimation results in this paper that the increase in international crude oil price does not cause the fluctuation of Boeing's return rate.

**Table 4.** ARMA-GARCH estimation results, variance equation

	(1)	(2)	(3)	(4)
Crude oil				
T=0		-36.6790*** (6.9656)	-29.0701*** (3.9242)	-33.6157*** (5.8819)
T=-1			34.6989** (10.4215)	4.9497 (22.0066)
T=-2				13.8734 (14.6383)
GARCH				
ARCH (-1)	.1588 (.0998)	.1434 (.1192)	-.0091 (-.0580)	.0923 (.0727)
GARCH (-1)	.7622*** (.1485)	.4981*** (.1416)	.6675*** (.1090)	.5262*** (.1260)
Constant	.0001 (.0001)	-8.7758*** (.4207)	-9.1449*** (.5114)	-8.8614*** (.3866)

## 4. Discussion

Compared to the past studies, this paper mainly focuses on the analysis of the empirical results which can help people find the relationship between Boeing company's stock price and oil futures price.

As we can see in this paper, the fluctuation of the international oil future price can influence the Boeing company's stock return in a short time. As time goes on, the effect on Boeing's stock decreases gradually. According to IATA, more than 45 airlines have flown more than 370,000

commercial flights powered by sustainable aviation fuel since 2016 [9]. So, fossil fuel is not the only way to get planes off the ground which causes a low effect on the Boeing company for a long time. Therefore, the government should improve its sensitivity to the financial market and designate a series of policies such as reducing the tax on sustainable fuel production, to stabilize stock prices to ensure the stability of the financial market when fluctuations occur. The government should promote investors' overall understanding of the market through publicity, education, and other means to maintain market stability.

For investors, investors should clearly understand that the stock market turbulence caused by oil volatility is temporary, avoid excessive anxiety, and formulate a more rational investment strategy to avoid huge losses and financial market disorder. Investors should take all factors into account which can affect the stock price whereas only considering the present profit and loss which may be a temporary phenomenon.

The conflict between Russia and Ukraine has once again made the world see the importance of energy. In the long run, developing new energy and realizing the development pattern of multi-energy complementarity will undoubtedly become the general trend in the future [10]. High fossil fuel prices provide opportunities for sustainable aviation fuels such as hydrogen and electricity to develop and compete. A company that relies on oil to run its business traditionally should innovate new technology to realize sustainable development. For example: "Boeing has committed to delivering commercial aircraft that can fly on 100% sustainable aviation fuel by 2030." [9].

## 5. Conclusion

Due to the Russia-Ukraine conflict, the international crude oil futures price raises which means the price of oil has increased greatly. And the fluctuation of oil prices has a huge influence on the aerospace industry while the Boeing company also be affected. This paper focuses on the impact of international crude oil futures price volatility on Boeing stock price volatility and return rate. Through the construction of models such as ARMA-GARCH, we find that although the stock return of Boeing company fluctuates with the fluctuation of international crude oil futures price in the short term, in the long run, it has a very limited effect on the stock return of Boeing Company.

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