The Impact of Oil Price Fluctuations on the Motor Vehicle Market under the Russia-Ukraine conflict

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Abstract. On February 24, 2022, Russian President Vladimir Putin dispatched Russian troops to invade the territory of Ukraine on the grounds of "demilitarization and de-Nazification." The conflict officially turned into a full-scale war from that day and quickly developed in Europe since World War II. the most significant war ever. After the Russian-Ukrainian war broke out, related industries also suffered from price fluctuations, especially crude oil. The crazy rise in crude oil prices has also changed people's car-using habits, which has considerably impacted electric vehicles and gasoline vehicles. NIO was selected as the representative of electric vehicles, and Honda is the representative of fuel vehicles. This paper intercepts their stock data from the months before and after the Russia-Ukraine conflict and uses the VAR model and ARMA-GARCH model to analyze the impact of WTI crude oil price rises caused by the Russian-Ukrainian conflict on new energy vehicles and fuel vehicles.

Keywords: Russia-Ukraine Conflict; WTI Crude Oil; Electric Vehicle; ARMA-GARCH; VAR model.

1. Introduction

The Russia-Ukraine region is a vital origin and export source of global energy, grain, non-ferrous metals, and other bulk commodities. It plays an essential role in the supply of energy, such as crude oil and natural gas, grain crops, like wheat and corn, and non-ferrous metals, such as aluminum and nickel. The outbreak of the Russian-Ukrainian conflict has led to a decline in the production of related products and an increase in export controls, which has significantly impacted the global commodity supply. In the early days of the Russia-Ukraine conflict, Russia dispatched troops to the eastern Ukrainian region, causing panic in the energy market. Driven by this panic, international oil prices began to rise. The active variable guiding the direction of oil prices in the international market is not only the future of this war. The sanctions imposed on Russia by the United States and Europe will also make us face an unprecedented increase in oil prices - the United States has decided to ban the import of Russian oil, and Europe also has a heavy dependence on oil and gas and has announced that it will gradually boycott Russian oil. International oil prices have once again shown a sharply higher trend. On the demand side, slowing global growth may weigh on demand, which may help to moderate oil prices. In 2021, the average daily demand for world oil will increase by 5.7 million barrels.

The most direct impact on citizens is the change in car usage caused by rising oil prices, which has also had a considerable impact on the auto industry. The war has adverse effects on the supply and demand of the auto industry, and cars with good fuel economy have obvious advantages under high oil prices. The conflict between Russia and Ukraine will affect not only the production of the automobile industry but also the demand for automobile consumption, which will affect the profits of automobile companies. The sales volume of the automobile industry is likely to be under pressure. Electric cars with a better economy will reflect the cost performance, and Japanese cars with better fuel economy have apparent advantages. The rise in oil prices has dramatically promoted the electric vehicle market, which is an opportunity and will bring an excellent increase to new energy vehicles.

After the continuous increase in oil prices, it was evident that for fuel vehicles, the cost of oil consumption has increased again, and the pressure of oil consumption has indeed increased a lot.

In contrast, electric vehicles do not need to consider the cost of oil too much. Under the influence of high oil prices, the sales of new energy vehicles have increased significantly. With the continuation of the phenomenon of high oil prices, everyone's attitude towards electric vehicles is continuously improving, and the annual sales of new energy vehicles are expected to rise. Consumers' willingness to purchase fuel vehicles has declined, and more people choose public transportation or purchase new energy vehicles.

The article is divided into five parts. The second part is the literature review. The literature review is to summarize the relevant research on the impact of the Russian-Ukrainian conflict on oil prices and the impact on the automotive industry. The response of the electric vehicle industry and the fuel vehicle industry to oil price fluctuations. The third part is the research design. The data mainly use WTI crude oil price, NIO company, and Honda company stock price. The ADF test is used to judge the stationarity of the data to make accurate predictions. The VAR model and ARMA-GARCH analysis the relevant data obtained. The fourth part is the empirical results and analysis. Use the tests and models used in the third part to determine crude oil price movements and the stock price movements of two companies during periods of crude oil price volatility. Analyze the impact of crude oil price changes caused by the Russian-Ukrainian conflict on NIO and Honda. The final section discusses the similarities and differences between the findings and other related studies and how relevant policymakers and business investors should view the findings of this article. The findings and results of the study will also be summarized in the final section.

2. Literature review

The escalation of the conflict between Russia and Ukraine has caused considerable fluctuations in the financial market, the global stock market has plunged across the board, and the share prices of mainstream multinational auto companies have all declined. In the context of the escalating conflict between Russia and Ukraine, many car companies such as Volkswagen Group, General Motors, Ford, and Mercedes-Benz announced the suspension of their Russian business. The global raw material supply chain was also disrupted, with price increases and interruptions. The production of a few multinational automakers in Europe has also been affected. As the Russian-Ukrainian conflict intensifies, the global auto industry, which is slowly recovering from the chip crisis, is again seriously threatened. Several market analysis agencies announced that they had lowered their forecasts for global new car sales in 2022 [1].

On March 8, 2022, international oil prices reached a high point, hitting a new high since 2014. Brent crude oil futures settled at $127.9 per barrel, up 62% from the beginning of the year; WTI crude oil futures settled at $123 per barrel, up 63% from the beginning of the year [2]. According to the AAA report, the average price of gasoline in the United States was $3.54 per gallon on February 24, 2022, and the price of gasoline in California, where gasoline is more expensive, reached a high price of $5.69 per gallon [3]. The rise in oil prices has further pushed up the cost of fuel vehicles. The annualized use costs of fuel vehicles in China, the United States, and Europe have risen by 12-16% yearly. At the same time, electricity prices in China and the United States are stable, and electric vehicle costs have changed little [4].

According to the latest data, NIO delivered 25,034 vehicles in the fourth quarter of last year, a record for quarterly deliveries and a year-on-year increase of 44.3%. Based on this calculation, the company delivered 91,429 vehicles last year, a yearly increase of 109.1%. In January 2022, 9,652 vehicles were delivered, a year-on-year increase of 33.6% [5]. NIO's price-to-earnings ratio is about five times its 2023 sales forecast, much lower than its direct competitors (other high-end EV makers). NIO also has the advantage of doing business in overseas markets [6]. In addition, the company has been expanding the setup of its charging, sales, and service network. As of January 31, 2022, NIO has built 836 swap stations, 3,766 charging stations, and 3,656 destination charging stations in China

and has opened 42 NIO centers, 341 NIO spaces, and 55 NIO locations. Service Centers and 180 Authorized Service Centers [7]. High inflation in economies such as the United States and Europe and the conflict between Russia and Ukraine are hitting the global economy, which is one of the reasons for the yen's decline. Honda Motor Co. said in its fiscal 2022 fourth-quarter and full-year financial report that it expects operating profit in fiscal 2023 to be 810 billion yen (about 6.3 billion U.S. dollars), far less than the 943 billion yen expected by analysts' consensus [8]. Many automakers responded to the war in Ukraine by stopping sales in Russia. Honda, Jaguar Land Rover, Volkswagen, and Volvo, among others, have announced they will stop selling cars in Russia [9]. General Motors Co and Honda Motor Co said they would build a new joint development platform to develop a range of cheap electric vehicles. They could produce millions starting in 2027 to beat Tesla in sales Pull. GM and Honda have reached a deal to see the former build two models of electric SUVs for Honda from 2024 -- the Prologue and the Acura [10].

3. Research Design

3.1 Data source

This paper utilizes the Choice financial terminal [11], a search engine, combined with the Oriental Fortune to do the search and figure out the closing prices of two cars brand – Honda, a traditional fuel car, and NIO, newly new energy vehicles and WTI crude oil, from June 2021 to now (August 10, 2022). One tremendous event causing giant fluctuations in price of oil is conflict between Russia and Ukraine. The goal is to highlight the stock price fluctuations of two car brands before and after the conflict between Russia and Ukraine, which refer to the impact of oil prices on two different track of car brands, to detect whether it could generate the rise of new energy vehicles and the decline of traditional oil vehicles.

3.2 ADF test

Firstly, we need to perform a unit root test (smoothness test) on the model which we constructed, where the null hypothesis is that the model is not smooth. The models we need to test are mainly about two parts: price and yield. After performing the ADF test in Stata, the outputs are listed in Table 1, containing the t-statistics and p-value. For the price of Crude oil, Honda, and NIO, the p-values of all three variables are all very large and are much greater than the significant level, which fails to reject the null hypothesis, indicating that the model for forecasting the price of these three variables are not smooth. Furthermore, for the yield of Crude oil, Honda, and NIO, the log-return are all 0, which is less than the significant level of 0.1, indicating that we reject the null hypothesis in favor of the alternative hypothesis that the model is smooth and stable, which could be used for forecasting the future yield.

Table 1 ADF test

	Variables	t-statistic	p-value
Price			
	Crude oil	-2.231	0.4722
	Honda	-3.213	0.0818
	NIO	-2.747	0.2172
Yield			
	Crude oil	-13.160	0.0000***
	Honda	-12.356	0.0000***
	NIO	-11.791	0.0000***

3.3 VAR model

$$y_{1t} = \beta_{10} + \beta_{11}y_{1,t-1} + \cdots + \beta_{1p}y_{1,t-p} + \gamma_{11}y_{2,t-1} + \cdots + \gamma_{1p}y_{2,t-p} + \ldots + \alpha_{11}y_{3,t-1} + \cdots + \alpha_{1p}y_{3,t-p} + \epsilon_{1t} \quad (1)$$

$$y_{2t} = \beta_{10} + \beta_{11}y_{1,t-1} + \cdots + \beta_{1p}y_{1,t-p} + \gamma_{11}y_{2,t-1} + \cdots + \gamma_{1p}y_{2,t-p} + \ldots + \alpha_{11}y_{3,t-1} + \cdots + \alpha_{1p}y_{3,t-p} + \epsilon_{1t} \quad (2)$$

$$y_{3t} = \beta_{10} + \beta_{11}y_{1,t-1} + \cdots + \beta_{1p}y_{1,t-p} + \gamma_{11}y_{2,t-1} + \cdots + \gamma_{1p}y_{2,t-p} + \ldots + \alpha_{11}y_{3,t-1} + \cdots + \alpha_{1p}y_{3,t-p} + \epsilon_{1t} \quad (3)$$

VAR model (Vector autoregression model) is a workhouse multivariate time series model that relates current observations of a variable with past observations of itself and past observations of other variables in the system [12]. From equation (1) above, it is the expression of the VAR of three independent variables. y_{1t} is the yield of Crude oil. From equation (2), y_{2t} is the yield of Honda. From equation (3), $y_{3t}$is the yield of NIO. The only difference among the three VAR expressions is y, which refers to different independent variables. VAR is one of the special AR(p) models, which forecasts one more variable at the same time based on previous data and analyzes the dynamic effect of random disturbance on the variable system instead of forecasting one variable at a time like the AR(p) model.

Specifically, in this paper, the VAR model uses the previous yield of WTI crude oil and stock yield of Honda and NIO from June 1, 2020, to present to investigate the dynamic impact of WTI crude oil price change on Honda and NIO returns.

3.4 ARMA-GARCH

$$x_t = \emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{t-i} + \alpha_i - \sum_{i=1}^{q} \emptyset_i \alpha_{t-i} \quad (4)$$

From equation (4) above, $\emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{t-i}$ represents the AR(p) model, which utilizes the historical price of two car companies and crude oil to forecast the future: while $\alpha_i - \sum_{i=1}^{q} \emptyset_i \alpha_{t-i}$ represents the MA(q) model, which utilizes the past volatility to estimate the future and the last part of the model.

More specifically, in this paper, AR(p) model utilizes the historical yield of two car companies over the period before and after several months of the Russia-Ukraine conflict, while MA(q) model utilizes an error term to forecast the future.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 \quad (5)$$

From equation (5) above, σ_t^2 represents the volatility of time interval t; ε_{t-1}^2 represents the square of the residual from the previous period. Overall, it means that the volatility of this period is determined by the square of residual from the previous period.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2 + \gamma_1 \sigma_{t-1}^2 + \cdots + \gamma_p \sigma_{t-p}^2 \quad (6)$$

$$\sigma_1^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 WTI \quad (7)$$

After that, in this paper, we need to construct the ARMA-GARCH models of returns and volatilities of the stock price of two car companies and crude oil at the same time.

From the equation (6) above, $\alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2$ represents the ARCH part, σ_t^2 represents the conditional variance of the disturbance term ε_t^2, t means that the period could change over time.

Furthermore, the GARCH model is set up based on the ARCH model, $\gamma_1 \sigma_{t-1}^2 + \cdots + \gamma_p \sigma_{t-p}^2$ represents the GARCH parts.

From equation (7), in this paper, the GARCH is designed as this form, which represents the volatility based on the yield of WTI crude oil.

4. Empirical design and result

4.1 VAR model

In this section of the paper, it is necessary to analyze the results based on some models we contrasted before and provide them with reasonable detail.

Table 2 VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1915.99				3.6e-10*	-13.2387*	-13.2234*	-13.2006*
1	1920.62	9.2637	9	0.413	3.7e-10	-13.2084	-13.1474	-13.0562
2	1924.14	7.0325	9	0.634	3.8e-10	-13.1705	-13.0637	-12.9041
3	1929.34	10.405	9	0.319	3.9e-10	-13.1442	-12.9917	-12.7636
4	1934.65	10.626	9	0.302	4.0e-10	-13.1187	-12.9204	-12.6239
5	1942.01	14.725	9	0.099	4.1e-10	-13.1074	-12.8634	-12.4984
6	1947.39	10.756	9	0.293	4.2e-10	-13.0823	-12.7925	-12.3592
7	1960.11	25.433*	9	0.003	4.1e-10	-13.108	-12.7725	-12.2707
8	1967.91	15.606	9	0.076	4.1e-10	-13.0997	-12.7185	-12.1482
9	1969	2.1838	9	0.988	4.3e-10	-13.045	-12.618	-11.9793
10	1975.27	12.542	9	0.184	4.4e-10	-13.0261	-12.5534	-11.8463
11	1977.88	5.2035	9	0.816	4.6e-10	-12.9818	-12.4633	-11.6878
12	1982.5	9.2411	9	0.415	4.8e-10	-12.9515	12.3873	-11.5433

Based on Table 2 VAR model identification, the total number of lag returns is twelve, and corresponding indexes of each log are listed in Table 1. The main indexes which need to pay more attention to are LR (likelihood ratio), FPE, AIC, HQIC, SBIC. Firstly, by checking indexes of FPE, AIC, HQIC, SBIC, the lag order is all zero; since these indexes are all based on the logarithmic fitting function, detecting the smallest number in each index are determine the corresponding lag order. However, the lag order for these indexes is all zero, which is meaningless. Another way to determine the lag order is determining by utilizing the LR index, which refers to the likelihood function. The main method to find lag order is to ensure the corresponding p-value is less than the significant level. Hence, for the VAR model, the lag order is seven. i.e., the log return of VAR model is seven.

After determining the lag order in the VAR model, the next job that needs to do is to figure out if the VAR model is in a stationary state. In Figure 1, which shows the Roots of the companion matrix, the x-axis is the Real value, and the y-axis is the imaginary data value. All the data points are in the circle, which refer to that the VAR model is stable.

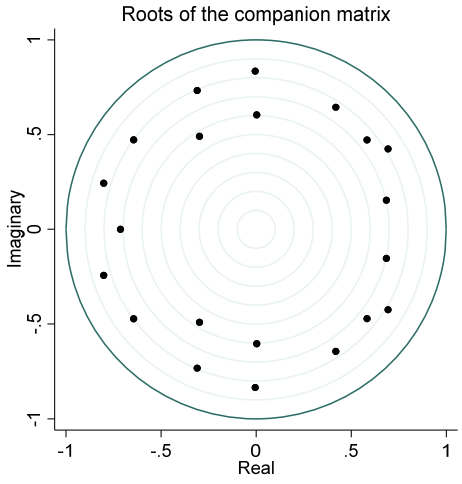

Figure 1 VAR stability test

4.2 Impulse and Response

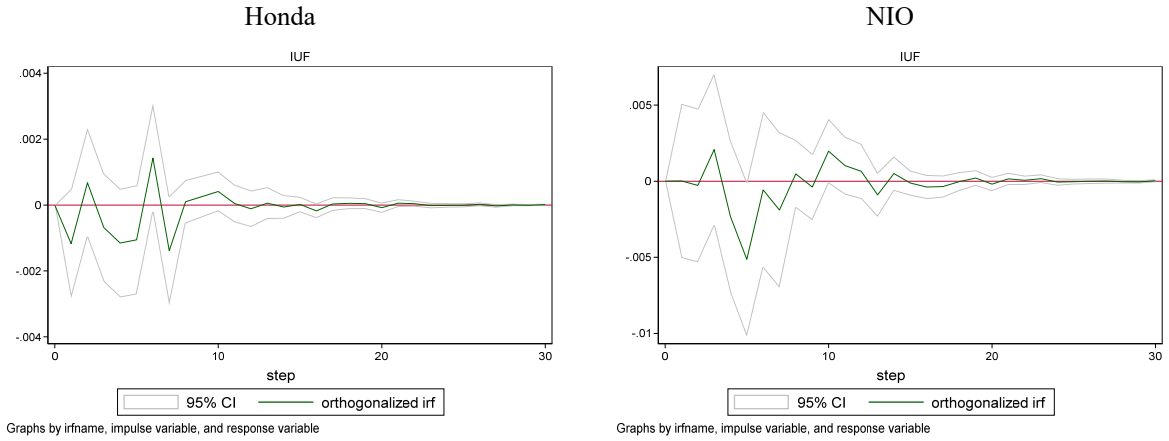

Figure 2 Impulse and response

After confirming the VAR model is stable, the next step needs to do is to determine how each model's variable is in reaction to a shock in the price of WTI crude oil (Figure 2).

Starting from the fundamentals, in the short period after the outbreak of the conflict between Russia and Ukraine, China's entire financial market fluctuated violently and went down rapidly along with the sharp rise in oil prices. But as the day went on, the indices largely recovered to their pre-conflict levels. This situation shows that the Russia-Ukraine conflict is more of a short-term shock to the whole financial market. In the medium and long term, the financial market reflects its fundamentals more than short-term shocks.

In terms of the auto industry, the increase in the price of oil in the traditional fuel automobile industry is a huge negative. As an alternative to traditional fuel vehicles, changes in oil prices have little impact on consumer vehicle costs.

From the perspective of the estimated results of the impulse response, the current unit of oil price shocks for the future period the influence of Honda yields a negative net effect. Specifically, an oil price shock of 1 unit in the current period has several negative effects in the future period, the size of which is slightly less than 0.2%. As a substitute for fuel vehicles, intuitively speaking, new energy vehicles should benefit from the oil price shock. But, the influence of the promotion of new energy vehicles oil prices, there are two completely different effects: first, the increase in the price of crude oil must raise the cost of the consumer's car, and then from the perspective of substitutes, rising oil prices can improve NIO to car sales. Second, as the blood of modern manufacturing, oil has played a vital role in production. The manufacture of complete vehicles involves various sub-industries of the manufacturing industry. The increase in oil prices will cause an increase in production costs in these industries. According to basic economic assumptions, firms cannot adjust their prices in the short term. Higher production costs must mean lower returns.

To sum up, the increase in the price of oil affects NIO to cars depending on whether sales growth brings a positive effect greater than the negative effect from the higher costs. Obviously, from the corresponding estimation results of pulse, the cost effect dominates; that is, NIO also loses in the environment of higher oil prices.

4.3 ARMA

In this section of the paper, firstly, it is necessary to order the first log-return series using the PACF and ACF pairs, the results of which are shown in Figure 3.

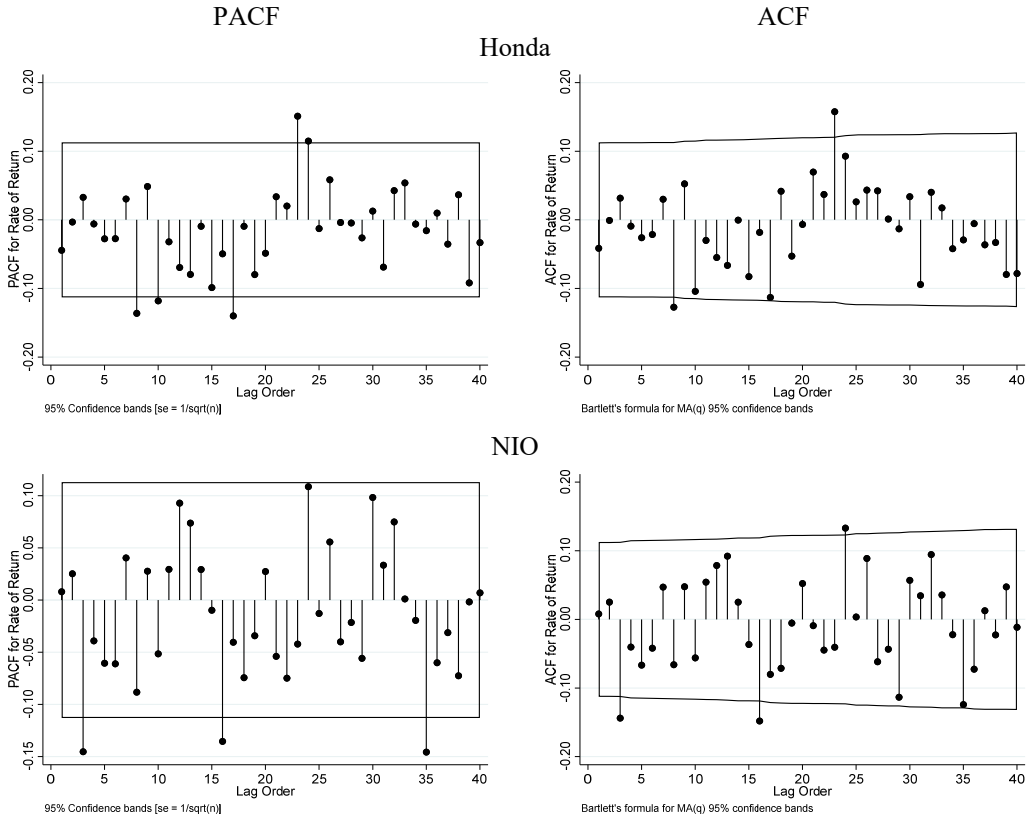

Figure 3 PACF and ACF

First, this part needs to order the log returns of traditional fuel car company Honda and the results are presented in the figure above.

From the fixed order result of the two images in the first row of Figure 3 PACF and ACF, for PACF in Honda, the first part beyond the box is eight, so AR(p) is of order eight. For ACF in Honda, the first part beyond the box is eight also, so MA(q) is also the order of eight. i.e., the value of p and q is eight.

Then, the next step of this part is to order the log-returns of the new energy car company—NIO, and the results are present in the second row of Figure 3 PACF and ACF.

From the fixed order result of the two images in the second row of Figure 3 PACF and ACF, for PACF in NIO, the first part beyond the box is three, so AR(p) is of order three. For ACF in NIO, the first part beyond the box is three also. So, the MA(q) is the order of four. i.e., the value of p and q is equal to four.

4.4 ARMA-GARCH

To better forecast, the variance of the future return of two car companies – Honda and NIO, the ARCH model is to investigate the impact of WTI crude oil price changes on Honda and NIO volatility.

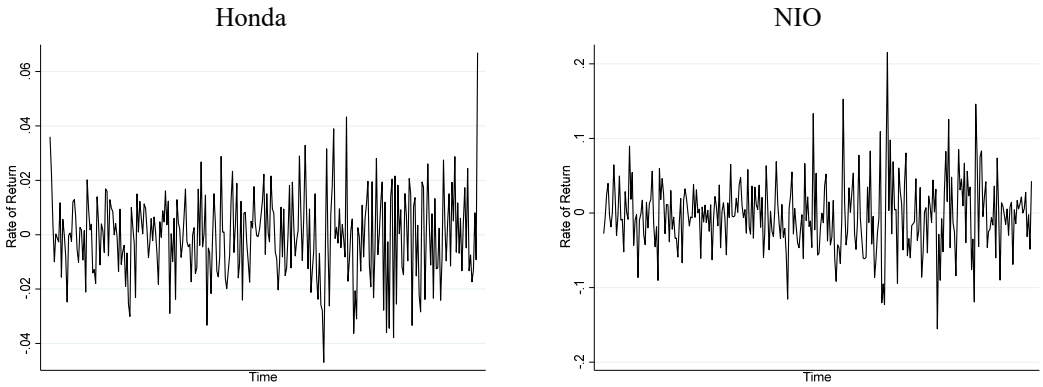

Figure 4 Yield

By detecting Figure 4, it is obvious that the two rates of return have been vibrating up and down for both Honda and NIO. In a certain period, the oscillation of rate of return for both Honda and NIO is dramatic. Hence, there is a clear conditional heteroskedasticity in two car companies' indices, which represents the return of stock in a certain period fluctuating sharply at one time and less at another. Theoretically, when the volatility(variance) of the current period or last period is large, the volatility(variance) of future periods is likely to be large as well, and vice versa. In other words, observations with large variances seem to cluster together, while observations with small variances seem to cluster together. However, whether there is autoregressive conditional heteroskedasticity and how significant the conditional heteroskedasticity is still needed to be examined by the model estimation results.

4.5 Estimation results

After constructing the model, Table 3 of ARMA-GARCH is listed below. After mean function controls the autocorrelation of returns, the returns of Honda and NIO both have a significant GARCH effect, since the p-value of all parameters is very large which is much bigger than the significance level. Thus, the returns of these two have statistically significant conditional heteroskedasticity, which can be used for GARCH model.

Table 3 ARMA-GARCHX estimation results

Variables	(1) Honda			(2) NIO		
	Coefficient	Std. err	p>|Z|	Coefficient	Std. err	p>|Z|
			Mean equation			
AR, L3	-.5916	1.2806	0.644	0.644	1.1200	0.860
MA, L3	0.6185	1.2423	0.619	0.619	1.1082	0.820
Constant	-.0004	0.0009	0.672	0.672	0.0024	0.387
			Variance equation			
Crude oil	-31.3498	41.2937	0.446	0.448	6.9291	0.000***
ARCH, L1	.0214	0.0189	0.257	0.257	0.0189	0.099*
GARCH, L1	.9774	0.0191	0.000***	0.000	0.0264	0.000***
Constant	-14.4667	4.7825	0.002***	0.002	0.6383	0.000***

Then, based on the result of the variance equation, for the car company Honda, the p-value is 0.446, which is much bigger than the significance level, suggesting that the log return on WTI crude oil did not increase Honda's estimated earnings volatility. For the car company NIO, the p-value is 0.000, indicating that the log return rate of crude oil will have an impact on Honda's estimated earnings volatility. To be more specific, when the log return of WTI crude oil increases by one unit, the volatility of NIO returns increases by 0.448 units.

5. Conclusion

The theme of this paper contains two parts. The first part is to figure out the price of WTI crude oil affects the yield of Honda and NIO; The other question solved in this paper is to figure out the price of WTI crude oil affects the volatility of Honda and NIO in the short run and the long period, especially in carmakers in two directions, Honda focuses on the traditional fuel car. However, NIO is the new energy carmaker replacing gasoline with electricity.

Since June 1st, 2020. the world experienced a long period of turmoil. On the one hand, most of the countries in the world support the slogan of reducing carbon emissions, especially since China has set a goal of becoming carbon neutral by 2030 and peaking by 2060. But on the other hand, traditional fuel vehicle companies still occupy a huge market share in the market and are still affected by the price fluctuations of crude oil. Saudi Arabia has made it clear that it cannot continue to pump more oil and conflict in major oil-producing countries in the Middle East. Furthermore, the Russia-Ukraine conflict in the first half of 2022 caused the world's second-largest oil producer to start restricting crude oil exports to outside countries. Wall street bosses are calling for oil to reach 150 dollars a barrel. In this context, this paper mainly uses the ARMA-GRACH model to test, forecast, and integrate the relevant data and suggests that in the short run, the fluctuation of WTI crude oil price could affect the volatility of two car companies. While the impact is not significant enough in the long run to have a remarkable influence on the future development of two car companies. Furthermore, by utilizing the VAR model to figure out both Honda and NIO have seen their yields fall amid rising WTI crude oil prices, indicating that policy, the cost of building cars, and so on all affect their return.

In the present day, after the Russia-Ukraine conflict, companies linked to not only traditional carmakers but also new energy car companies, the stock price returned to the previous range. In addition to our yearning for future peace, such rare events will become less and less frequent, and the price of crude oil will tend to be stable, which will have a limited impact on the stock return of car companies.

Furthermore, the UK has already announced that the UK will not sell traditional fuel cars in 2030. China also announced that the carbon peak in 2030, began to protect the environment and control carbon emissions, more car companies will choose to vigorously develop new energy vehicles, and gradually get rid of dependence on crude oil. BMW, Mercedes-Benz, and Audi, these traditional fuel car companies, have launched new energy vehicles, and the performance is not worse than the fuel car. In addition, Tesla is in the US. And BYD in China, which pay attention to the development of new energy vehicles, is promoting the future development of new energy vehicles. It is also necessary to actively seek corporation between traditional fuel carmakers and new energy companies and promote technological innovations.

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