Research on the Correlation between China's Crude Oil Futures Market and Spot Market

Yin Duan

Abstract*一The oil crisis in the first half of 2020 has had a huge impact on the international crude oil spot and futures markets. "Yuanyoubao", a Chinese crude oil financial product based on US WTI crude oil futures, has always been favored by investors. However, in this oil price crisis, the product has also suffered huge losses. This accident has focused the eyes of Chinese investors on China's own crude oil futures market. Since this market was established in 2018, there is not much research and analysis on it. Thus, this article applies time series analysis methods such as Johansen test, Granger causality test, and establish a bivariate autoregressive model to analyze the relationship between China's crude oil futures market and the spot market. The final results show that there is a long-term stable relationship between the two markets and that the Chinese crude oil futures market has a predictive effect on the future price of the spot.

Index Terms*—Chinese oil futures, Johansen test, Granger causality test, autoregressive model.

I. INTRODUCTION

Nowadays, when it comes to the crude oil futures market, everyone first thinks of the WTI and Brent crude oil futures markets in the United States. Other financial products based on these contracts have also been created in other countries around the world, such as the "yuanyoubao" of Bank of China. However, in the first half of 2020, due to the impact of the COVID-19, the global demand for oil has decreased, coupled with geopolitical factors that former OPEC+ oil production agreement broke down, both increase in the supply of crude oil and decrease in demand triggered a global oil price crisis, and the crude spot and futures markets have been severely affected. Take yuanyoubao as an example, it is a kind of financial product based on WTI oil futures that enables Chinese investors to participate in the trading of WTI oil futures. Unfortunately, yuanyoubao was delivered at a price of -37.63 US dollars per barrel as a result of price collapse in WTI oil futures, which caused huge losses to Chinese investors. It also refocused the public's attention on China's own oil futures market.

On March 26, 2018, Shanghai crude oil futures were listed on the Shanghai International Energy Exchange. For the first time, China has its own crude oil futures, which are priced in Chinese yuan. This also means that China's crude oil futures market is gradually being established and completed. This also provides us with an opportunity to study the correlation between China's original spot market and the futures market, which has important instructional

significance for the management of futures market and price discovery of spot market. Besides that, having a good knowledge of Chinese own futures market can prevent similar crisis effectively and efficiently

Thus, time series analysis methods such as Johansen test, Granger causality test, bivariate autoregressive model are applied in this article to analyze the correlation between Chinese Oil Futures Market and Oil Spot Market. The main purpose is to discover the long-term relationship between the two markets and test the causality between futures price and spot price. It will be helpful for fair pricing of oil spot and futures markets.

II. LITERATURE REVIEW

Since the birth of futures, the research on the relationship between the futures market and the spot market has never stopped. Early literature showed that there is indeed a relationship between the futures market and the spot market. Alien H. Levine (1991) shows that oil price volatility can have an impact on futures market, which means that oil futures market will response to oil price changes [1]. In recent research, Yin Fuqi, He Li and Zhao Tao (2020) use time series methods such as Johanson co-integration test, Granger causal relation test and regression analysis to analyze correlation between apple spot market and apple futures market [2]. They draw the conclusion that apple spot prices are positively correlated with futures prices. Similar approaches can also be used to test the relationship between oil spotmarket and oil futures market.

Besides that, John H. Herbert (1993) establishes first-order bivariate autoregressive model to analyze the causal relationship between changes in natural gas futures prices and changes in natural gas spot prices [3]. Although his hypothesis is that changes in natural gas futures prices can be affected by changes in natural gas spot prices, he finds that changes in natural gas futures prices can be explained by previous changes in both futures and spot prices. Moreover, by analyzing the performance of market index futures contracts, Richard Zeckhauser and Victor Niederhoffer (1983) shows that futures prices have predictive value, particularly for the near term [4]. For the futures markets of different varieties and in different periods, although the general trend is that they all have a stable correlation with spot markets of their underlying assets, their specific relationships are different among different varieties and different time periods [4].

Finally, it is necessary to analyze emerging Chinese oil futures market on the basis of the former achievements. This article borrows the methods Yin Fuqi, He Li and Zhao Tao used [2] to analyze the emerging Chinese oil futures

market. Because oil prices are time-sensitive, research based on the outdated data cannot guide current markets any more. Thus, data for the last two years are used to conduct the research.

III. CHINESE OIL FUTURES MARKET

A. Correlativity between Chinese Oil Futures Market and Oil Spot Market

China's crude oil futures market began on March 26, 2018. Its main characteristic is that it is priced in Chinese yuan, which greatly facilitates Chinese investors to participate in crude oil futures market transactions and also greatly enhances China's influence in the international crude oil futures market. Fig. 1 shows the price trend of Shanghai crude oil futures since 2019. It can be found that the futures price fluctuated between 400-500 yuan per barrel throughout 2019. At the beginning of 2020, affected by the COVID-19 epidemic, crude oil futures prices began to fall. At the end of April, the price fell to the bottom, and then the price rose slowly.
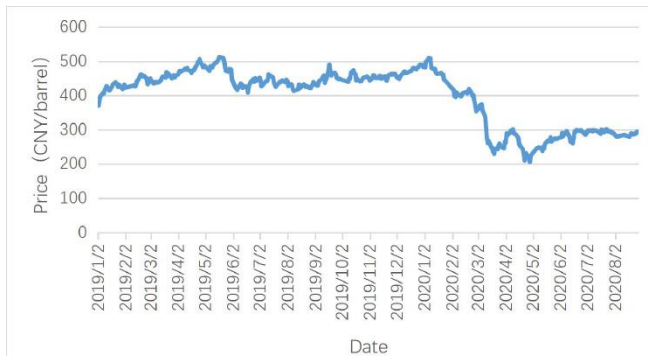

Fig. 1. Shanghai crude oil futures price trend.

Daqing is the largest and most productive oil field in China, producing 1.91 billion tons of crude oil accumulatively, accounting for more than 40% of the total onshore crude oil production in the same period of the country. Therefore, the spot price of crude oil in Daqing oil field is relatively representative, which can reflect the general level of the spot price of crude oil in China.
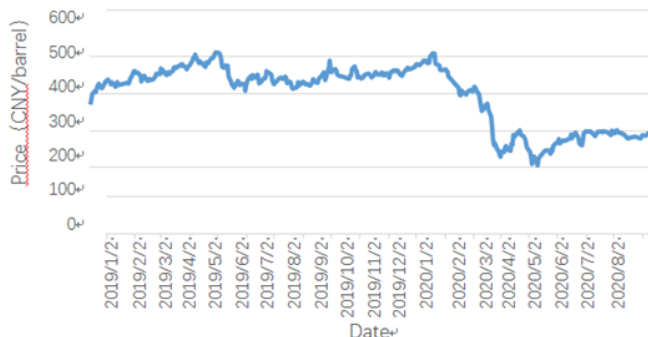

Fig. 2. Daqing crude oil spot price trend.

Observing the trend chart of oil spot prices, as shown in Fig. 2, the overall trend is basically the same as that of oil futures prices. In 2019, the spot price also showed a stable and volatile state. It began to decline at the beginning of 2020, and the spot price fell to the bottom in May 2020. Afterwards it began to slowly rise again. Since the futures

market is a financial market derived from the spot market, and the two have similar price trends and fluctuations, this connection is particularly obvious during the oil price crisis in 2020. There must be a certain correlation between the two markets.

B. Hypotheses

Hypothesis 1: Here is a long-term and stable correlation between China's crude oil futures and the spot market, and the two coexist.

A closer look at the above two images shows that the volatility of the futures market will be slightly earlier than that of the spot market. Besides, from the function of the futures market, it is clear that because the futures price is obtained by market bidding, it is determined by the supply and demand relationship, which reflects investor's expectations of the future price of the underlying asset., so futures prices are bound to have a predictive effect on spot prices. Applying this theory to the crude oil market we are discussing; another hypothesis is proposed:

Hypothesis 2: Oil futures prices have a predictive effect on spot prices.

IV. RESEARCH METHODS

A. Data Sources

This paper selects the daily data of the main continuous Shanghai crude oil futures contract (SCM) of the Shanghai International Energy Exchange Center and the daily data of the crude oil spot price of Daqing Oilfield from January 1, 2019 to August 27, 2020 as the research samples. The above two series of data are the most frequently traded kind of oil futures and spot products in the market, which are relatively representative. After removing the holidays and missing values, a total of 394 samples are obtained in each series of data. Next, my research based on these data. The whole data come from East Money Choice financial database, and R studio is used for data analysis.

B. Research Methods

In economics, ADF test is often used to test whether there is a unit root process in time series data, thereby judging whether the data used for analysis is stable or not. In order to ensure the stationarity of the time series data, avoid the phenomenon of pseudo-regression, and eliminate the influence of heteroscedasticity on the model, the two groups of time series data are first logarithmicized to obtain lnSP and lnFP. However, it is ambiguous that whether the data thus obtained are stable or not. Thus, ADF test is still required.

Next, the Johansen test is used to verify the cointegration relationship between the time series data of oil spot prices and oil futures prices. Here we use the first- order difference data that pass the ADF test, this can make the results more accurate and reliable. Our goal is to test whether there is a long-term stable linear relationship between the two sets of data through the test of the cointegration relationship.

The above tests only show whether there is a long-term and stable relationship between the oil futures market and the spot market or not, but this relationship does not reveal which one is the cause and which one is the result. Next, the

Granger test will be used to exam the causal relationship between the two market.

Finally, after determining the cause and effect, a bivariate autoregressive model can be constructed to reveal the long-term equilibrium relationship between the two prices.

V. RESULTS AND DISCUSSION

A. ADF Test

TABLE I: RESULT OF ADF TEST

Variable	ADF value	P-value	Result
LnSP	-2.329	0.4383	Unstationary
LnFP	-2.1749	0.5034	Unstationary
D(lnSP)	-7.2016	0.01	Stationary
D(lnFP)	-6.2748	0.01	Stationary

It can be seen from the Table I that at the confidence level of 5%, the ADF value of logarithmic time series data LnSP and LnFP are -2.329 and -2.1749, whose P values are 0.4383 and 0.5034, this proves that logarithmic time series data are not stationary. However, the P values of their first-order difference data D(lnSP) and D(lnFP) are both less than 0.01 in the ADF test. Thus, they can be considered as stationary series, which means that they can be used to verify the long-term equilibrium relationship between crude oil futures and spot.

B. Johansen Test

According to the results of the Table II, at the 5% confidence level, the test values of Trace statistic and Maximal eigenvalue statistic under the hypothesis r≤1 are 123.88 and 123.88 respectively, the above values are both greater than the critical values, which are 8.18 and 6.50 respectively. Thus, the null hypothesis that there is less one cointegration relationship between the two markets is rejected. In other word, the result indicates that there is at least one cointegration relationship between the two groups of time series data. It can be considered that the price of oil futures is an unbiased estimate of the spot price. It is easy to understand the result because that the futures market is derived from spot market, there must be some connections between the two market.

TABLE II: JOHANSEN COINTEGRATION TEST RESULTS

Test Type	Hypothesis	Test Value	0.05 Critical Value	Result
Trace statistic	r=0	330.25	17.95	Reject
	r≤1	123.88	8.18	Reject
Maximal eigenvalue statistic	r=0	206.37	12.91	Reject
	r≤1	123.88	6.50	Reject

C. Granger Test

The results in the Table III show that the P-value of the Granger test under the original hypothesis that the oil spot price is not the Granger reason of futures price is 0.5708, which is much higher than the critical value of 0.05. It has not passed the significance test. It can be considered that the spot price is not the Granger reason of the futures price. The P-value of the second test is 0.0001118, which is much lower than 0.05 and thus pass the significance test. Therefore, it can be considered that the futures price is the Granger reason for the spot price. This also confirms that the futures price has a certain guiding significance for the spot price, and the futures market has the function of price prediction and price discovery for the spot market.

TABLE III: GRANGER CAUSALITY TEST RESULTS

Null hypothesis	F-Statistic	P-Value
LNSP dose not Granger Cause LNFP	0.7317	0.5708
LNFP dose not Granger Cause LNSP	5.9836	0.0001118

D. Autoregression Analysis

Finally, the period t-1 futures price and the spot price are used as explanatory variables, and the period t spot price is used as the dependent variable to construct a bivariate autoregressive model to reveal the long-term equilibrium relationship between the two prices.

TABLE IV: AUTOREGRESSIVE ANALYSIS RESULTS

Coefficients	Estimate	Std. Error	t-value	Pr(>|t|)
Intercept	-0.30500	0.09116	-3.346	9e-04
LNSP.L1	0.88010	0.02462	35.753	<2e-16
LNFP.L1	0.16744	0.03617	4.629	5e-06
Residual standard error: 0.05122 on 390 degrees of freedom				
Multiple R-squared:	0.9779		Adjusted R-squared: 0.9778	
F-statistic:	8633 on 2 and 390 DF, p-value: <2.2e-16			

In the Table IV, the value of F-statistic is 8633, which means that the regression model is very significant as a whole. While multiple R-squared and adjusted R-squared both exceed 0.90, reaching 0.9779 and 0.9778, respectively, the values indicate that the autoregression model has a very good fitting degree to the actual situation.

Meanwhile, the coefficient of lnSP.L1 is 0.8810 and that of lnFP.L1 is 0.16744, both P-values are less than 0.05, indicating that both coefficients is significant at the 95% confidence level. Thus, the final autoregressive model is as follows.

$$LnSP_t = -0.3050 + 0.8801 \times LnSP_{t-1} + 0,1674 \times LnFP_{t-1} \tag{1}$$

This model explains that the future price of the crude oil spot market is not only affected by itself, but also affected by the price of crude oil futures. In the long run, the historical information of the futures market and the spot market determines the future price of the spot market, and the futures market does play an important role in predicting the trend and price of spot market. Theoretically, futures price is the unbiased estimate of excepted future spot price. This notion is also applicable in Chinese oil futures and spot market.

VI. CONCLUSION

The Johansen test can prove hypothesis 1, that is, there is a long-term and stable relationship between crude oil futures and spot market prices. This relationship helps us analyze the impact of changes in one market price on changes in another market. In addition, when the volatility of the two markets does not match, market regulators can find problems early to get prepared for crises in advance.

Through the Granger test, it can be found that the futures price is the Granger reason for the spot price. We construct a first-order bivariate autoregressive model, which proves our hypothesis 2. The crude oil futures price does have a predictive effect on the spot price. The futures market helps us to judge whether the pricing of the spot market is reasonable and predict the trend of the prices of oil spot market.

Since China's crude oil futures market is an emerging market, the available research samples are limited, so the research results may a bit differ from the actual situation. In the future, when China's crude oil futures market is gradually improved, it will be more meaningful to study the economic laws of the market.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Yin Duan was born in Hohhot, Inner Mongolia on November 13, 1998.

Currently, he is a senior student majoring in financial engineering at Economics and Management School of Wuhan University, Wuhan University, Wuhan, Hubei Province, China. He is expected to get his bachelor degree in 2021.

He is working as an intern in Changjiang Securities Company in Wuhan Currently. Besides, he also worked as an intern in Dahua Certified Public Accountants in 2019.

Mr. Duan was awarded as advanced person during the summer social practice in 2019 by Wuhan University, China.