ISSN : 0974 - 7435 Volume 10 Issue 18

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(18), 2014 [10602-10606]

Analysis on the effectiveness of using energy futures to avoid oil price fluctuation risks by Chinese enterprises

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ABSTRACT

As the world's second largest oil consumer, the drastic fluctuations of international oil price in recent years have posed huge uncertainties to the survival and development of China's related enterprises. On the other hand, with the reduced of liquidity in Shanghai fuel oil futures market, its risk aversion function decreased too. In order to find the reasonable ways and strategies to circumventing the risks resulting from international oil prices for China's enterprises, this paper analyzes the feasibility of using Shanghai fuel oil futures and NYMEX light sweet crude oil futures contracts to mitigate the risks brought by WTI Crude Oil Spot Price. According to the results on the latest data, the consistency between Shanghai fuel oil futures and WTI Crude Oil Spot Price is not significant, showing a lack of the premise of hedging. The NYMEX light sweet crude oil futures, under the current market conditions, can be a better choice for China's enterprises. At last, this paper estimates the best risk hedge ratio by virtue of the ECM-GARCH Model. The performance analysis results show that with this hedging strategy, nearly 92% spot price fluctuation risks can be avoided.

KEYWORDS

Energy futures; Crude oil spot market; Risk aversion; Co-integration test; ECM-GARCH Model.

INTRODUCTION

Currently, oil is the most important industrial raw material and strategic resource, so its price fluctuation affects every aspect of economy. Since 2000, the sharp rises and falls in international oil price have posed great threats to the development of the world economy. China, as the second largest oil consumption country in the world, has taken it as one of the important measures in its oil strategy to use the futures market to avoid and resolve the risks brought by oil price fluctuation. To ease the increasing energy crisis, Shanghai Futures Exchange issued fuel oil futures on August 25, 2004, which are currently the only energy futures in China. On the other hand, the mature international crude oil futures market has provided Chinese enterprises with other options to spread and transfer risks. With the latest data, the author makes an empirical analysis on the fluctuation consistency between the price of Chinese fuel oil futures market and international crude oil futures market with the international crude oil spot price. Then this article analyzes the hedging ratio and its performance of the two energy futures markets, explore the effective methods that Chinese enterprises can adopted to avoid international oil price fluctuation risks.

LITERATURE REVIEWS

Using the futures market to avoid the price risks of spot market is always a hot research subject, and numerous results have been obtained. Renowned American futures expert Working (1962)[1] brought up the hedging theory named pursuit for profit based on basic spread. Johnson(1960)[2] and Stein(1961)[3], who also considered basis risk, adopted the assets portfolio theory to find the optimal hedging strategy. Thereafter a series of static and dynamic hedging ratio determination methods were brought, including static hedging models like OLS, VAR and VECM and dynamic models like VECH-GARCH, GARCH and VGARCH. Compared to the overseas futures market, there are relatively less researches on the risk aversion functions of the Chinese futures market. These researches mainly focus on metal and stock index futures. For example, Wang Jun, Zhang Zhongcheng (2006)[4] etc. adopt OLS, B-VAR, ECM and EC-GARCH models to analyze the hedging ratio and effects of the Chinese soybean, hard wheat and nonferrous metals futures markets. They found that ECM and EC-GARCH have the optimal results; Tong Menghua (2011)[5], Gao Yang (2011)[6], Ma Feng (2012)[7] and Shi Meijing (2012)[8] have conducted empirical analysis on the hedging ratio and effectiveness of Chinese stock index futures, and found that dynamic hedging methods yield better effects. In the research on energy futures, Liao Zhaoli, Zhang Hongmin (2009)[9], Cao Peishen, Tang Lufang (2011)[10], etc. have studied the hedging function of Shanghai fuel oil futures, and think that Shanghai fuel oil futures can help relevant enterprises to resist the risks effectively. To give a comparative analysis of the efficiency between using Chinese fuel oil futures and using international crude oil futures to avoid international oil price fluctuation risks, this article will conduct an empirical analysis on the risk aversion possibility, hedging ratio and hedging performance of Shanghai fuel oil futures market and the international crude oil futures market, with methods like the Johansen co-integration test and ECM-GARCH models and so on. Finally, find the optimal strategies for Chinese enterprises to deal with oil price risks.

DATA PROCESSING AND SOURCE

As every futures contract is due at certain time, to overcome the discontinuity of futures prices, the author has adopted the closing price of the futures contract with the largest trading volume as the representative to obtain continuous price series. The author has adopted the three-month continuous price (indicated as SF) for Shanghai fuel oil futures, and Cushing, OK Crude Oil Future Contract 1 of NYMEX for international crude oil futures. WTI spot price (indicated as S) is adopted as the spot price of international crude oil. As the listing date of Shanghai fuel oil futures is later, the time interval of the samples is between August 25, 2004 and September 30, 2014. The NF and S sample interval is between January 2, 2000 and September 30, 2014. In order to reduce the possible heteroscedasticity in the price series and increase statistical accuracy, the author carry on logarithmic treatment on the three price series and indicated them as LNSF, LNNF and LNS respectively. The data is taken from the website of the US Energy Information Administration and Shanghai Wind Information.

EMPIRICAL ANALYSIS

Stationarity and cointegration test

The time series of Shanghai fuel oil futures prices, light, sweet crude futures prices of NYMEX and WTI crude oil spot prices are as shown in the Figure below. Considering the difference of measurement, Shanghai fuel oil futures prices and WTI crude oil spot prices is standardized.

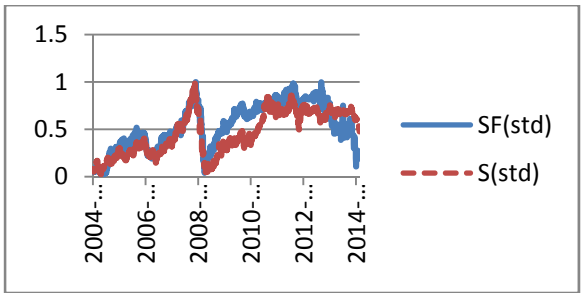

Figure 1 : Time series of Shanghai fuel oil futures prices and WTI crude oil spot prices

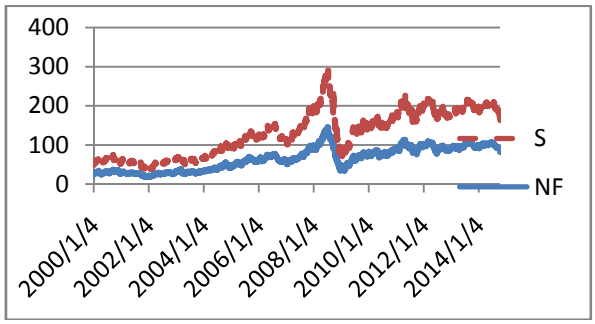

Figure 2 : Time series of light, sweet crude futures prices of NYMEX and WTI crude oil spot prices

From the time series charts above, we can see that there is a significant positive correlation between the price series of the two energy futures and the WTI crude oil spot prices. Before 2009, there was a greater correlation between Shanghai fuel oil futures and WTI spot price, and after 2009, the correlation reduced. To further verify the consistency in price fluctuation between the two future contracts and the spot, we perform ADF and cointegration test on the three price series to find out the long-term stable relation between the prices of the two futures types and the spot price. The test results are as follows:

TABLE 1 : The result of augmented dickey-fuller test

	ADF Test Statistic	1%Critical Value	5%Critical Value	10%Critical Value
LNNF	-2.7452	-3.96052	-3.41102	-3.12732
LNS	-2.83671	-3.96052	-3.41102	-3.12732
LNSF	-2.01459	-3.96189	-3.41169	-3.12772
ΔLNNF	-62.4733	-3.96052	-3.41102	-3.12732
ΔLNS	-62.347	-3.96052	-3.41102	-3.12732
ΔLNSF	-50.3931	-3.96189	-3.41169	-3.12772

The ADF test results show that the three time series LNNF, LNSF and LNS are non-stationary series, and the absolute values of the ADF test values of their first-order difference series ΔLNNF, ΔLNSF and ΔLNS are all greater than 1% of the absolute value of the critical value under the confidence level. The three time series are all first-order single whole sequence, meeting the cointegration test conditions. Furthermore, we have conducted Johansen cointegration test[4] on the three series. The results are as follows:

TABLE 2 : Cointegration test between LNSF and LNS

Hypothesized No. of CE(s)	Eigenvalue	Likelihood Ratio	5%Critical Value	Prob.**
None	0.007136	17.05786	19.38704	0.1056
At most 1	0.002481	5.918038	12.51798	0.4708

TABLE 3 : Cointegration test between LNNF and LNS

Hypothesized No. of CE(s)	Eigenvalue	Likelihood Ratio	5%Critical Value	Prob.**
None	0.007136	17.05786	19.38704	0.1056

As indicated by the results in Tab.2, Shanghai fuel oil futures show no co-integration relations with WTI Crude Oil Spot Price. In fact, to restrain excessive speculation in Shanghai futures market, the Shanghai fuel oil futures contract has increased from 10 tons per lot to 50 tons per lot since 2011. The enthusiasm for market participation and contract liquidity has been greatly discounted due to the raising of investment threshold. Therefore, it is impossible for the spot enterprises to effectively achieve risk hedging through domestic fuel oil futures market. Therefore, China's enterprises now are confronted by great difficulties in using Shanghai fuel oil futures to mitigate the risks of international oil price fluctuations.

On the other hand, according to the co-integration test results of NYMEX Crude Oil Futures and WTI Crude Oil Spot Price, there is a co-integration relation between them. The co-integration relationship model is shown as follows.

$$EC_t = LNS_t - 1.00051 LNNF_t + 0.000000966$$

To sum up, NYMEX Crude Oil Futures shows a stronger consistency with WTI Crude Oil Spot when compared to Shanghai fuel oil futures. It becomes the preferential choice for China's enterprises to circumvent international risks. The hedging strategies and performances associated with NYMEX Crude Oil Futures will be analyzed below.

ARCH effect Test

ARCH Effect means that the conditional variance of a sequence is not a constant, there exists large fluctuations over time. It is characterized by the volatility clustering. Based on the previous co-integration equation, we can further obtain the ECM model as follows:

$$\Delta LNS_t = 0.001126 + 0.93788 \Delta LNNF_t + 0.455613 EC_{t-1}$$

Carry out ARCH-LM test for its residual sequence and get the following result:

TABLE 4 : The result of ARCH test

ARCH Test:			
F-statistic	109.6456	Probability	0
Obs*R-squared	392.5894	Probability	0

The above result indicates that the equation residual exhibits heteroscedasticity and ARCH Effect, which is a ideal candidate for dynamic simulation based on GARCH model. Meanwhile, considering the co-integration between NYMEX Crude Oil Futures and WTI Crude Oil Spot Price, this paper attempts to employ ECM-GARCH method to estimate the optimal hedging ratio.

Analysis of the optimal hedging ratio and hedging performance

ECM-GARCH model was set up by Lien (1996)[11] based on the studies of Engle, Granger, Bollerslev, Engle, Wooldridge and Ghosh. When establishing this model, the spot price difference sequence and futures price difference sequence are expressed as follows:

$$\Delta S_t = C_s + \delta_s \Delta Z_{t-1} + \varepsilon_{s,t-1}$$

$$\Delta NF_t = C_s + \delta_s \Delta Z_{t-1} + \varepsilon_{f,t-1}$$

In this equation, $\Delta Z_{t-1} = S_{t-1} - (\alpha + \beta F_{t-1})$. It is the residuals in the long-term relationship and is considered as the error correction term.

The minimal risk hedging ratio in this model is:

$$h = \frac{Cov(\Delta S_t, \Delta NF_t | Z_{t-1})}{Var(\Delta F_{t-1} | Z_{t-1})}$$

The minimal risk hedging ratio in ECM-GARCH can be obtained from the following regression equation:

$$\Delta S_t = \alpha + \beta \Delta NF_t + \gamma Z_{t-1} + \varepsilon_t$$

The regression coefficient β of ΔNF_t is the minimal risk hedging ration to be measured. As ECM-GARCH model is dynamic, what we get is a time sequence of the optimal hedging ratio. Using Matlab to establish the model, this paper gets an average of ECM-GARCH's hedging ratio as 0.957318.

Further, this paper uses the indexes Ederington[12] offers to measure its hedging performance (H_e) as follows:

$$H_e = \frac{Var(\Delta S) - Var(\Delta S - h\Delta NF)}{Var(\Delta S)} = 0.916769$$

The result shows that hedging by NYMEX Crude Oil Futures within the sample interval and hedging position by ECM-GARCH at the same time can lower risk level by 91.86% for enterprises and thus has a good effect on risk aversion.

CONCLUSIONS

To deal with the risk aversion issue caused by international oil price fluctuations, this paper conducts an empirical analysis of the risk aversion functions of the Shanghai Fuel Oil Futures Market and the International Crude Oil Futures Market, then draws the following conclusions:

(1) It is not feasible to use Shanghai fuel oil futures to avoid international oil price fluctuation risk. The relevance between Chinese fuel oil futures with international crude oil futures has been weakening since 2009. The result of co-integration test shows there is no significant long-term equilibrium relationship. And the current Shanghai fuel oil market would not create good conditions for risk aversion.

(2) There is a co-integration relationship NYMEX Crude Oil Futures between WTI Oil Price. This paper conducts co-integration and ARCH tests for NF and S Price Sequence. The empirical result shows that there is a long-term stable relationship between the two, make it feasible for Chinese enterprises to avoid international oil price fluctuation risk by using NYMEX Crude Oil Futures. In addition, since there exists fluctuation clustering, ECM-GARCH model would be suitable for estimating the optimal hedging ratio.

(3) This paper uses ECM-GARCH model to calculate the optimal hedging ratio of NYMEX Crude Oil Futures and analyzes its performance. The result shows that using NYMEX Crude Oil Futures and selecting the dynamic hedging ratio of ECM-GARCH can get better hedging performance.

After all, the Shanghai Fuel Oil Futures Market nearly can hardly avoid risk due to lower market activity. The government department and institutions concerned should properly pay more attention to the capital of Shanghai Fuel Oil Futures, increase investors' participation or add new energy varieties, hoping to provide effective ways to help Chinese enterprises avoiding price risk. At present, Chinese enterprises can realize risk aversion of international oil price fluctuations by purchasing international crude oil futures varieties and using better hedging ratios.

ACKNOWLEDGEMENT

This paper is supported by Sichuan Provincial Social Science Research "Twelfth Five Year Plan" of the year 2014(No.SC14C051), Scientific research starting project of SWPU(No.2014QHS003), Young scholars development fund of SWPU(No.200731010003).

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