Research on Influencing Factors of Oil Futures Price and Short-term Forecast

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Abstract. Oil futures market has the characteristics of avoiding risks. In addition, it is important to balance oil supply and demand. The trading volume of the oil futures market is increasing year by year, and it has become an important part of the futures market. The research on the factors of oil futures price can not only provide direction for individual investment, but also guarantee the balance between supply and demand of national oil. Combined with Chinese and foreign literature, five main factors are selected as independent variables, and a multivariate function is established with oil futures price as dependent variable by stepwise regression analysis. Because the emergency has a great influence on the oil futures price and is difficult to quantify, the grey prediction model is used to predict the oil futures price in the short term. Combined with the results of the mathematical model, effective suggestions are provided for investors in the oil futures market to reduce investment risks.

Keywords: Oil futures，Stepwise regression analysis，Grey forecasting model，Grey correlation analysis，SPSS.

1 Introduction

"Industrial blood" points out the importance of petroleum for modern industry succinctly. Its application scope is not only in the industrial field, but also in the daily needs of clothing, food and transportation. Moreover, the development of the national economy and security also need petroleum for logistics support. The importance of oil is obvious, so maintaining the balance between oil supply and demand in various countries is the cornerstone of social stability. In the early 1970s, due to the oil crisis caused by the Middle East war, the oil supply was insufficient, the oil price soared, and the economic market was severely hit, which directly gave birth to the oil futures market. After the birth of the oil futures market, due to its characteristic effects of avoiding market risks, the trading volume keeps rising and becomes an important part of the international energy futures market.

The operation of the oil futures market is the joint action of many factors. The influencing factors of oil futures price are studied to clarify the specific impact caused by each factor and the dominant factors, and the short-term oil futures price is further

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predicted. At the personal level, studying the price fluctuation of oil futures can help individual investors make more scientific investment, avoid certain risks, reduce the loss caused by the change of influencing factors, and increase the personal investment income. At the national level, studying the price fluctuation of oil futures can generally master the activity rules of oil futures market, flexibly formulate policies, guarantee the balance of domestic oil supply and demand, and maintain the stable development of national economy.

After the formation of the oil futures market, the research on the oil futures price was gradually carried out. After entering the 21st century, when the sample size was large enough, the research on oil futures was formally formed. In 2002, Ye studied the impact of oil inventory on crude oil prices in OECD countries [1]. It was the same as Kaufmann's empirical study of quarterly oil price data from 1986 to 2000 by quantitative method in 2004 [2]. There is a correlation between prices and oil reserves in OECD countries. In 2006, Lutz Kilian analyzed oil data from 1975 to 2005 and believed that supply and demand were the most important factors affecting oil price fluctuations [3]. Chandrasekhar and Ghosh believed that the used exchange rate can indirectly affect international oil prices through its impact on oil supply and demand [4]. In 2010, Stevans and Sessions used cointegration analysis to test the relationship between oil futures price, purchasing power of us dollar, oil supply and demand and other variables, pointing out that supply determines the trend of crude oil price in the short term, while in the medium and long term, oil price is determined by more speculative futures price, and oil inventory has a significant impact on futures price [5]. Quantitative analysis of factors affecting oil futures prices started late in China. In 2007, Zhao and Li used PLS regression analysis to analyze the negative correlation between us dollar exchange rate and crude oil supply and oil futures prices, and positive correlation between demand, oil spot price and US GDP growth rate and dependent variables [6]. In 2009, Wang Shuping, Chen Yu and Jin Anping confirmed that emergencies would have a certain impact on oil futures prices by constructing ariMA-GarCH transfer function model [7]. In 2014, Jiang used vector autoregression (VAR), Granger causality test, error correction model and other function methods to make quantitative analysis and found that speculation significantly affected the volatility of oil futures prices, and public expectation was also an important factor affecting the volatility of oil prices [8].

Combined with domestic and foreign literature, the author finally decided to choose oil inventory, oil supply, oil demand, oil export volume and exchange rate as the independent variables for quantitative analysis, studied the correlation and specific correlation function between them and WTI oil futures price, and tried to use the model to predict short-term oil futures price. According to the results of the model, the investment advice for the oil futures market is given. In addition, speculative behavior and emergencies, two variables that have been studied more, are difficult to be quantitatively analyze, so a simple qualitative analysis is made for these two indicators.

2 Method

2.1 Data source

WTI crude oil futures price data from January 2018 to May 2022 (unit: USD/barrel) are used as the research object. In terms of variables, choosing RMB as the measurement index to define the us dollar exchange, rate crude oil production (unit: MMB) on behalf of the supply, the monthly into exports (unit: hundreds of BPD) as consumption, in the month of crude oil inventory (unit: thousands of barrels) on behalf of the crude oil the inventories. For oil speculation, Jiang Ying and other scholars at home and abroad used the net position of WTI non-commercial futures contract to reflect this behavior. However, according to ITF's empirical analysis of the data from January 2003 to June 2008, they believed that there was no significant evidence to prove that the change of position of oil futures would affect the oil price. In addition, the positive correlation between this variable and oil price fluctuations in the above analysis is weak, so this paper does not carry out quantitative analysis on this factor. Data source US dollar exchange rate from China's State Administration of Foreign Exchange, and other data from Energy Information Administration.

2.2 Indicators show

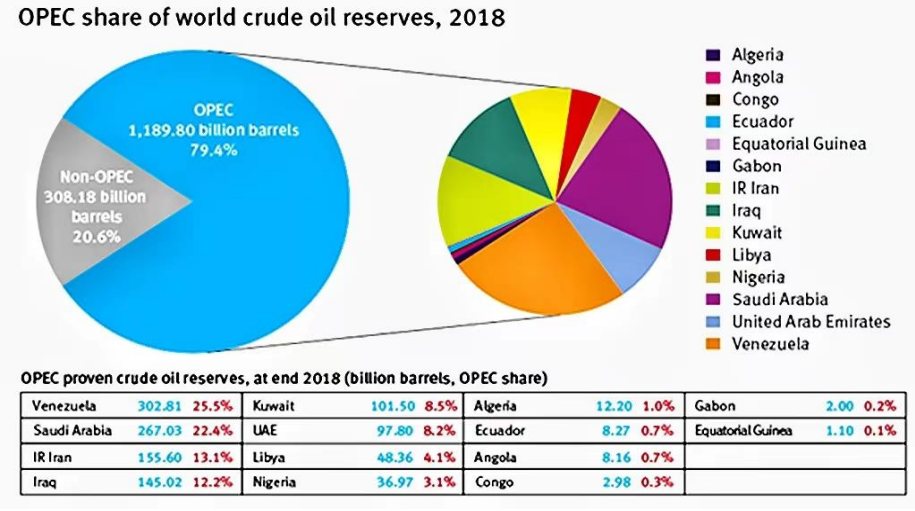

Fig. 1. OPEC share of world crude oil reserves, 2018

Combined with the research results at home and abroad, this paper finally decides to select oil supply, oil demand, oil reserves, dollar exchange rate and oil production as five independent variables to analyze the dependent variable oil futures price. Meanwhile, speculative behavior and political emergencies are described through qualitative analysis. As a non-renewable resource, oil plays an important role in global economic development. Obviously, the change of oil supply will have a direct impact on

oil futures price. While 79.4% percent of oil reserves are located in OPEC countries, the majority of OPEC reserves are in the Middle East, accounting for 64.5% percent of OPEC's total reserves. According to Kaufmann's research on the impact of OIL production in OPEC and non-OPEC regions on international futures prices, it is concluded that the actions of OPEC to control oil production and export have a significant impact on oil futures prices [2].

In the oil has dominated the international energy market under the premise of the economic development of countries around the world, the production to improve and upgrade the level of consumption will increase national demand for oil, thus promote the increase of oil futures prices, relative economic recession will lead to reduced demand for oil, the oil futures prices fell. Taking the United States as an example, due to the prosperity of the SHALE revolution and the original export lifting policy, demand for oil was reduced. Accordingly, the international oil futures price also has a downward trend in 2019.

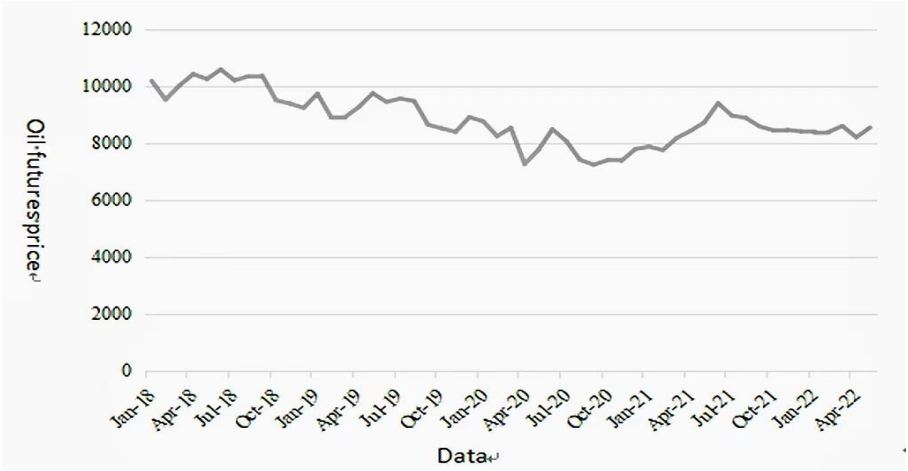

Fig. 2. The US imported oil quantity from 2018-2022

According to Qiang's research, after two Middle East oil crises since the last century, all countries have a certain amount of oil reserves, especially those of OECD member countries, which to some extent reduces the impact of possible emergencies on the international oil market [9]. If oil price rises sharply because of the shortage of supply of oil, some oil reserve countries will open their inventories to slow down the upward trend of oil prices. On the other hand, if the embargo on U.S. crude oil exports is lifted in 2015, oil reserve countries will increase their reserves to prevent oil prices from falling too much.

Oil production affects oil supply, so the analysis of oil production only needs to analyze the impact of production on supply.

According to Kaufmann and Ullman, the rise in oil prices is driven by a combination of oil market fundamentals and speculation [10]. In the oil market, there are two kinds of speculation, the first is because the capital has inherent speculative demand, oil futures market itself has tremendous opportunity attracted a large number of non-

commercial speculators, the second is due to the oil futures market has the effect of risk aversion, some oil companies will be to reduce the loss of hedging, too intense value actions exacerbate market volatility.

Political factors and emergencies also have a significant impact on the price of international crude oil futures, and due to their variety and frequency, this factor has also become an important factor affecting the price of international crude oil futures.

By studying the trend chart of oil futures prices, it can be clearly seen that before and after the occurrence of emergencies, oil futures prices will cause large fluctuations, and the growth rate of futures prices will also peak.

Fig. 3. The impact of emergencies on oil futures prices

From the impact of oil futures prices, it can be seen that the change in the growth rate caused by war-type events is larger than that of other events.

2.3 Data Preprocessing

Use boxplot to screen futures prices to find outliers. The principle is to sort the total data, and then get Q1-25% quantile, Q3-75% quantile, and iterquartile range (IQR) value of 75%-25% quantile; Then, the interval [Q1-1.5IQR, Q3+ 1.5IQR] is used to obtain outliers.

Table 1. Boxplot eigenvalues

ITEM	IQR	Q1-1.5IQR	Q3+1.5IQR
FUTURES PRICE	18.581	23.955	98.279

From April 2020 and March to June 2022. The main cause of outliers is the influence of emergencies. April 2020 produced a 16.699 abnormal decline phase. The main reason is that on March 6, When Russia rejected OPEC's proposal to expand production cuts and fell by more than 9% in a single day, the price trend began to

change [11]. At this time, Saudi Arabia, the second largest oil producer in the world, lowered oil prices and expanded production and funds in the oil futures industry were mainly hedging shorting, so the oil futures fell again. The abnormal rise in oil prices from March 2022 to now is mainly the chain reaction of the Russia-Ukraine war. On February 27, the United States and the European Union announced the ban on the use of SWIFT in Russia, which makes more than 300 banks in Russia, the second largest oil exporter, unable to conduct cross-border transactions. Secondly, as a big oil exporter in the Middle East, Iran is still under sanctions by the United States, which makes its oil exports difficult. Finally, many OPEC members cut production in response to low oil prices last year, leaving them unable to make up for shortages this year.

2.4 Model Introduction

2.4.1. Grey chird orrelation analysis.

The model first changes the blessing sequence over time and the subsequence of each evaluation factor over tim [12]. Let the reference sequence Y (parent sequence) be $Y = \{Y(k)|k = 1,2,\Lambda,n\}$,comparison column is $X_i = \{X_i(k)|k = 1,2,\Lambda,n\}$ $i = 1,2,\Lambda,n$.Then the correlation coefficien $\zeta_i(k)$ of $Y(k)$ and $X_i(k)$ is calculated by using resoultion coefficient ρ

$$\zeta_i(k) = \min_i \min_k |Y(k) - X_i(k)| + \rho \max_i \max_k |Y(k) - X_i(k)| / |Y(k) - X_i(k)| + \rho \max_i \max_k |Y(k) - X_i(k)| \quad (1)$$

Then calculate the correlation degree r_i

$$r_i = \frac{1}{n} \sum_{k=1}^{n} \zeta_i(k), k = 1,2,\Lambda,n \quad (2)$$

The larger the r_i between the independent variable and the dependent variable, the higher their correlation, that is, the greater the influence of the variable on the independent variable. After that, the correlation degree was sorted and the independent variables with higher correlation degree were further analyzed by linear regression.

2.4.2. Linear regression analysis.

Multiple linear regression model Y is

$$Y = w_0 + w_1 x_1 + w_2 x_2 + \ldots + w_n x_n + \varepsilon \quad (3)$$

where $w_0, w_1, \ldots w_n$ is unknown parameter, regression constant and partial regression coefficient respectively, and ε is random error.

For the model with a small amount of data, the least square estimation is generally used. The difference of the i_{th} explanatory variable is e_i, Q is the sum of the total squares.

$$e_i = y_i - \widehat{y_i} \quad (4)$$

$$Q = \sum_{i=1}^{m}(y_i - \widehat{y_i})^2 = e_i e_i^T = (y - x_w)(y - x_w)^T \quad (5)$$

To minimize Q, take the partial derivative and set it to 0

$$\frac{\partial Q}{\partial W} = \frac{\partial \frac{1}{2}(y-x_w)(y-x_w)^T}{\partial W} = X^T(X_w - X^T Y) \quad (6)$$

Then we can get $W = (X^T X)^{-1} X^T Y$.

2.4.3 Stepwise regression analysis.

Let the dependent variable Y and independent variables $x_1, x_2, .. x_m$ meets the multiple linear regression model, then assuming the introduced variables are, calculating the partial regression sum of squares P_{ik} and partial R^2_{ik} of variables x_{ik} already in the equation. Q (.) or R^2 represent the sum of squares of residuals of the regression model.

$$P_{ik} = Q(i_1, \ldots, i_{k-1}, i_{k+1}, \ldots i_r) - Q(i_1, \ldots i_r) \quad (7)$$

$$R^2_{ik} = \frac{P_{ik}}{l_{yy}} \quad (k = 1, \ldots, r) \quad (8)$$

Next, setting $P_{i0} = \min(P_{i1}, \ldots, P_{ir})$ as a measure. The significance test of regression coefficient is carried out, $H_0: \beta_{i0} = 0$, and the test statistic are F_{i0} and probability p

$$F_{i0} = \frac{P_{i0}}{Q(i_1, \ldots i_r)/(n-r-1)} \quad (9)$$

While the probability is $p = P\{F \geq F_{i0}\}$($F \sim F(1, n-r-1)$). If $p \geq \propto_{out}$, eliminate this variable, re-establish the regression equation of Y and other R-1 variables, and then test whether unimportant variables need to be eliminated until no variables can be eliminated.

Consider whether new variables can be introduced. Assuming that r variables are selected and the variable not included in the equation is $x_{j1}..x_{jm-r}$.

First, the five evaluation items (import, export, exchange rate, production and inventory) and futures prices are analyzed to rank the correlation between the evaluation items and futures prices. The software used here is SPSS.

Calculate the corresponding partial regression sum of squares P_{ik} and partial R^2 of variables not in the equation

$$P_{ik} = Q(i_1, \ldots i_r) - Q(i_1, \ldots i_r, i_k) \quad (10)$$

$$R^2_{ik} = \frac{P_{ik}}{l_{yy}} \quad (k = 1, \ldots, m-r) \quad (11)$$

Assume the measure $P_{j0} = \max(P_{i1}, \ldots, P_{im-r})$. The test statistic is F_{j0} and probability p,

$$F_{j0} = \frac{P_{j0}}{Q(i_1,\ldots i_r,j_0)/(n-r-2)} \quad (12)$$

The probability is $p = P\{F \geq F_{j0}\}$ $(F \sim F(1, n-r-2))$. If $p < \propto_{in}$, then introduce variables and transfer to the step of considering whether to eliminate variables; Otherwise, the process of gradually filtering variables ends.

2.4.4 Grey prediction model.

Before gray prediction, data processing of the original time series is required. Let the original data be $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots x^{(0)}(n))$,1-AGO is $x^{(1)} = (x^{(1)}(1), x^{(1)}(2), \ldots x^{(1)}(n))$

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1,2,\ldots,n \quad (13)$$

Let the sequence $z^{(1)}(k)$be generated for the adjacent value of the sequence $x^{(1)}$, that is:

$$z^{(1)}(k) = \propto x^{(1)}(k) + (1-\propto)x^{(1)} \quad (14)$$

Establish GM (1,1) model is

$$x^{(0)}(k) + \alpha z^{(1)}(k) = b \quad (15)$$

And get an estimate of a and b using regression analysis, and get a

$$\frac{dx^{(1)}(t)}{dt} + \alpha x^{(1)}(t) = b \quad (16)$$

$$x^{(1)}(t) = (x^{(0)}(1) - \frac{b}{a})e^{-a(t-1)} + \frac{b}{a} \quad (17)$$

Then getting the predicted value

$$\widehat{x^{(1)}}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}, k = 1,2\ldots n-1 \quad (18)$$

$$\widehat{x^{(0)}}(k+1) = \widehat{x^{(1)}}(k+1) - \widehat{x^{(1)}}(k), k = 1,2\ldots., n-1 \quad (19)$$

3 Results and discussion

First, the five evaluation items (import, export, exchange rate, production and inventory) and futures prices are analyzed to rank the correlation between the evaluation items and futures prices. Assume that there is no obvious collinearity among the five independent variables. The software used here is SPSS.

Table 2. Correlation result

EVALUATION OF ITEM	CORRELATION	RANKING
IMPORT	0.747	1
INVENTORY	0.716	2
EXCHANGE RATE	0.702	3
OUTPORT	0.694	4
PORDUCE	0.685	5

Combined with the processing of the correlation coefficient results, the correlation degree value is obtained. The larger the association value indicates the stronger the degree of correlation of the evaluation term with the parent sequence. Among the five evaluations, import had the highest evaluation of 0.747, followed by inventory at 0.716, and the lowest was production at 0.685. While the correlation between futures price change and import change and production change is the lowest, the correlation value between the five evaluation items and the parent sequence is greater than 0.5, that is, the correlation between the five evaluation items and the parent sequence exists.

Gray correlation degree analysis determined the correlation between the selected independent variables and the oil futures prices. In order to determine the specific correlation between them, a multiple linear regression model is used to fit here for the correlation

Table 3. The linear regression results n=53

	COEFFICIENT	SD	BETA	P	VIF	R^2	F
CONSTANT	403.902	34.636	-	0.000***	-		
IMPORT	0.003	0.001	0.168	0.018**	1.331		
INVENTORY	0	0	-0.709	0.000***	1.964		
PRODUCE	-0.003	0.002	-0.133	0.244	3.601	0.833	F=46.893 P=0.000***
EXCHANGE RATE	-0.15	0.058	-0.256	0.013**	2.778		
OUTPORT	0.002	0.002	0.077	0.401	2.304		

The fitting function of linear regression is

$$y = 0.003x_1 - 0.003x_3 - 0.15x_4 + 0.002x_5 + 403.902 \quad (20)$$

Y is the oil futures price, x_1 is the import volume (demand), x_2 is the inventory, x_3 is the production (supply), x_4 is the exchange rate of US dollars, x_5 is the export volume (supply). First, the corresponding value obtained by F test is 46.893. While the P value at the level of 1% significance test is also small enough, almost 0. In conclusion, the model has a high degree of fitting. This conclusion can also be further confirmed by analyzing R^2. The R^2 value obtained by the function fitting reaches 0.833, close to

1, which further confirms the good fitting degree of the function. Although the fitting result of multiple linear regression model is good, in order to further determine the usability of the model, it is necessary to clarify whether the model has col-linearity. The corresponding variance inflation factor (VIF) values of the five variables are all less than 10, that is, the independent variable VIF values perform well. However, when testing the independent variable -- export and production, the corresponding P value does not meet the significance test level of 10% and reaches more than 0.2, so it is necessary to optimize the linear regression model and conduct stepwise regression analysis.

Table 4. Stepwise linear regression analysis n=53

	COEFFICIENT	STANDARD ERROR	BETA	P	VIF	R^2	F
CONSTANT	403.542	30.421	-	0.000***	-		
IMPORT	0.003	0.001	0.156	0.014**	1.058	0.828	F=78.591 P=0.000***
EXCHANGE RATE	-0.194	0.038	-0.33	0.000***	1.219		
INVENTORY	0	0	-0.668	0.000***	1.257		

After stepwise regression, the exportation and production, which are not significant independent variables, are removed, and the optimal multiple linear regression equation is constructed by using the remaining three independent variables. In the improved multiple linear regression model, at the level of 1% significance test, the P value is close to 0 and the F value is 78.591, which is higher than the multiple linear regression model fitted by the least square method. At the same time, combined with the R^2 value, it can be inferred that the multiple linear regression equation obtained by stepwise regression can better fit the actual WTI oil futures price fluctuation.

$$y = 0.003x_1 - 0.194x_4 + 403.542 \quad (21)$$

Through the above two linear regression fitting function can be clearly seen that the constant influence on WTI oil futures price, namely the uncertainty of the impact of difficult quantitative factors on the oil futures prices cannot be ignored, directly using gradual regression analysis for prediction may have a large error, so try to use the gray prediction model in the short term. First, rank test is performed on time series to determine whether this study is applicable to the grey prediction model.

Table 5. Level Test in Grey forecasting model

INDEX ENTRY	ORIGINAL VALUE	MAGNITUDE RATIO
1	91.629	-
2	108.262	0.846
3	101.641	1.065
4	109.26	0.93

As can be seen from the above table, all the rank ratios of the original series are located in (0.67, 1.492), which indicates that the original series is suitable for building a gray prediction model.

Table 6. Grey forecasting model

DEVELOPMENT COEFFICIENT	GREY ACTION	POSTERIOR DIFFERENTIAL RATIO
-0.005	105.185	0.171

The development coefficient represents the development law and trend of the sequence, and the gray action reflects the change relationship of the sequence. The posterior ratio verifies the accuracy of the gray prediction, and the smaller the ratio, the higher the accuracy. It can be seen from the above table that in this gray prediction model, the posterior ratio is 0.17.

Existing data were inserted into the model for testing. As table 7 shows.

Table 7. Grey forecasting model test

INDEX ENTRY	ORIGINAL VALUE	PREDICTIVE VALUE	RESIDUAL
1	91.629	91.629	0
2	108.262	105.878	2.385
3	101.64	106.386	-4.746
4	109.26	106.898	2.362

The average relative error of the model is 2.258%, which means that the model fitting effect is good. Therefore, the grey prediction model can be used to predict the WTI oil futures price in a short term.

By using the grey forecasting model, the forecast value of WTI oil futures average price in 7 months after May 2022 is obtained. It can be seen that the WTI oil futures price will remain high in the next 7 months, and it has a continuous upward trend.

Table 8. Short-term forecasting

FORECAST PERIOD	PREDICTIVE VALUE
1	107.411
2	107.927
3	108.446
4	108.967
5	109.491
6	110.017
7	110.545

This paper first introduces grey correlation degree analysis to determine the selected five independent variables, which are correlated with the WTI oil futures price from May 2018 to 2022, confirming the indicator description in the second part.

Then, the stepwise regression model is used to fit the five independent variables with the oil futures price from 2018 to 2022.5 months. From the fitting effect, the stepwise regression model has a good fitting effect, which not only solves the problem of insignificance of variables in the multiple linear regression model, but also avoids collinearity and over-fitting. The regression model obtained by the stepwise regression model is roughly consistent with the results obtained by the grey correlation analysis, and the effects of inventory, US dollar exchange rate and import volume on WTI oil futures prices are more significant. For oil supply and production, the stepwise regression model excluded these two variables due to insignificance in the fitted model. The impact of the US dollar exchange rate Since the US dollar plays an important role in international trade, the price of WTI oil futures is the price of the US dollar, so the fall in the US dollar exchange rate will directly lead to an increase in the price of oil futures. On the contrary, the rise of the dollar exchange rate will also lead to the decline of oil futures prices, reduce the oil import cost of non-dollar countries, stimulate the export behavior of oil-producing countries, and stimulate the decline of oil futures prices from the supply and demand side. The existence of inventory is the buffer zone of oil futures market. The increase of oil inventory is most likely caused by the increase of oil production, and the increase of oil supply will directly lead to the decline of oil futures price. Finally, the change of oil import volume, that is, the change of supply, is the direct influence of supply and demand on oil futures price. If the supply of oil increases, the supply of oil may exceed the demand in the market, and oil futures price will fall. According to the fitting model obtained by stepwise regression, it can be seen that there is a large error in predicting oil futures price directly by using the model, so the gray prediction model is used to predict the short-term change of oil futures price. The prediction results show that oil futures prices still cannot fall in the next 7 months after May 2022, and the high probability is still rising slowly.

4 Conclusion

In this paper, the previous scholars on the research achievements of oil futures prices are introduced, and the qualitative analysis of the oil supply and demand for oil, oil inventories, oil production, the dollar exchange rate, speculation and political events, such as impact on oil futures prices, on this basis, using stepwise regression model and grey forecasting model for empirical analysis.

By stepwise regression analysis, a well-fitting functional model with oil inventory, oil supply and US dollar exchange rate as independent variables is finally obtained. Among them, the dollar exchange rate has the biggest impact on oil futures prices, followed by oil supply. Then the grey forecasting model is introduced to predict the short term, and it is concluded that the oil futures price will rise slowly in the following period of time. Although data can be used to complete the fitting, due to the availability of data, only monthly data can be used, which cannot be further accurate. It is hoped that this can be improved in future studies. According to the empirical analysis, the following investment suggestions can also be put forward for investors in the oil futures market: pay attention to the trend of oil futures prices and also pay attention to

the change of us dollar exchange rate, and make an accurate judgment; Information on large events that can be captured, such as technological innovation; Worldwide, especially in Russia, the Middle East, the United States and other countries oil production policies and changes in the situation should be constantly paid attention to.

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