The yield and volatility of automobile industry under the rapid changes in crude oil prices

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Abstract. The increasing conflict between Russia and Ukraine since February 2022 has had a significant effect on the world's political and economic condition. In the early days of the conflict, crude oil prices were subject to extreme swings. The auto industry is impacted as it is a part of the macroeconomy and is closely linked to the oil sector. This essay intends to investigate how changes in crude oil prices brought on by the war between Russia and Ukraine affect both the traditional and the new energy auto industries. The modeling, analysis, and probable explanation of the fall in new energy vehicle stock returns brought on by the rise in crude oil prices, which is contrary to economic intuition, are the research contributions of this work.

Keywords: Conflict between Russia and Ukraine; Crude oil; Automobile; New power automobile.

1. Introduction

The Russian Defense Ministry announced in the public eye on February 15, 2022, that it was pulling back some of its land forces stationed along the Russian-Ukrainian border and previously involved in significant military drills. It looks like the eastern Ukraine crisis, which started in October 2021 and lasted until February 2022, is gradually abating.

The situation in eastern Ukraine unexpectedly worsened quickly on February 17, 2020, with the Ukrainian government and local militias accusing one another of engaging in provocative bombardment along the contact line. Vladimir Putin, the president of Russia, issued a decree on February 21st night recognizing the "Donetsk People's Republic" and the "Luhansk People's Republic" in eastern Ukraine. Then, the following day, Sergei Lavrov, the foreign minister of Russia, declared that his country will ensure the safety of the "Donetsk People's Republic" and the "Luhansk People's Republic." On February 23, Russian President Vladimir Putin gave his approval for the use of Russian military forces abroad. The Russia-Ukraine war reportedly started on February 24, 2022, when Russian President Vladimir Putin formally declared war on Ukraine.

Although war is a continuation of politics, in the final analysis, the goal of war is economic. The economy is the end of politics, and politics is the means of the economy [1]. Since the end of February, the situation between Russia and Ukraine is still changing, which has had a profound impact on the international political economy. The sudden turmoil has spilled over into global economic markets. Wheat, aluminum, nickel, and other commodities surged on February 23. Many countries including The United States, Britain, and Canada have announced economic sanctions against Russia. And the natural gas business in the European market also suffered a considerable negative blow.

One of the most significant energy markets, crude oil, has also been affected by the conflict. Three months after the start of the Russian-Ukrainian conflict, reports claim that the oil dynamic has become more obvious, with Europe now importing record levels of crude from the US and the North Sea as well as more barrels from West Africa as governments work to lessen their reliance on Russian oil and eventually wean themselves off of it entirely. In order to comply with present and potential sanctions on Russian oil exports, UK and EU trading houses, insurers, reinsurers, and tanker owners are avoiding engaging with Russian oil supplies. According to ship monitoring data published by Bloomberg, the U.S. exported the most crude oil to Europe in April since lifting its export restrictions in 2016. In May, Europe imported 1.45 million barrels per day of U.S. crude, an increase of 15%

from March. According to Petro-logistics, a tanker tracker, Europe is also importing significantly more crude from North and West Africa.

The economic impact of war is largely a matter of experience rather than a theory [2]. Looking at market dynamics during past wars, it is easy to note the negative impact of wars on commodities. In contrast, however, it has been observed that crude oil prices usually rise sharply in the run-up to wars. Crude oil is a strategic commodity and is tied to the dollar, for the current financial instability and uncertainty increasing, the influence of its direct impact not only on the United States and other developed countries and developing the national economy, but also on the related financial markets - exchange rates, stock prices have important containment and influence [3]. The market is the only factor long-term trend of oil price, and price volatility is dominated by war, political situation mutations, the futures market speculation, the psychology of the market, and some non-market factors such as climate change and the political, especially the war had a huge impact on oil prices [4].

High oil prices do serious reverse damage to the economy, as has been documented in the past [5]. And the continuous rise of crude oil price will have varying degrees of impact on the financial market, aviation, automobile manufacturing, transportation, and aluminum industries which use more electricity, as well as the lives of the general people [6]. As a component of the macroeconomy and an industry closely related to crude oil, it seems intuitive that the traditional automobile industry should be affected by the surge in crude oil prices caused by the conflict between Russia and Ukraine. Similar to this situation, as early as around 2005, the international oil price continued to rise, and China's oil-related industries were greatly affected [7]. In particular, the automobile industry, which had a very good development momentum in those years, bore the brunt. Although automobile manufacturers took various measures to reduce costs and promote sales through low prices, automobile sales still changed the momentum of rapid growth and remained stagnant [8]. Also in 2005, some scholars pointed out that the rising price of oil and steel is putting the world's car manufacturers in a difficult position [9]. In the context of global warming, emission reduction commitments, and a low-carbon economy, in the context of political and economic turmoil in the world, oil shortage, and high crude oil prices, it has become fashionable to look for the direction of new energy vehicles and use economical and fuel-efficient cars [10]. Therefore, it seems intuitive to think that the current rise in international crude oil prices will have a positive impact on the whole new power automobile industry

This article aims to study the impact of the crude oil price fluctuation on the traditional automobile industry and the new power automobile industry and try to demonstrate whether it conforms to this intuition and give possible explanations.

The next sections of the essay are arranged in the following order: Section 2 is the study design, which includes data sources, model formulation, and introduction of identification approach. Section 3 comprises the estimation findings of the VAR, ARMA-GARCH model. Discussion is in Section 4. Conclusion is in Section 5.

2. Research Design

2.1 Data source

This paper's financial information, including the stock prices of automobiles, new power vehicles, and crude oil, were acquired through the Choice Financial terminal. Since February 15th, when the Russian Defense Ministry announced the withdrawal of some of its land soldiers stationed along the Russian-Ukrainian border and previously involved in sizable military drills, the adjusted closure price is chosen every day. Every year, hundreds of papers and reports use data from this website, indicating the excellent caliber of the data. All of the data used in the analysis of the remaining portions of the article are logarithmic, which means that data on stock prices, daily yields, etc. refers to the logarithm of the sum of price, yield, and 1, etc.

2.2 Unit root test

It is necessary to test each variable's stationarity before building models.

The model is as follows:

$$x_t = C_t + \beta x_{t-1} + \sum_{i=1}^{p-1} \phi_i \Delta x_{t-i} + e_t \quad (1)$$

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In (1), the null hypothesis is β=1 which means x_t is not stationary and the alternative hypothesis is β<1. Rejecting the null hypothesis, when the p-value is smaller than 0.05.

According to Table 1, the ADF test reveals that while the stock price is non-stationary and has a p-value greater than 0.05, the yield of automobiles, new power automobiles, and crude oil are all stationary and all have p-values less than 0.05. Given that they are all stationary, the yield of automobiles, new power vehicles, and crude oil are all qualified introduced variables in the ARMA-GARCH model.

Table 1 ADF test

Variables	t-statistic	p-value
Price		
Automoblie	-0.585	0.9797
New power automobile	-0.510	0.9830
Crude oil	-2.297	0.4354
Yield		
Automoblie	-8.151	0.0000***
New power automobile	-8.629	0.0000***
Crude oil	-7.468	0.0000***

2.3 VAR model specification

This section of the article builds a VAR model to investigate the dynamic influence of crude oil yield on stock returns for the automotive and new powertrain industries. To ensure that the predictions are mutually compatible, the variables are combined and predicted as a single system. Model settings are as follows:

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

The impact of a single unit disturbance on how other variables will evolve is examined through the impulse response function.

The model is as follows:

$$\frac{\partial y_{t+s}}{\partial \varepsilon_t} = \varphi_s \quad (3)$$

This equation determines the degree to which the disturbance term ε_t of the variable at the t-th period grows by one unit, while other variables and disturbance terms in other periods remain constant, affecting the value of the variable at the (t+s)-th period, y_{t+s}.

2.4 ARMA-GARCH model specification

In order to anticipate the rate of return and volatility of stocks of automobiles and new power vehicles, this study currently builds the ARMA-GARCH model. The crude oil yield is employed as an exogenous variable.

As a result, it can assess the relationship between the outbreak scenario and the yield and stock volatility.

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

$$x_t = \phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i} + a_t - \sum_{i=1}^{q} \theta_i a_{t-i} \quad (4)$$

In (4) a_t is white noise, and both p and q are nonnegative integers.

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

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2 + \gamma_1 \sigma_{t-1}^2 + \cdots + \gamma_p \sigma_{t-p}^2 \quad (5)$$

The term $\alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2$ is an ARCH component in (5). The subscript t indicates that the conditional variance, σ_t^2, of the disturbance term, ε_t, varies over time. The square of the disturbance term in the preceding p periods determines σ_t^2.

The ARCH model serves as the foundation for the GARCH model, which also includes the autoregression of σ_t^2.The term $\gamma_1 \sigma_{t-1}^2 + \cdots + \gamma_p \sigma_{t-p}^2$ is a GARCH component in (5).

The GARCH model is made to have fewer parameters. By repetition, it can reduce ARCH(p) to GARCH (1,1).

3. Empirical results and analysis

3.1 VAR identification

Table 2 shows that whereas FPE, AIC, and HOIC achieve a minimum at lag=1, LR reaches its minimum at lag=24. Therefore, this paper determines the order of the VAR model as 24.

Table 2 VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1038.1				3.9E-11	-15.4493	-15.4229	-15.3844*
1	1059.04	41.873	9	0.000	3.3E-11*	-15.6274*	-15.522*	-15.3679
2	1064.68	11.296	9	0.256	3.4E-11	-15.5774	-15.3928	-15.1232
3	1068.57	7.7708	9	0.557	3.7E-11	-15.501	-15.2374	-14.8523
4	1073.8	10.452	9	0.315	3.9E-11	-15.4447	-15.102	-14.6013
5	1079.72	11.85	9	0.222	4.1E-11	-15.3988	-14.977	-14.3608
6	1085.18	10.919	9	0.281	4.4E-11	-15.346	-14.8451	-14.1133
7	1091.31	12.25	9	0.200	4.6E-11	-15.3031	-14.7231	-13.8758
8	1096.2	9.7914	9	0.368	4.9E-11	-15.2418	-14.5827	-13.6199
9	1098.93	5.4542	9	0.793	5.4E-11	-15.1482	-14.41	-13.3316
10	1107.42	16.982	9	0.049	5.5E-11	-15.1406	-14.3233	-13.1294
11	1112.68	10.516	9	0.310	5.8E-11	-15.0847	-14.1884	-12.8789
12	1117.3	9.2542	9	0.414	6.3E-11	-15.0195	-14.044	-12.619
13	1122.28	9.9524	9	0.354	6.8E-11	-14.9594	-13.9049	-12.3643
14	1126.81	9.0683	9	0.431	7.3E-11	-14.8928	-13.7591	-12.103
15	1132.41	11.183	9	0.263	7.8E-11	-14.8419	-13.6291	-11.8575
16	1149.43	34.047	9	0.000	7.1E-11	-14.9616	-13.6698	-11.7827
17	1159.08	19.308	9	0.023	7.2E-11	-14.9714	-13.6005	-11.5978
18	1166.65	15.14	9	0.087	7.5E-11	-14.9501	-13.5	-11.3818
19	1172.8	12.302	9	0.197	8.1E-11	-14.9075	-13.3784	-11.1447
20	1184.31	23.011	9	0.006	8.1E-11	-14.9449	-13.3367	-10.9874
21	1191.77	14.909	9	0.093	8.6E-11	-14.9219	-13.2346	-10.7697
22	1203.01	22.496	9	0.007	8.6E-11	-14.9554	-13.189	-10.6087
23	1211.04	16.058	9	0.066	9.2E-11	-14.9409	-13.0955	-10.3995
24	1223.21	24.334*	9	0.004	9.2E-11	-14.9882	-13.0636	-10.2522

The first step is to check the stationarity of the parameters before estimating them.
The model is set as follows, for k>1,

$$VAR(k): Yt = C + AYt{-}1 + U\ t \tag{6}$$

To declare that this VAR system is stationary, all the roots of the characteristic equation $|A - \lambda I| = 0$ must be inside the unit circle. Figure 1 displays the final result. Figure 1 demonstrates that the VAR system is stationary since all of the black dots are contained within the unit circle.

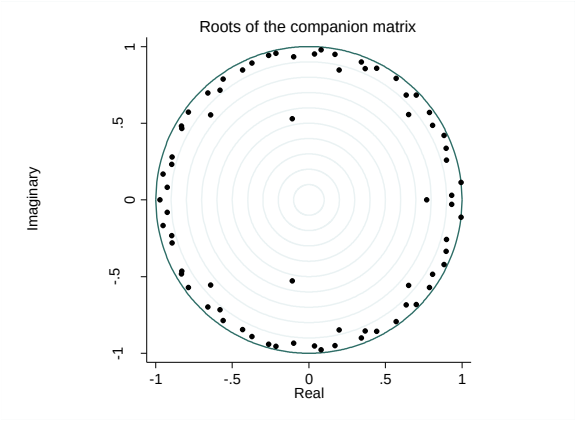

Figure 1 VAR stability

3.2 Impulse and response

The next step is to take the stock return of automobile and new power automobile as the response variable separately, and crude oil as the impulse variables, respectively, to generate the impulse response diagram. The left portion of figure 2 evaluates the relationship between automobile and crude oil, and the right portion evaluates the relation between new power automobile and crude oil.

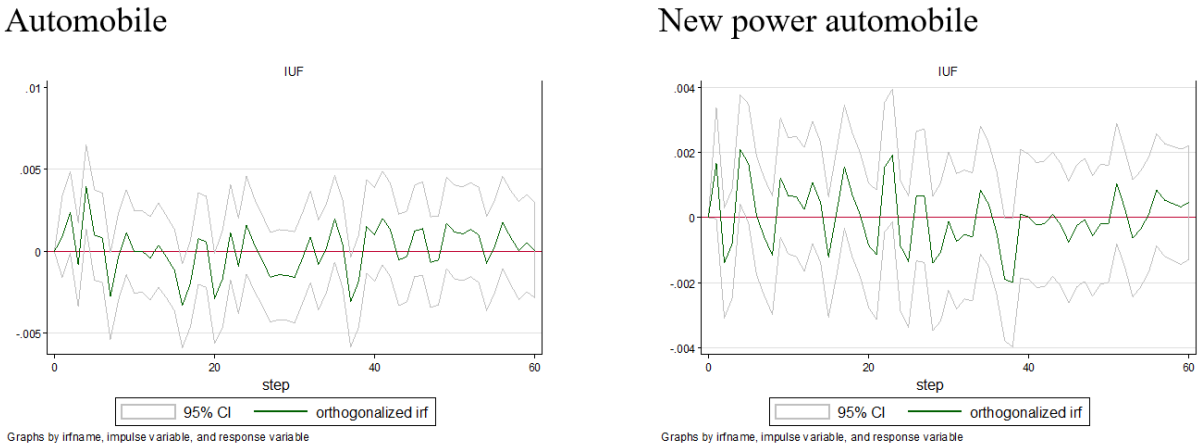

Figure 2 Impulse and response

Note: The Y-axis represents the impact of the pulse in crude oil yield on the rate of return for automobiles and new power automobiles, while the X-axis represents the period change.

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.

According to the estimated results of the impulse response, the current oil price change will cause drastic fluctuations in the return rate of the automobile industry and the new energy automobile industry in the future. When the oil price changes by 1%, the return rate of the automobile and new energy automobile index oscillates between 0.2% and 0.3% in amplitude.

The possible reason is that oil is the blood of the modern industry, and the automobile industry is highly dependent on the manufacturing industry. The fluctuation of oil prices is transmitted to the manufacturing industry, which further affects the automobile industry.

3.3 ARMA identification

This component must first establish the AR model's order using the PACF test and the MA model's order using the ACF test.

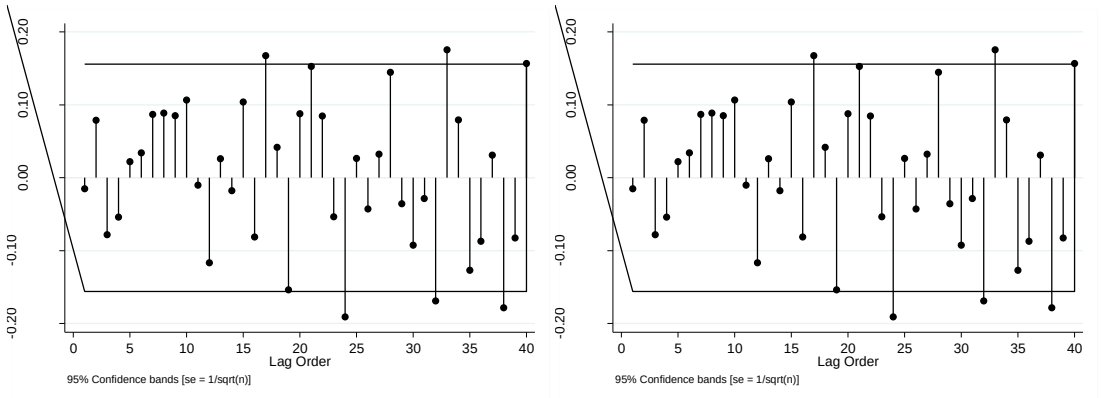

Figure 3 PACF and ACF, automobile

For PACF figures, the dependent variable, PACF of the log of automobile and new power automobile's rate of return, is on the Y-axis, and time lag order is on the X-axis in Figures 2 and 3. For ACF figures, the right-hand sides of Figures 2 and 3, the Y-axis is the dependent variable, ACF of the log of automobile and new power automobile's rate of return, and the X-axis is the time lag order. The region enclosed by y=-0.1 and y=0.1 denotes the 95% confidence interval for AR(p). The 95% confidence interval for MA is what is meant by the bounded region (q).

From Figure 3, it is clear that for the automobile industry, PACF and ACF both start to decline in the 95% confidence range after lag=17.

In Figure 3, the PACF for new power automobiles starts to decline in the 95% confidence interval after lag=25, but the ACF does not perform to decline in the 95% confidence interval.

Hence, for automobile, AR (17) and MA (17) are taken into the ARMA portion in ARMA-GARCH model; and for new power automobile this paper takes AR (25) and MA (0) into the ARMA portion in ARMA-GARCH model.

The ARMA-GARCH model is then used in this study to determine the relationship between crude oil yield, car stock returns, and new power vehicle sales.

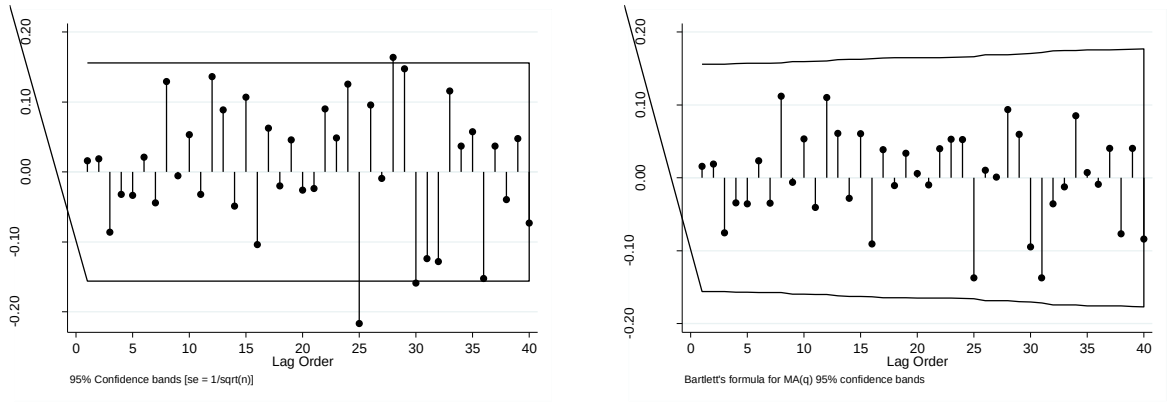

Figure 4 PACF and ACF, new power automobile

3.4 ARMA-GARCH estimation results

Table 3 is the estimation result of the variance equation based on ARMA-GARCH model.

According to the estimation results of variance equation, the GARCH term of the index return rate of the entire automobile industry is significant, indicating that the index return rate of the automobile industry has significant conditional heteroscedasticity, which can be used for GARCH modeling. The ARCH term and GARCH term of the new energy vehicle index return rate is not significant, so the model in column (2) is meaningless.

According to the estimation results in column (1), the change in oil yield has no significant impact on the daily volatility of the automobile industry.

Table 3 ARMA-GARCH estimation results

Variables	(1) Automoblie		(2) New power automobile	
	Coef.	Std. err	Coef.	Std. err
Crude oil	16.2782	115.6902	6.5024	9.7221
ARCH (-1)	0.0395	0.0394	0.1299	0.0973
GARCH (-1)	0.9525***	0.0577	0.0794	0.6295
Constant	-12.1875***	3.5795	-8.5809***	0.7959

4. Discussion

This article finds that the change in crude oil prices caused by the conflict did lead to a small swing in yields of automobile and new power automobile. But from the whole range, it did not cause an increase in daily volatility.

In combination with the existing literature on new energy vehicles, many scholars have mentioned that the continuous rise in international oil prices will be an excellent opportunity for the new energy vehicle industry to further seize the opportunity of the traditional fuel vehicle market. This paper, based on data, seems to violate this conclusion, but they do not conflict. As discussed above, the rise and fall of international oil prices are still relatively in line with the global economic development cycle, which is a long-term and dynamic result. And this round of crude oil price surge, the main reason is the stress reaction of the market panic caused by the war between Russia and Ukraine. Policymakers should take note that market jitters caused by small wars, while short-lived, should not be taken lightly, to stabilize market confidence and preserve the economic balance within countries. For investors, taking advantage of the impact of state-to-state skirmishes on the oil market and the auto industry can also help boost returns in the short term.

5. Conclusion

In order to study the impact of the crude oil price fluctuation on the traditional automobile industry and the new power automobile industry and try to demonstrate whether it conforms to this intuition and give possible explanations, this paper uses VAR and ARMA-GARCH models to model the stock return of automobile, new power automobile, and crude oil.

Combined the impulse response results and ARMA-GARCH estimation results, the main conclusion of this paper is: the change in oil price caused by the Russia-Ukraine conflict has caused a small shock in the return rate of automobile and new energy enterprises in the future, but from the whole range, it has not caused the increase of daily volatility.

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