Regression analysis of influencing factors on the future price of crude oil

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ABSTRACT: This paper analyzes the influencing factors of future price of crude oil, and makes quantitative analysis of the correlation between US dollar index, crude oil inventory, spot price of crude oil, US dollar exchange rate and future price of crude oil, establishes a multiple linear regression model, analyzes the influencing factors of future price of crude oil by the use of the regression model of the least square method, finds out the best function matching of a set of data by minimizing the quadratic sum of error, finds out the multiple linear regression equation of the influencing factors and future price of crude oil, establishes the multiple linear regression model by the use of statistical software, researches the correlation between the future price of crude oil and the influencing factors, thus providing useful basis for quantitative analysis of crude oil futures trading.

Keywords: future price of crude oil; least square method; multiple linear regression model; influencing factors

1 INTRODUCTION

With the continuous development of social economy, various countries in the world have a growing demand for the crude oil. Crude oil has become the most important basic energy, chemical materials and strategic materials, and its violently fluctuated price brings great risks and challenges to the world economic development. As an important derivative tool, the future price of crude oil has two basic functions of price discovery and hedging, which are very necessary to effectively avoid production and transaction exposure brought by huge fluctuations in the price of crude oil.

2 LITERATURE REVIEW

Mandelbrot (1999) observes many time-varying economic variables, and discovers that the financial econometric model always assumes the yield of financial assets obeying the normal distribution, thus obtaining the feature of changes in speculative price and yield. Robert (2002) researches the crude oil futures market, and carries out empirical analysis by the use of the method of data collection, comparative statistical analysis and time series analysis and modeling, and finds that the future price and spot price of crude

oil simultaneously increase or decrease. Serletis (2003) researches the relationship between influencing factors of the price of crude oil. Song Danyang (2012) analyzes the crude oil futures and finds that the future price of crude oil and crude oil inventory has the same growth relationship. Lu Dawei (2013) interprets the efficient market theory of the future price of crude oil through qualitative analysis of oil market, and application for independence test. Fang Hui (2013) researches the co-integration relationship between the future price of crude oil and US dollar exchange rate, and finds out there exists long-and-short-term Granger causality. Dou Xian (2014) analyzes the status quo and existing problems of Petro China pricing mechanisms, and proposes policy suggestions to Petro China pricing mechanisms. Zhang Tingting cites the partial least squares regression method to analyze the influencing factors of future price of crude oil. Zhang Hui (2015) points out the correlation between the international future price of crude oil and US dollar index. Cheng Weili carries out quantitative analysis of influencing factors of the international oil price and empirical research of the dynamic relationship between the future price and spot price of crude oil, and finds out a positive correlation between the future price and spot price.

Most of the above literatures make a quantitative analysis of the influencing factors of the future price of crude oil by the use of error correction model, or

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the ordinary least square method, co-integration analysis, regression analysis and other methods. By the use of this method for analysis, the model may have multicollinearity, and affect the accuracy of the model. The domestic and foreign countries generally predict the trend of future price of crude oil through two opposite aspects of demand and supply. Its relevant factors of the economic policy, economic cycle, interest rate and natural conditions are often selected to analyze the changes in the future price of crude oil. The influencing factors of changes in the future price of crude oil are also analyzed by the use of index analysis method, tangent line analysis method and K line analysis method. However, with the passage of time, these methods can be only used to predict the future price in a short term, with many limitations. On the whole, these methods are used for limitations and qualitative analysis, which do not consider the impact of time series, and ignore the issue of multicollinearity; Peng Min analyzes the future price of crude oil and US dollar index, and finds out a long-term negative correlation between the future price of crude oil and US dollar index by the use of correlation analysis and residual test.

On the basis of above research, this paper mainly analyzes the influencing factors of future price of crude oil by the use of multivariate statistical method, and provides a useful basis for quantitative analysis, in order to predict the future price of crude oil, thus carrying out hedging of the future price of crude oil.

3 BASIC INFLUENCING FACTORS OF FUTURE PRICE OF CRUDE OIL

3.1 *US dollar index*

Since the United States reached an agreement with OPEC, US dollar has become the sole currency of settlement for crude oil, and the fluctuation of the international oil price has a close relation with the trend of US dollar. When US dollar index rises, US dollar and other currencies will also rise. In other words, the value of US dollar is rising. Most countries in the world views US dollar as the foreign exchange rate. When US dollar index falls, other major currencies will be devalued. In addition, American economy relies on two markets of crude oil and US dollar, which controls the right of price settlement of US dollar by the production right of US dollar and its settlement position on the international market; its market and related markets indirectly control the supply of international crude oil, thus capturing the price of crude oil.

The output results of correlation test of US dollar exchange rate and future price of crude oil are as shown in Table 1.

As it can be seen from Table 1: r=0.904984, indicating a highly negative correlation between US dollar

index and the future price of crude oil. Since crude oil futures and US dollar index has become to be listed, the future price of crude oil has a very close relation with US dollar index. When the US dollar index falls, the price of crude oil will rise; when the US dollar index is positive, the price of crude oil will be declined.

Table 1. Correlation between US dollar exchange rate and future price of crude oil

Covariance Correlation	USID	CL
USID	264.0317	
	1.000000	
CL	-459.6196	976.9208
	-0.904984	1.000000

3.2 *Crude oil inventory*

Supply and demand are the fundamental factors to determine the crude oil inventory. Other factors directly or indirectly affect supply and demand, thus affecting the future price of crude oil. The crude oil inventory is a buffer between supply and demand, and it plays a positive role in stabilization of oil price and a stabilizer. The crude oil inventory in various countries is generally divided into conventional and unconventional inventory. Generally, the unconventional inventory has an impact on the price of crude oil, which is significantly higher than the conventional inventory.

The output results of correlation test of crude oil inventory and future price of crude oil are as shown in Table 2:

Table 2. Correlation between crude oil inventory and future price of crude oil

Covariance Analysis: Ordinary		
Date: 05/11/15 Time: 10:58		
Sample: 2001 2014		
Included observations: 14		
Covariance Correlation	CL	EIA
CL	976.9208	
	1.000000	
EIA	111714.7	1.92E+08
	0.758274	1.000000

As it can be seen from Table 2: r=0.758274, indicating a significant positive correlation between US dollar index and future price of crude oil. The crude oil inventory is closely related to the futures price of crude oil. The changes in crude oil inventory may have an impact on the changes of the price of crude oil in accordance with the changes of people's expectations. Major oil companies and governments generally buy up under the upward price trend, and sell out under the downward price trend, therefore the fluctuation range of oil price will be increased to some extent, and

the supply capacity of the world's crude oil will be decreased.

In addition, as non-renewable energy, the impact of crude oil inventory on oil price is complex, and its production costs will affect the intertemporal production configuration decision of the producer, thereby affecting the market inventory, and indirectly causing the price fluctuation of crude oil.

3.3 *Changes in US dollar exchange rate*

In general, US dollar tends to be a "safe haven" of capital. Therefore, when a large amount of capital select US dollar as a "safe haven", the capital are very likely to flow from the international market of crude oil futures. In the standard model of non-renewable resources, the rising exchange rate will result in decreased exploitation value of future crude oil compared to the present exploitation value, so the exploitation path of crude oil tends to be present, and away from the future. A high interest rate will reduce capital investment, resulting in a smaller initial exploitation scale; a high interest rate will also increase the capital cost of alternative technology, resulting in the decrease of exploitation rate. In recent years, in response to the lack of domestic demand and growing trade deficit, the Federal Reserve reduces the interest rate several times, causing a large number of international capitals outflow to the United States, thus resulting in the depreciation of US dollar, while the international oil price is mostly settled in US dollars. In the case of continuous depreciation of US dollar, the US dollar earnings of crude oil of OPEC have a continuous decreasing real purchasing power in the international market. In response to the depreciation of US dollar and declined earnings of crude oil, OPEC can only maintain a high price of crude oil as an effective measure. The changes in the US dollar exchange rate also have a certain impact on the price of crude oil: the depreciation of US dollar will stimulate the price of crude oil to rise in the crude oil market. Continuous depreciation of US dollar will bring a huge panic to the international financial industry. In order to avoid risks, the speculators will choose to convert US dollar into the crude oil futures contract, which may result in imbalance between supply and demand in the crude oil market, thus affecting the stability of the price of crude oil; stable, or rising and falling US dollar exchange rate will directly affect the future price of crude oil.

The output results of correlation test of US dollar exchange rate and the future price of crude oil are as shown in Table 3.

As it can be seen from Table 3: r=0.775104, indicating a significant negative correlation between US dollar index and the future price of crude oil. During a long time of changes of the exchange rate, US dollar is always an authorized price and settlement currency in the world's crude oil futures market. When US dollar

is t the settlement currency of the crude oil in the market, the changes in US dollar will directly affect the future price of crude oil. We can say that the trend of US dollar will become another important reason to affect the changes in the future price of crude oil.

Table 3. Correlation between US dollar exchange rate and future price of crude oil

Covariance Analysis: Ordinary

Date: 05/11/15   Time: 10:58

Sample: 2001 2014

Included observations: 14

Covariance Correlation	AUD	CL
AUD	0.728228	
	1.000000	
CL	-20.67392	976.9208
	-0.775104	1.000000

3.4 *Spot price*

The futures market has the linkage of the relevant market, which has a strong correlation with the fluctuation of the spot market price. The output results of correlation test of spot price and future price of crude oil are as shown in Table 4:

Table 4. Correlation between spot price and future price of crude oil

Covariance Analysis: Ordinary

Sample: 2001 2014

Included observations: 14

Covariance Correlation	MOPS	CL
MOPS	758.5916	
	1.000000	
CL	694.0273	976.9208
	0.806200	1.000000

As it can be seen from Table 4, r=0.806200, indicating a significant positive correlation between US dollar index and the future price of crude oil. The trend of the spot price of crude oil is the same with the future price of crude oil. There is a long-term stable equilibrium relationship between the future price and spot price of crude oil. When the future price of crude oil is greater than the spot price of crude oil, the crude oil suppliers will substantially increase the crude oil inventory, and reduce the current supply, thereby stimulating the spot price of crude oil to rise, and narrow the difference between future price and spot price; when the spot price is higher than the future price, the crude oil supplier will reduce the crude oil inventory and increase the current supply, thereby reducing the spot price and reaching a balance with the future price.

4 ESTABLISHMENT OF MULTIPLE REGRESSION MODEL

4.1 *Multiple regression model*

If the independent variables, x_1, $x_2...x_n$ and the dependent variable y have a higher linear relationship, and:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_n x_n + \varepsilon \qquad (1)$$

Where, β_0, β_1, $\beta_2...\beta_n$ are the regression coefficients, ε is a random error, and $\varepsilon \sim N(0, \sigma^2)$. The model (1) is called as the multiple linear regression model.

4.2 *Multiple regression model of influencing factors of future price of crude oil*

The multiple linear regression model is established, of which the US dollar index (USID), crude oil inventory (EAL), spot price of crude oil (MOPS), US dollar exchange rate (AUD) are explanatory variables, and the future price of crude oil (CL) are explained variables.

The data herein are consulted from the website of the National Bureau of Statistics of China (http://www.stats.gov.cn/). The data of the future price of crude oil and variable indicators from 2005 to 2015 are as shown in Table 5:

Table 5. Data of representative indicators in China's security industry from 2005 to 2015

Year	CL	USID	MOPS	EIA	AUD
2001	29.52	127.36	25.96	21537.2	8.2768
2002	19.72	125.13	26.11	22769.1	8.2768
2003	33.03	114.50	31.08	25187.1	8.2725
2004	34.21	109.57	41.84	29012.3	8.2768
2005	56.56	111.69	56.70	30089.2	8.0860
2006	60.84	106.67	66.29	32249.2	7.8790
2007	93.85	99.48	72.07	34035.1	7.4543
2008	45.59	108.52	99.72	35498.6	6.8283
2009	77.93	101.15	61.94	38130.5	6.8276
2010	94.59	80.03	86.46	42876.6	6.6636
2011	107.08	77.66	89.28	43961.1	6.3353
2012	111.26	81.14	102.23	46684.7	6.2855
2013	110.90	79.56	109.45	4.8723	6.1675
2014	56.46	90.05	81.32	5.0812	6.1468

In order to reflect the statistical relationship between the explained variable of the future price of crude oil and various variable indicators, we adopt Eviews statistical software to analyze Table 5, and the output results are as shown in Table 6.

According to the output results in Table 6, we establish the following multiple linear regression model:

CL=0.000297E-1.642259U+0.259506M+6.609958A+ 158.03

Table 6. Statistical relationship between the explained variables and explanatory variables

Dependent Variable: CL
Method: Least Squares
Date: 05/27/15   Time: 13:01
Sample: 2001 2014
Included observations: 14

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	158.0296	98.71942	1.600796	0.1439
AUD	6.609958	12.98718	0.508960	0.6230
EIA	0.000297	0.000309	0.960951	0.3617
MOPS	0.259506	0.345763	0.750531	0.4721
USID	-1.642259	0.571281	-2.874698	0.0183

The output results of goodness of fit (coefficient of determination) are as shown in Table 7:

Table 7. Results of goodness of fit

R-squared	0.951097	Mean dependent var	66.53857
Adjusted R-squared	0.884918	S.D. dependent var	32.43561
Prob (F-statistic)	0.000916		

As it can be seen from Table 7, after adjustment $R^2 = 0.951097$ goes to $\overline{R} = 0.884918$, indicating that the model has a better fit on the whole; the actual value of the explained variables is closer to the fitted value.

The output results of t test of multiple linear regression model and parameter estimate are as shown in Table 8:

Table 8. t test and parameter estimate results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	158.0296	98.71942	1.600796	0.1439
AUD	6.609958	12.98718	0.508960	0.6230
EIA	0.000297	0.000309	0.960951	0.3617
MOPS	0.259506	0.345763	0.750531	0.4721
USID	-1.642259	0.571281	-2.874698	0.0183

In the test results, when the significance level is set at 5%, p values corresponding to t test of the variables of AUD, EIA and MOPS are respectively 0.6230, 0.3617 and 0.4721, which are greater than 0.05 (5%), so the estimate parameter does not pass t test; p value corresponding to t test of *Usid* is 0.0183, less than 0.05 (5%), so the estimate parameter of *Usid* passes t test.

The output results of F test of the multiple linear regression model are as shown in Table 9.

The results of F test show that F statistics is 12.86052, and the corresponding P value is 0.000916, which is less than the significance level, 0.05 (5%), indicating that the null hypothesis is refused, and alternative hypothesis is accepted, the equation passes F test, and the linear relation of model is established.

By the observation of the least square method and correlation test, after test, the linear regression model is:

$$CL=0.000297E\text{-}1.642259U+0.259506M+6.609958A+158.03 \qquad (2)$$

The meaning of (2) is a unit of the change in crude oil inventory, and the future price changes 0.0032 units; US dollar index changes one unit, and the future price changes 1.6432 units; the spot price changes one unit, and the future price changes 0.2556 units; US dollar exchange rate changes one unit, and the future price changes 6.6099 units. Thus, its biggest influencing factor is the US dollar exchange rate, and the future price of crude oil will be strongly influenced by the US dollar exchange rate. In addition, there is a strong negative correlation between the future price of crude oil and US dollar. The correlation analysis and test show that the US dollar exchange rate and the degree of fitting of future price of crude oil have a better effect, and their negative correlation is also in line with the actual situation.

Table 9. Output results of *F* test

R-squared	0.951097	Mean dependent var	66.53857
Adjusted R-squared	0.884918	S.D. dependent var	32.43561
S.E. of regression	15.04264	Akaike info criterion	8.532107
Sum squared resid	2036.529	Schwarz criterion	8.760342
Log likelihood	-54.72475	Hannan-Quinn criter.	8.510980
F-statistic	12.86052	Durbin-Watson stat	2.617624
Prob (F-statistic)	0.000916		

5 CONCLUSION

The time series complies with the historical regularity, so its future development trend is related to the historical trend, with a certain error; the considered factors also have deficiencies, and the adopted variables are less. The interlink substitution method increases the carrying capacity, However, with the passage of time series, there are analysis models without considering influencing factors. In addition, the crude oil is a strategic material, and non-renewable resource. The weather and natural factor and national policy decisions will continue to reduce the future price of crude oil in a certain period, which will make the analysis model herein have transient failure, therefore the analysis method and analytical model of this paper do not have the effect of short-term prediction.

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