

Yield and Volatility of Air Transport Industry under Rapidly Changes in Crude Oil Prices: Evidence from Time-series Model

Jiakang Xie^{1, *}

¹Jilin University, School of Business and Management, Changchun, 130012, China

*Corresponding author: xiej3420@jlu.edu.cn

Abstract. The tense atmosphere of energy supply in the international market is gradually strengthened, and with the continuous development of the conflict, the Western countries continue to strengthen the sanctions, which makes it difficult to eliminate the impact of oil in a short time. Based on WTI crude oil price, Brent crude oil price, and the stock price closing price of air transport industry, this paper establishes VAR model and ARMA-GARCH model through empirical analysis to analyze the impact of the Russian-Ukraine conflict and oil price changes on air transport industry. The empirical results show that the increase of WTI crude oil price has a significant negative impact on the return rate of air transport industry, Brent crude oil price has no similar effect. Further research shows that the change of crude oil price has a significant positive impact on the volatility of air transport industry. This paper provides evidence for the economic results caused by changes in oil prices.

Keywords: Air transport industry; Crude oil prices; Time-varying influence.

1. Introduction

Since the outbreak of the conflict between Russia and Ukraine, the oil problem has gradually attracted the attention of the world. As a world energy power, Russia has always been very dependent on energy exports [1]. With the worsening situation between Russia and Ukraine, many Western countries have also strengthened sanctions against Russia. As the energy crisis spreads around the world, the impact on the international aviation market is further expanding [2].

Since the 1990s, with the smooth flow of energy between the two countries and trade development between China and Russia, the two sides by taken advantage of geographical conditions, the construction of gas pipelines, and crude oil pipelines. In 2021, China's crude oil imports of 513 million tons, domestic crude oil output is 199 million tons, and only external dependency on crude oil is as high as 72%. In terms of crude oil imports for distribution in China, crude imports from Russia for 83.57 million tons, only much less than Saudi Arabia ranks the first 1.4 million tons, accounting for 15.4% of China's crude oil imports. With the increase in China's crude oil demand, the size of future China's imports from Russian oil may also further expand. Once the oil trade between China and Russia there is a problem, it is difficult to find an alternative object in the short term, so as to constitute a major hidden danger to China's energy security.

Generally speaking, the Russia-Ukraine conflict will lead to airport suspension and increased risk of air transport [3], which will have a direct impact on our air transport industry. In a conflict, aircraft may be attacked not only by war but also by signal jamming. In addition, the closure of some airports and the reduction of flights lead to the reduction of passenger flow in the airline industry, which affects the transportation efficiency and revenue of the airline industry [4]. However, for China, Russia's trade with Ukraine is not a large proportion of China's total import and export trade.

Therefore, this article will discuss the indirect impact of the conflict between Russia and Ukraine on our aviation industry from the perspective of oil.

At the end of 2020, Russia was the sixth largest oil producer in the world. The blocking of Russian oil exports will inevitably lead to higher oil prices around the world. Oil prices, apparently spurred and dominated by the war, have been riding high ever since Russia launched its special military operation on Feb. 24. Brent and WTI hit a record high of \$139.13 and \$130.50 per barrel, the highest since the 2008 financial crisis. Since the operating costs of shipping companies include the cost of jet

fuel and the salary of staff, the rise in oil price may have an impact on the cost of jet fuel for shipping companies [5].

According to economic theory, the stock market is a "barometer" of the macroeconomy, and the stock price reflects the value and prospects of a company. Relevant data show that the cost of aviation fuel, accounts for about 40 percent of the total cost. Changes in the price of oil can affect a company's share price by affecting its production costs and profits [6]. On the other hand, fluctuations in international oil prices may cause inflation in oil-importing countries [7]. Generally speaking, inflation will lead to higher living costs for residents, while residents' wages will not increase in the short term [8]. As a result, residents may reduce their holdings of stocks, leading to a decline in the price of shares in the air transport sector.

Brent crude oil and WTI crude oil are used in this article to represent the many brands of oil. Brent crude oil is a light, sweet crude from the Brent and Ninian fields in the North Sea that is widely traded in futures, over-the-counter swaps, and forward and spot markets. More than 65% of the world's physical crude oil is now priced in the Brent system. WTI crude is the U.S. West Texas light crude oil futures contract with good liquidity and high price transparency, is one of the world oil market's three benchmark prices. All crude oil produced or sold in the United States is priced on the light, sweet WTI benchmark.

Katie [9] analyzed the Internet views, the conflict between Russia and Ukraine to fluctuations in the price of energy, proved the Brent crude oil of the China and international crude oil market has a significant effect, and because the Brent crude oil is a kind of low sulfur oil, this suggests that China advocates green environmental protection concept has domestic energy market to play an active role [9]. Yu Peng [10] analyzed the impact of the Russia-Ukraine conflict on China's energy trade and put forward corresponding countermeasures. He believes that we should actively prepare for the possible problems in the energy trade between China and Russia. We should not only adjust the way of energy trade between China and Russia according to the actual situation but also strengthen the analysis and early warning of international energy prices, so as to ensure China's energy security [10]. Zhou Ziyang and Deng Yi [11] made an empirical analysis of the change rate of Brent crude oil price and the excess return rate of the aviation sector based on VAR model and impulse response function and found that there was a certain correlation between them [11].

2. Research Design

2.1 Data source

The data of WTI and Brent is obtained by the Choice Financial Terminal. Choice Financial Terminal is a professional financial data analysis and investment management software of Oriental Wealth, which is committed to providing high-quality financial data and related services for financial institutions, academic research institutions, and professional investors. The terminal covers stock, fixed income, fund, commodity, foreign exchange, macro industry, and other fields. It provides application tools such as Excel plug-in, quantitative interface, and portfolio management, which integrates information query, statistical analysis, and application. It is an essential tool for financial market participants.

2.2 Unit root test

In the study of time series, we first need to test the stationarity of the series. The quantitative analysis of time series requires stationary data. Generally speaking, non-stationary time series will lead to the phenomenon of "spurious regression" in the subsequent empirical analysis, so it is necessary to carry out unit root test for each variable.

When performing a unit root test, assume that time series x_t formula for:

$$x_t = c_t + \alpha x_{t-1} + \sum_{i=1}^{p-1} \varphi_i x_{t-i} + \varepsilon_t \quad (1)$$

The null hypothesis of the test is that the coefficient $\beta = 1$, which indicates that the series has a unit root and is not stationary, while the alternative hypothesis is that $\beta < 1$, indicating the series under test is stationary.

Table 1 gives us the test results of raw data. According to the ADF test results, the three main variables in this paper, the log return rate of shipping, the log return rate of WTI crude oil, and the return rate of Brent crude oil, are stationary time series

Table 1. ADF test

Variables	t-statistic	p-value
Price		
WTI	-2.8180	0.1903
Brent	-3.0930	0.1079
Air transport	-2.1510	0.5176
Yield		
WTI	-8.6820	0.0000***
Brent	-8.6050	0.0000***
Air transport	-7.8430	0.0000***

2.3 VAR Model Specification

The VAR model requires very little theoretical basis. To build a VAR model, only two things need to be determined: (1) Variables under study (whether endogenous or exogenous); (2) The maximum order of the lag.

The VAR model (proposed by Sims in 1980) does not need to distinguish endogenous variables from exogenous variables and is easy to predict because the explanatory variables all use lagged variables. Of course, there may be more parameters to be estimated.

VAR models are usually used to estimate the dynamic relationship of joint endogenous variables. It is realized by using all current period variables in the model to perform autoregression on several period lag variables of all variables.

In the process of VAR modeling, the following shall be determined: (1) the number of variables with mutual influence (N); (2). How many lag variables are needed to explain the endogenous variables (K) with mutual influence?

If K is too small, it will lead to the autocorrelation problem of the error term, which may lead to the excessive error of the model parameter estimation.

If K is too large, the degrees of freedom of the model will decrease, which will directly affect the effectiveness of the model parameter estimator.

$$LR = -2(\text{Log}L_k - \text{Log}L_{k+1}) \quad (2)$$

$$LR \sim \chi^2_{(N^2)} \quad (3)$$

When the LR statistic is less than the critical value, the lag order of the VAR model is considered moderate.

When the LR statistic is greater than the critical value, it is considered that the lag order of the VAR model is not high enough, and more lagged variables should be added as explanatory variables.

When the sample size is not sufficiently large compared with the number of estimated parameters, the finite sample distribution of LR will be quite different from the asymptotic distribution of LR.

$$\text{LiteAIC} = \log \left[\frac{\sum_{t=1}^T e_t^2}{T} \right] + \frac{2k}{T} \quad (4)$$

$$\min\{kAIC\} = \log \left[\frac{\sum_{t=1}^T e_{kt}^2}{\sum_{t=1}^T e_{(k+1)t}^2} \right] - \frac{2}{T} \quad (5)$$

The two VAR models with lag orders k and $k+1$, respectively, indicate that the lag order is more moderate as long as their AIC statistics are closer.

$$SC = \log \left[\frac{\sum_{t=1}^T e_t^2}{T} \right] + \frac{k \log T}{T} \quad (6)$$

$$\min\{kSC\} = \log \left[\frac{\sum_{t=1}^T e_{kt}^2}{\sum_{t=1}^T e_{(k+1)t}^2} \right] - \frac{\log T}{T} \quad (7)$$

Two VAR models with lag orders k and $k+1$, respectively, indicate a more moderate lag order as long as their SBIC statistics are closer

2.4 ARMA-GARCH Model Specification

The ARCH model assumes that, if the serial variance of a time series in the last period is large, then the variance of the next period is also high. This is an AR model of autoregressive logic that can be used to predict the variance of time series in the future.

Normally, an $ARCH(p)$ model can be written as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \quad (8)$$

More generally, a $GARCH(p, q)$ model can be written as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 + \beta_1 \sigma_{t-1}^2 + \dots + \beta_q \sigma_{t-q}^2 \quad (9)$$

In general, the risk is positively correlated with the return, so we need to focus on the risk of a market. This paper establishes the ARMA-GRACH model to analyze the volatility of corporate share prices in the air transport industry.

3. Empirical Result

3.1 VAR Model Results

3.1.1 VAR Order Selection

In this part, this paper put three stationary time series: aviation log return, WTI oil log return, and Brent oil log return, into our Vector autoregressive system. The result is shown in Table 2 indicating that a VAR with 10 lagged orders can be taken into account.

Table 2. VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	789.575				3.9e-11*	-15.4481*	-15.417*	-
1	807.045	16.939	9	0.050	4.0e-11	-15.4378	-15.3134	-15.1308
2	809.29	4.49	9	0.876	4.5e-11	-15.3066	-15.089	-14.7694
3	811.919	5.2573	9	0.811	5.1e-11	-15.1829	-14.8721	-14.4155
4	822.826	21.814	9	0.009	4.9e-11	-15.2199	-14.8159	-14.2223
5	831.032	16.413	9	0.059	5.0e-11	-15.2045	-14.7072	-13.9767
6	839.212	16.359	9	0.060	5.2e-11	-15.1886	-14.598	-13.7305
7	840.926	3.4283	9	0.945	6.0e-11	-15.0471	-14.3633	-13.3588
8	849.017	16.182	9	0.063	6.1e-11	-15.0295	-14.2524	-13.111
9	853.537	9.0402	9	0.434	6.8e-11	-14.9425	-14.0722	-12.7938
10	864.431	21.788*	9	0.010	6.6e-11	-14.9792	-14.0157	-12.6003
11	872.032	15.202	9	0.086	7.0e-11	-14.9521	-13.8953	-12.3429
12	874.502	4.9407	9	0.839	8.1e-11	-14.8253	-13.6752	-11.9859

3.1.2 Stability Condition of VAR Estimates

Analyze whether the impact of a pulsating shock on the VAR model will gradually disappear over time. If it disappears gradually, the VAR model is stable. Otherwise, it's not stable.

Similar to the AR model, the VAR model with unit root is non-stationary, that is, when there is a pulsating shock in the information, the response of endogenous variables in the VAR model will not disappear with time.

As shown in Figure 1, all points represent eigenvalues. If all the points are inside the unit circle, we know that the estimate of VAR is stable. As can be seen from Figure 1, the stability conditions are met by the VAR system. After estimating the parameters of vector autoregressive, the eigenvalue stability condition is examined. For convenience, a unit circle is next drawn to visualize the results.

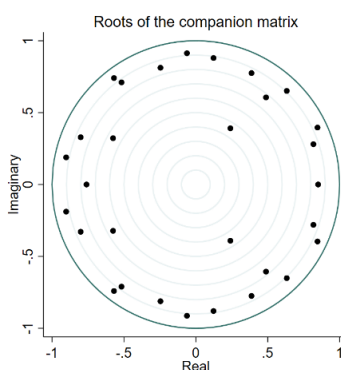


Figure 1. VAR stability

3.2 Impulse Response Graph of the VAR model

From the estimation results of impulse response, it can be seen that the change in international crude oil price has a short-term impact on the return rate of air transport industry.

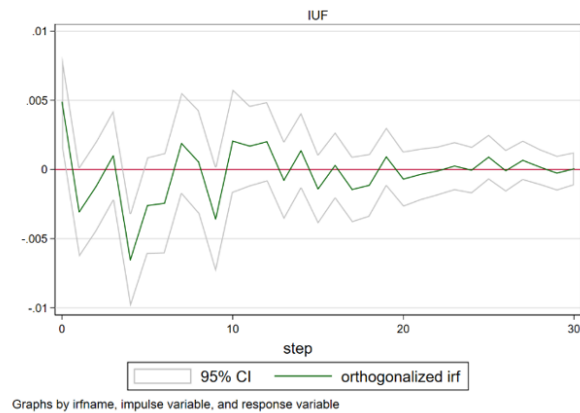
Specifically, the return rate of WTI crude oil increases by 1% in period $t=0$, the return rate of air transport industry decreases by about 0.25% in period $t=1$, and expands to about 0.6% in period 4, and shows a positive effect until period 7.

The net effect of the first 10 periods shows that the impact of higher WTI crude oil prices on the air transport industry is negative. After 10 periods, the effect gradually attenuated to 0.

According to the estimated results of Brent crude oil price, the net effect of the first 10 periods is positive, and the net effect of the 10th to 15th periods is negative, and it starts to decay after the 20th period.

In general, WTI has a greater impact on the yield of the air transport industry.

WTI



Brent

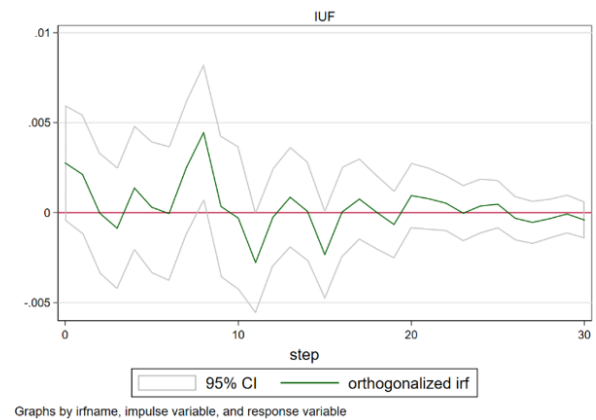
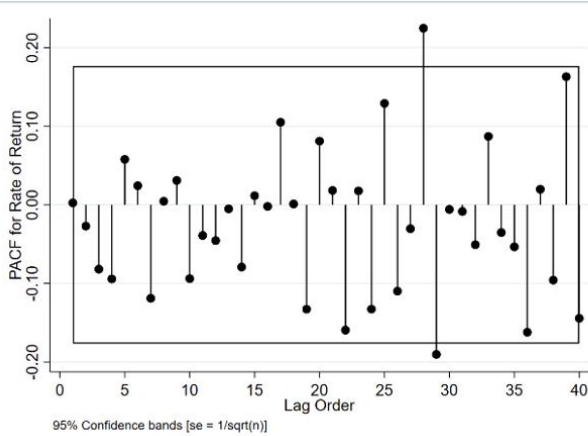


Figure 2. Impulse and response

3.3 ARMA Model Result

To build an ARMA model, the paper first finds out the suitable AR and MA part of AAL stock price data. Check the partial autocorrelation plot (PACF plot) of the series and the proper order p of the AR model in Stata, the result is shown in Figure 3. The black rectangle is the benchmark to find out the statistically significant term in the AR model.

PACF



ACF

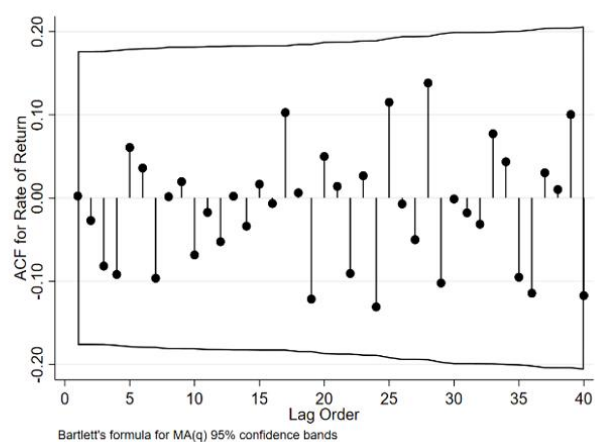


Figure 3. PACF and ACF

3.4 ARMA-GARCH Model Result

VAR model and impulse response investigate the impact of international crude oil price changes on the return rate of air transportation industry, and ARMA-GARCH model is used to investigate the impact on return volatility in this part.

From the estimation results, WTI crude oil yield increases by 1%, the daily volatility of air transport industry return increases by 40.7330, which is significant at 1% level.

Brent crude oil yield increased 1 percent and the daily volatility of air transport earnings increased 45.6302 to be significant at the 1 percent level.

To sum up, oil is the main fuel for air transport, its price changes can cause huge fluctuations in the industry's yield.

Table 3. ARMA-GARCH estimation results, variance equation

	(1)		(2)	
	Coef.	Std. err	Coef.	Std. err
WTI	40.7330***	10.0781		
Brent			45.6302***	8.6506
ARCH (-1)	0.0307	0.0505	-0.0339	0.0511
GARCH (-1)	0.9048***	0.0615	0.9587***	0.0565
Constant	-11.2959***	1.0816	-11.4491***	0.9814

4. Discussion

From the existing literature, there have been a lot of studies on the Russia-Ukraine conflict and its changes in oil prices. However, the existing literature mainly focuses on the macroeconomic level, and the research on the relationship between the Russia-Ukraine conflict and the air transport industry in China is less. From the perspective of the conflict between Russia and Ukraine and the change in oil price, this paper discusses the impact of the air transport industry based on the change in stock price.

The Chinese government should timely adjust the content of the Sino-Russian energy trade according to the changing times. On the one hand, under the current situation, the Chinese government should expand the scale of trade with Russia's energy. On the spot trade, the Chinese government should increase imports, in terms of long-term energy trade, should open energy talks with Russia to show, at a lower price more energy import contracts, ensure the future of China's energy imports. On the other hand, when the situation is changing, scientific research makes the Sino-Russian energy trade adjustment strategy in China's interest.

Because WTI crude oil has a greater influence on the air transport industry in our country, the change in WTI crude oil price has a greater impact on the profits of investors in the air transport industry. Although changes in international crude oil prices may not have a long impact on air transport yields, investors still need to be prepared for risk. Investors should focus on the stock price and performance changes of airlines, and increase or decrease the investment principal in time to the stock price fluctuations. In terms of stock allocation, investors can choose some of the leading airlines in the air transportation industry, as well as airlines that use Brent crude oil as fuel. Above all, investors should insulate their assets from the conflict with Ukraine and changes in oil prices by avoiding airlines with more exposure to Russia [12].

5. Conclusion

The conflict between Russia and Ukraine has reduced oil exports, and therefore the world's oil reserves. On the one hand, the conflict between Russia and Ukraine will have a direct impact on the air transport industry by hindering the normal transport of airplanes. On the other hand, the rise in oil prices around the world will have an indirect impact on the air transport industry by increasing the operating costs of aircraft and inflation.

According to the empirical analysis results, the change in international crude oil price has a short-term impact on the return rate of air transport industry. WTI crude has a bigger impact on air transport returns than Brent. Changes in the price of oil, the main fuel for air transport, can cause huge fluctuations in the industry's yields. Airlines in addition to adopting various ways to reduce fuel consumption and reduce fuel costs, are also based on capacity, strictly management, increase in the productivity of the aircraft and staff, and other measures to reduce the fuel cost to cope with the present situation of high oil prices.

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