Predict Changes in Crude Oil Price and New Energy Automobile Industry Impacted by the Russian-Ukraine War

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Abstract. The Russian-Ukraine War is a hot topic nowadays as it causes a sharp rise in the world crude oil price, due to fears of supply shortages mount, which affects the cost of production for many industries. Meanwhile, the fear of running out of crude oil pushes the world to find new energy as a substitute. The car industry is an outstanding example that is experiencing transit from oil cars to new energy cars. Hence, there exist close relationships between the crude oil price and the new energy car industry. The article will discuss the short-run and long-run impact of the Russian-Ukraine War on crude oil prices and the Chinese new energy car industry using the VAR and ARMA-GARCH model. The models show that the effect of rising crude oil prices on the Chinese new energy automobile industry depends on whether the positive effect of sales growth is greater than the negative effect of the increase in cost in the short run, plus there's no significant impact for the long term.

Keywords: Russian-Ukraine War, Brent Crude Oil Price, Chinese New Energy Automobile Industry.

1. Introduction

Although electric vehicles have been on the road for over a century, the past decade has been the most significant 10-year period for electric vehicles. This is due to the worldwide energy shortage problem and the environmental issues are urgent and they raise people's awareness. The nonrenewable resource – crude oil – is one of the main energies used in the production of cars and in powering cars will also face a shortage situation in the near future. The 2022 Russian-Ukraine war again pulled out fear of a shortage in crude oil and surges the crude oil price. This change reminds people of the transition period in the car industry and arouses people's interest in the changes that the war would bring to the new energy car industry. Since the Chinese new energy car sector has entered a period of rapid development, the study will focus on how the war impacted the Chinese new energy car sector.

This article is meant to access the impact of the Russian-Ukraine war on crude oil price change and the Chinese new energy automobile industry. By analyzing the impact of the Russian-Ukraine War, it will provide logic for future predictions if there's a similar positive shock in oil prices like war, how would the new energy industry react. With this logic, policymakers can adjust faster when things happen. Investors can know whether the Russian-Ukraine war creates a good time to invest in the Chinese new energy automobile industry. Additionally, previous articles mostly only discuss relationships between war and crude oil prices or relationships between crude oil prices and energy cars, but barely put these three things together. It is meaningful to learn about their three relationships from this recent shock. Hence, based on the most recent Brent crude oil price and Chinese electronic car industry index data, this article predicts crude oil price change and the Chinese new energy automobile industry impacted by the Russian-Ukraine War based on the VAR model and ARMA-GARCH model.

After the introduction, the paper is organized as follows: the second part is a literature review, which talks about the relevant studies on the causes and impacts of the Russian-Ukraine war on crude oil prices and how the crude oil price would affect the new energy car industry, concluding with a summary of the literature review. The third part writes samples, variables, and models of the Brent crude oil price and the Chinese new energy car index. The samples were tested using ADF, and the VAR and ARMA-GARCH model were used to demonstrate the variables' relationships. They are

backup by tables and figures generated from Stata. The fourth section will then use empirical results and analysis to show the impact of Brent crude oil price change on the Chinese new energy car industry. Then, it discusses how this article compares to existing ones, enlightens, and how policymakers and investors should interpret it. Last, it concludes the war's impact on oil prices and Chinese new energy car industry. The goal of this paper is to evaluate whether the 2022 Russian-Ukraine war shock would help the Chinese new energy car industry growing or not by affecting the Brent crude oil price in the short run and long run.

2. Literature Review

2.1. Studies Related to War and Crude Oil Price

In many previous studies, they reveal that a war incur would increase crude oil prices and fall back to pre-war levels after the war ended. It is observed from the Gulf War and mentioned in Kaboudan's research about compumetric forecasting of crude oil prices [1]. The oil prices were also lifted in the 1990 Kuwait invasion and the Iraq war in 2003 stated in Coleman's study [2]. This is also supported by one of the most recent studies that analyzed the Russia-Ukraine war and US oil price conducted by Isaac Appiah-Otoo [3] points out that the war increased oil prices and suggest a policy to transit towards renewable energy sources. Based on the previous literature, it is obvious that war is a positive shock to oil prices, and the Russia-Ukraine war, specifically, also increased crude oil prices. With this understanding, the change in Brent crude oil price can quantify the impact of the Russian-Ukraine war. Then, the focus of this study would be mainly on how the Chinese new energy car industry is affected by the Brent crude oil price which captured the war impact.

2.2. Studies Related to Crude Oil Price and New Energy Car Industry

It seems straightforward that if using an oil-powered car is more expensive, people would switch to a new energy car instead and pushing the electric car industry to grow. As suggested in Dijk, Orsato, and Kemp's study [4], the high oil price expectation and the unpredictability of future prices brought attention to vehicles that do not depend on oil. However, as crude oil price grows, the cost of producing new energy car will also grow and decreases the surplus for people to buy new energy cars instead. As revealed by Du and Lin's research [5], only when oil price rise considerably will the consumer change his purchase intention to a lower-emission car, for a household income of more than 300,000 yuan. Knowing that oil prices will fall back to pre-war level after the war ends from the previous review section, the intention of buying a lower-emission car might only last for a short period. This inference will be proven in the later section.

2.3. Review of the Literature

Overall, the research on the impact of the war on crude oil prices has been relatively well researched, but there is still relatively little research on the impact of the Russian-Ukraine war on the new energy car industry, especially on China's domestic electric car industry. It is difficult to predict the effect caused by the Russian-Ukraine war on the Chinese new energy car. Therefore, this paper aims to find the relationship between them and use empirical data to prove the impact of the Russian-Ukraine war on the short and long-run development of the Chinese electric car industry.

3. Samples, Variables and Models

3.1. Data Resource

Among the price standard for crude oil, Brent is the benchmark for African, European, and Middle Eastern crude oil and is often considered the benchmark targeted by OPEC. The study extracted daily closing Brent crude oil price and daily Chinese electronic car index from June 1, 2021, to September 16, 2022, from the choice financial terminal. Data processing is required to figure out the impact of

the increase in Brent crude oil prices throughout the world on Chinese electric car industry index fluctuations. To elaborate, the return rates, Brent oil price, and electronic car index, equal to today's number subtracted from yesterday's number and then divided by yesterday's number. Then log of the return rate plus one, ln(x+1), is used for further analysis in the VAR and ARMA-GARCH model. Some data on Brent and the electric car index are omitted because they are missing on specific days. With the filtered data, Stata was used to analyze the data and construct models for further exploration.

3.2. Units and Test

The first step before performing the VAR and ARMA-GARCH model is to test whether or not the data are stationary. Based on the ADF test conducted in Stata, the p-values in Table 1 for Brent crude oil price and the electronic car index all equal 0, which is considered statistically significant. The result demonstrates that the null hypothesis that the variable has a unit root should be rejected. This means the data are stationary and the model built on top is feasible.

Table 1. ADF test

Variables	t-statistic	p-value
	Price	
Brent	-1.964	0.6211
Electronic Car	-2.012	0.5951
	Yield	
Brent	-13.000	0.0000***
Electronic Car	-12.489	0.0000***

3.3. VAR Model

The use of the VAR model can be traced back to a study on linear stochastic difference equations [6] and research on the autoregressive nature used for Tinbergen's model [7] before reaching Sim's well-known contribution to VAR model application [8-9]. The VAR model can be employed to capture the relationship between multiple variables while avoiding the challenge of model construction based on rigorous economic theory [10].

$$x_{t,1} = \alpha_1 + \phi_{11}x_{t-1,1} + \cdots + \phi_{1p}x_{x-p,1} + \beta_{11}x_{t-1,2} + \cdots + \beta_{1p}x_{t-p,2} + e_{1t} \quad (1)$$

$$x_{t,2} = \alpha_2 + \phi_{21}x_{t-1,1} + \cdots + \phi_{2p}x_{x-p,1} + \beta_{21}x_{t-1,2} + \cdots + \beta_{2p}x_{t-p,2} + e_{2t} \quad (2)$$

$$\begin{bmatrix} x_{t,1} \\ x_{t,2} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \phi_{11} & \cdots & \phi_{1p} \\ \phi_{21} & \cdots & \phi_{2p} \end{bmatrix} \begin{bmatrix} x_{t-1,1} \\ \vdots \\ x_{t-p,1} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \cdots & \beta_{1p} \\ \beta_{21} & \cdots & \beta_{2p} \end{bmatrix} \begin{bmatrix} x_{t-1,2} \\ \vdots \\ x_{t-p,2} \end{bmatrix} \quad (3)$$

Equation (1) and (2) above are for Brent crude oil price and Chinese new energy car index, respectively, while equation (4) is in matrix form. To clarify, in equation (1), $\alpha_1 + \phi_{11}x_{t-1,1} + \cdots + \phi_{1p}x_{x-p,1}$ represents a linear function of past lags of Brent crude oil price, while $\beta_{11}x_{t-1,2} + \cdots + \beta_{1p}x_{t-p,2}$ represents past lags of Chinese new energy car index, e_{1t} is the error term. As a result, the variable Brent crude oil price is modeled using historical values for the variable and another variable. Similarly, the structure of the equations for the other variable is the same, but the variable on the left of the equation and coefficients are changed.

3.4. ARMA-GARCH Model

The ARMA-GARCH model can evaluate both the return and volatility of the log returns of the new energy car index. This is broken down into two sections below: ARMA and GARCH.

$$\mathrm{x}_t = \emptyset_0 + \sum_{i=1}^{p} \emptyset_i \mathrm{x}_{t-i} + a_i - \sum_{i=1}^{q} \emptyset_i a_{t-i} \quad (4)$$

In the equation (4) above, $\emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{t-i}$ represents the AR(p) model. This uses the historical returns of the log-returns of the new energy car index from June 2021 to September 2022; while $a_i - \sum_{i=1}^{q} \emptyset_i a_{t-i}$ uses past volatility to estimate the future and the MA(q) of the model with an error term.

Then comes another section GARCH. Fundamentally, GARCH is driven by ARCH. Both treat volatility as a variance to be modeled [11]. In this paper, GARCH (1, 1) was taken into account. The first "1" denotes one autoregressive lag and the second "1" denotes one moving average lag. Since GARCH (1, 1) has fewer parameters than ARCH(p), it fits many time series well [12], it is sufficient to identify the volatility clustering in the data [13], and it only requires one lag for analysis [14], GARCH (1, 1) is selected.

$$\sigma_t^2 = \alpha_{0,1} + \alpha_1 \varepsilon_{t-1}^2 + \beta_t m_t + \gamma_1 \sigma_{t-1}^2 \quad (5)$$

In the equation (5), term $\alpha_1 \varepsilon_{t-1}^2$ is ARCH part, $\gamma_1 \sigma_{t-1}^2$ stands for GARCH part, and $\beta_t m_t$ represents an extra explanatory variable which is log-returns of Brent crude oil price in the model.

4. Empirical Results and Analysis

4.1. VAR Lag Order

To decide the optimal lag order for a VAR model, each lag's LR statistic and other information criteria should be assessed. An asterisk sign (*) appears after the data representing the preferred lag order.

Table 2. VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1450.97				2.5e-07	-9.5326	-9.5229*	-9.5082*
1	1457.07	12.201	4	0.016	2.4e-07*	-9.5465*	-9.5171	-9.4731
2	1460.94	7.7449	4	0.101	2.5e-07	-9.5456	-9.4967	-9.4233
3	1462.3	2.7203	4	0.606	2.5e-07	-9.5282	-9.4598	-9.3571
4	1462.8	1.0023	4	0.909	2.6e-07	-9.5052	-9.4172	-9.2851
5	1464.01	2.4254	4	0.658	2.6e-07	-9.4869	-9.3793	-9.2179
6	1471.56	15.088	4	0.005	2.5e-07	-9.5102	-9.3830	-9.1923
7	1474.11	5.1103	4	0.276	2.6e-07	-9.5007	-9.3540	-9.1339
8	1475.33	2.4362	4	0.656	2.6e-07	-9.4824	-9.3161	-9.0667
9	1477.69	4.7221	4	0.317	2.6e-07	-9.4716	-9.2858	-9.0070
10	1481.42	7.4463	4	0.114	2.6e-07	-9.4698	-9.2644	-8.9563
11	1486.54	10.254*	4	0.036	2.6e-07	-9.4772	-9.2522	-8.9148
12	1489.3	5.5213	4	0.238	2.6e-07	-9.4691	-9.2245	-8.8577

Table 2 above shows that lag 11, 1, and 0 all have the sign. Because too low a lag order will cause the residuals to be autocorrelated, Lag orders 0 and 1 are omitted and lag 11 from LR is the lag order for the VAR model.

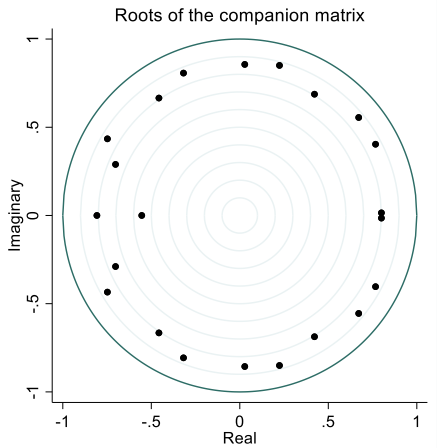


Figure 1. VAR stability (Photo credit: Original)

Figure 1 above shows that all the roots of the companion matrix are in the circle. This means that lag order 11 satisfies VAR stability.

4.2. Impulse Response

First, starting from the fundamentals, shortly after the Russia-Ukraine war, with a steep rise in crude oil prices, the whole financial market in China was volatile severely in that short period and went down quickly. However, as time passed by, stock indexes recover to pre-war levels in general. This demonstrates that the Russian-Ukraine war is most likely causing a short-term shock to the financial market. In the mid-long run, the financial market reflects more of its fundamental rather than short-run shock.

From the automobile industry perspective, an increase in crude oil prices creates a huge bearish market for the traditional fuel vehicle industry. New energy automobile as a substitute of traditional fuel vehicle, crude oil price changes barely affects the cost of driving for consumers.

As a substitute for fuel car, intuitively speaking, new energy vehicle seems to be gained from crude oil price shock. On the contrary, an increase in crude oil price has two opposite influences on new energy car companies:

First, an increase in crude oil price must increase the cost of driving for consumers. Then, as a substitute, an oil price increase does help promote new energy cars.

Second, crude oil as the blood of modern manufacturing has essential use in production. The production of the whole car is related to many sub-industries of manufacture. An increase in crude oil prices will also increase the production cost for these industries. According to the basic economic assumptions, an enterprise cannot adjust its price in the short run. If that's the case, then a rise in cost must mean a decrease in profit.

In summary, the impact of rising crude oil prices on new energy automobiles depends on whether the positive effect of sales growth is greater than the negative effect of an increase in cost.

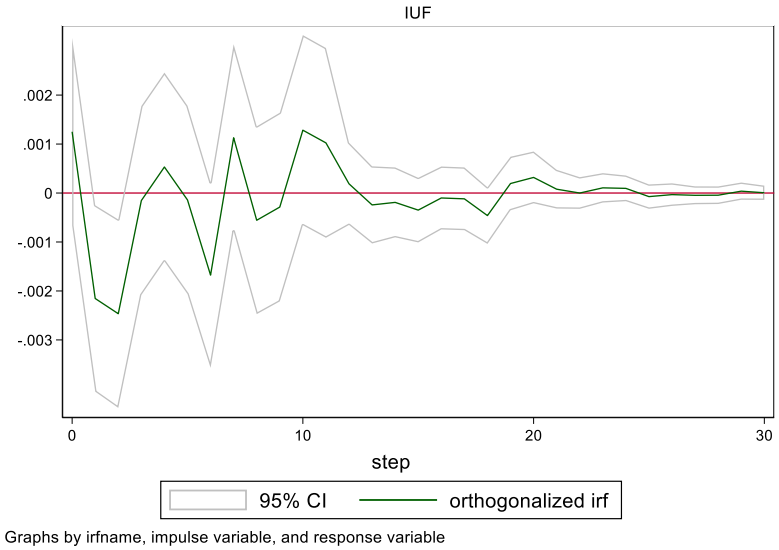


Figure 2. Impulse response (Photo credit: Original)

From the impulse response (Figure 2), at t=0, one unit of oil price shock has a positive effect on the new energy automobile industry in the current period, the market reaction is dominated by the positive factors, yet the greatest negative effect is only a bit higher than 0.1%. From the future perspective, cost effect, the highest 0.25%, and second highest 0.15%, obviously dominates. This indicates that the new energy vehicle industry will also face some losses under oil price rising situations.

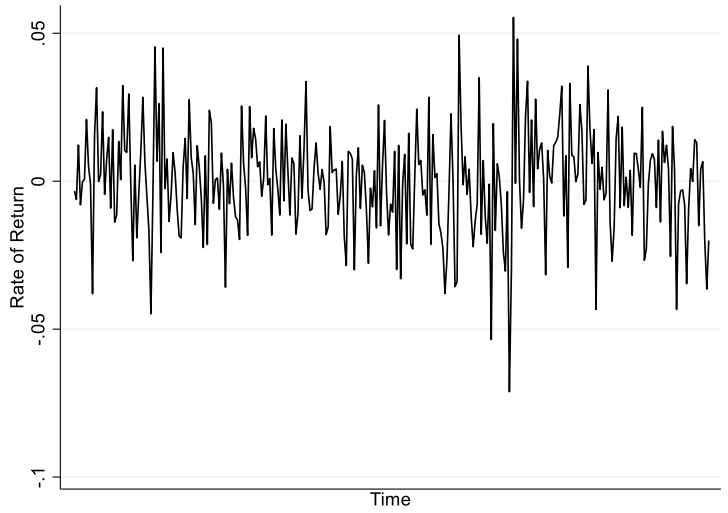


Figure 3. Yield (Photo credit: Original)

From the timing diagram shown in Figure 3, the yield of the new energy vehicle industry has obvious aggregation, but whether it is statistically significant or not still needs to be empirically tested.

4.3. ARMA Lag Order

In this section, the lag order for the log returns of the new energy car index and the log returns of Brent crude oil price is determined.

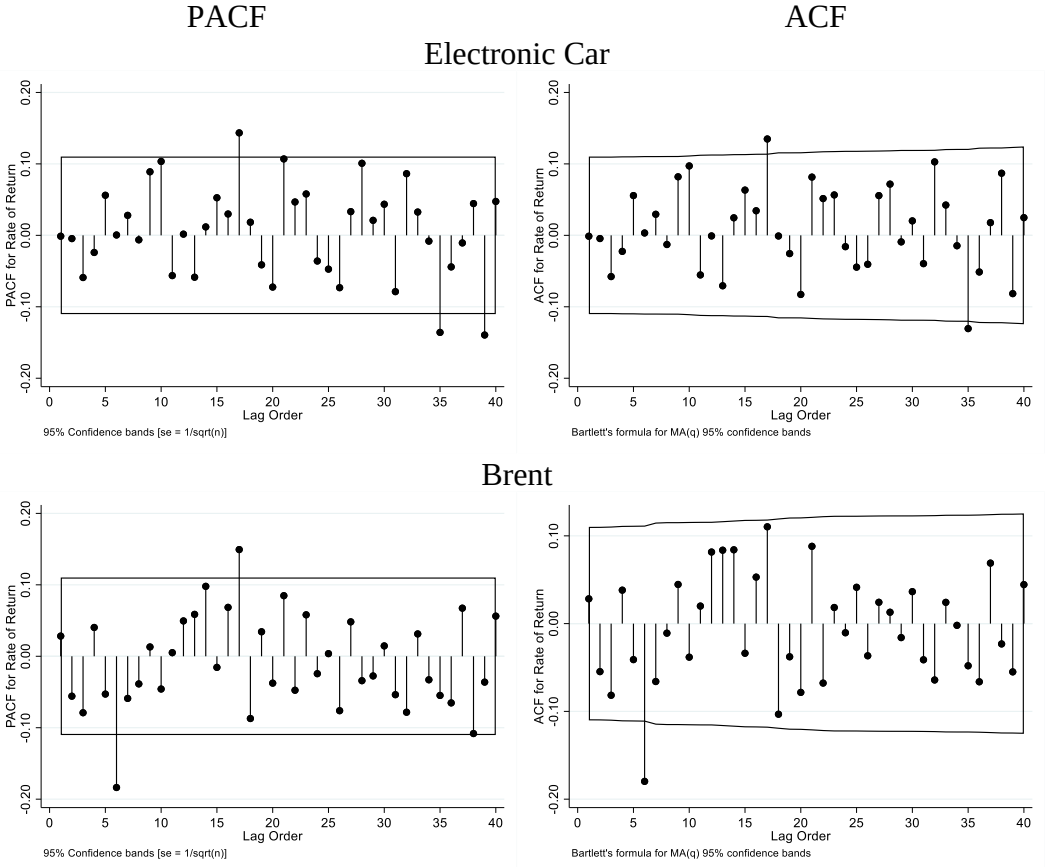


Figure 4. PACF and ACF (Photo credit: Original)

First, looking at the first row, which represents the log-returns of the new energy car index, of Figure 4, the first part beyond the x-axis is 17. Thus, AR(p) has an order of 17, and MA(q) also has an order of 17. This is equivalent to the value of p and q is 17.

Then, looking at the second row, which represents the log-returns of Brent crude oil price, in figure 3, the first part beyond the x-axis is 6. Thus, AR(p) has an order of 6, and MA(q) also has an order of 6. This is equivalent to the value of p and q is 6.

4.4. ARMA-GARCH Estimation

According to the ARMA-GARCH Estimation result, after the mean equation controls the autocorrelation of returns, the return of the new energy car industry has an obvious ARCH effect and GARCH effect. This suggests that there is a statistically significant conditional heteroskedasticity in the returns of the two, which can be modeled by GARCH.

Judging from the estimated results of external explanatory variables, the volatility of Brent crude oil returns increased by 1 unit, and the volatility of new energy vehicle industry returns would increase by 0.0568 units, with a significant coefficient at the level of 1%.

Table 3. ARMA-GARCH estimation results

	Coef.	Std. err	z	p>|Z|
Brent, sigma	.0568	.0279	2.03	0.042
ARCH, L1	-.0460	.0108	-4.24	0.000
GARCH, L1	-.6571	.1628	-4.04	0.000
Constant	-7.9583	.2591	-30.71	0.000

5. Conclusion

According to the analysis, the models show that the impact of rising crude oil prices on the Chinese new energy automobile industry depends on whether the positive effect of sales growth is greater than the negative effect of an increase in cost in the short run, plus there will barely have any impact in the long term. This conclusion aligns with the existing articles that are discussed in the literature review.

In this study, the Brent crude oil price is used to fully represent the impact of the Russian-Ukraine war. However, as stated in Coleman's study, oil prices are additive to the influence of speculators. There could be other factors affecting the Brent crude oil price despite the Russian-Ukraine war, for example, COVID-19. Future studies can access other factors that have been unintended captured by the Brent crude oil price in the period from June 1, 2021, to September 16, 2022. By extracting them to get more precise data that represent the impact of the Russian-Ukraine war on the crude oil price.

This research can benefit both policymakers and investors. Policymakers should adjust short-term monetary policy to contractionary to prevent stagflation due to the increase in crude oil prices bought by the Russian-Ukraine war. Investors should seize short-term investment opportunities in the Chinese new energy automobile industry.

The objective of this study is to show how the electric car industry in China has been affected and impacted in the short and long term in the context of the Russian-Ukraine war and to forecast and make recommendations on the future direction and development of the new energy car industry in China. The paper uses the VAR model and ARMA-GARCH model to analyze and integrate the relevant data and stands for the impact on the related Chinese industry by examining the changes in index returns and the volatility of the electric car industry after they were subjected to a shock of the war, and concludes that the Chinese new energy car industry will be affected by the Russian-Ukraine war in the short term, while this impact is not significant enough in the long-term to have a notable impact on the future development of the Chinese electric car industry.

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