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Based on the Price Change of the Petroleum's Superior Mining Model and Prediction Research

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Abstract: Oil is known as the economy and even the entire society's "black gold", "economic blood", and it is one of the world's major energy supply. As China's economy and world markets become increasingly closer, the sensitivity of oil in China is getting higher and higher, the sensitivity of the importance of oil to our economy has been raised to strategic attention.In this paper, based on the analysis of oil prices changes and impact factors, through the establishment of profit maximization model, we can obtain the oil price most superior mining path, and predict the optimal exploitation of oil by using Bellman optimization theory.

Keywords: oil; price changes; superior mining

1 Introduction

Nearly a decade, China's GDP grew by an average 9.7%, oil demand growth at 5.77%, while domestic oil production grew at an average annual of just 1.67%. China's reliance on imported oil in 2009 reached 53.6%. Strong demand, reduced excess production capacity, insufficient oil refining capacity and hot money speculation remain oil prices high. This gap between supply and demand makes the oil pricess extremely uncertain, oil prices sensitivity on supply and demand is significantly enhanced, and small fluctuations in demand may lead to sharp price changes. China's domestic crude oil prices from June 1, 1998 starting with international oil prices, and since 1993, China has become a net importer of crude oil. In 2010, China imported a record 239.3 million tons of crude oil. So changes in international oil prices significantly impact on the China's oil price changes and economic development.

1955∼2010 world oil prices shown in Figure 1, we can see that the price of oil has gone through several stages of change:1955∼1973 oil prices have remained stable level, average price at 1.80$/barrel; 1973∼1977 due to the first oil crisis outbreak, oil exporting countries of the Middle East make its oil embargo benchmark, oil prices from 2.95$/barrel suddenly up to 11.65$/barrel in 1974; During 1978∼1998, due to the second, the third oil crisis outbreak, the reduce of Iranian oil supply, the destruction of Kuwaiti oil fields and the disruption of Iraq crude oil supply, as well as Western countries have taken measures such as energy conservation and alternative energy, resulting oil price from 13$/barrel up to 42$/barrel, oil prices at the weak and vulnerable adjustment stage[1]. 1999∼2007, with the world economic recovery, the world crude oil prices from 19.3$/barrel in 1999, all the way up to the financial crisis in July 2008 of 147$/barrel; Since the second half of 2008, the U.S. subprime mortgage crisis triggered a global economic recession, resulting international oil prices gradually lower in the fluctuations, and then the countries all over the world took measures effectivly, world low oil prices from early 2009 have surged, since 2010 the world oil prices remain at high levels, with an average annual price at 75$/barrel.

2 Analysis of oil price volatility's influence factors

The influence factors of oil price mainly as demand and supply, the emergence of alternative resources, exchange rates change, social and political factors and so on.

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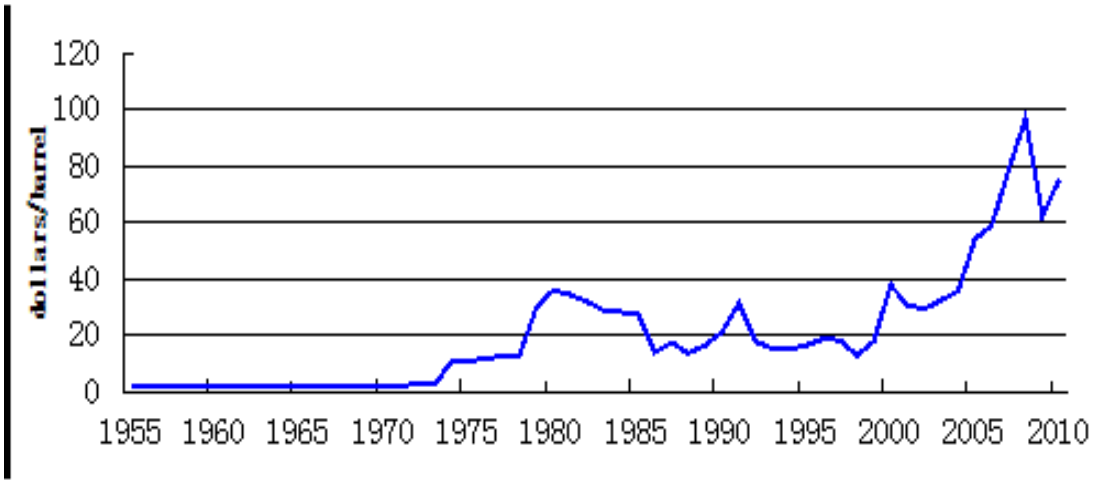

Figure 1: World Oil price(Dubai oil) (dollars / barrel)

2.1 Oil supply and demand

As a commodity, oil supply and demand is a major factor of affecting the price volatility. According to General equilibrium theory, we know that when the oil supply and demand is shortage,oil prices will be higher or show a rising trend, on the contrary, when the oil glut, oil prices are low or declining trend. For example, during the second oil crisis, the global oil supply in the short term to reduce 560 million barrels/day, resulting price from 13$/barrel rise up to 42$/barrel.And then, the high level oil prices stimulated the development of the world oil industry, the decline in oil demand and increases of alternative sources of oil, resulting in oil prices nearly from 40$/barrel fell to 15$/barrel in 1983. This shows, the amount of supply and demand changes significantly influenced the price of oil.Therefore, the international oil price will ultimately depend on the balance of both the international oil market supply and demand, in the future for a long time, the international oil market and demand situation will be the decision of the determinants of changes in international oil prices.

2.2 Emergence of alternative resources

In the 1970s, after the Middle East war, rising world oil prices led countries to redouble their efforts to develop new energy sources, there have been more clean, alternative energy, its development and the price affect the price of oil to some extent. According to some estimates, in the first oil crisis, oil consumption decreased 17% due to other energy sources instead of oil. After that, western countries actively develop alternative energy sources and strongly adopted oil-saving measures, oil in the proportion of the world total energy consumption from 47.3% in 1973 to 38.3% in 1985, then slow down, to the current is still about 38%, but natural gas increased from 17.3% in 1965 to 25.4% in 2009. From the perspective of low-carbon economy, the natural gas is the main oil alternative energy sources and with gas industry internationalize, natural gas prices will likely become an important factor influencing oil prices in the future.

2.3 Exchange rates change

World oil prices expressed in U.S. Dollars,different monetary unit measuring oil prices will affect exchange rate. Currency movements are different, the oil prices measured by currency will be different. For example, during the 2008 financial crisis, the dollar index in 2005 of 91.589 points down to 2008 of 72.637 points, the New York oil futures prices from 70.68$/barrel in June 2007 rose to 139.64$/barrel in June 2008. As the dollar depreciation and financial speculation, the real income of oil-producing countries reduced, oil producers need to raise prices to compensate for losses.

2.4 Social-political factors

The socio-political factors is the unexpected political events, such as war, mutiny, coups and to achieve some kind of political and economic purposes to take political behavior–the oil embargo, multinational mention price or cut production and so on. For example, in 2011, Libya conflict events led to the partial disruption of oil production, prompting oil prices

continued to surge, Europe Brent spot crude oil prices briefly broke through 113$/barrel. On the whole, social-political factors is one of major factors as affecting the fluctuation of oil prices, or even the direct cause of resulting oil prices significant changes in the short term.

3 Oil optimal exploitation model's building, solving and prediction

3.1 Model construction and solution

Suppose that the crude oil manufacturers is in market, marginal extraction cost is a constant, written as c, after oil prices's surge, the profit function can be written as:

$$\pi = P_t Q_t - cQ_t \tag{1}$$

Crude oil constraints is $R = \sum_{t=0}^{n} Q_t$, satisfy:$R' = -Q_t$, R_0 is the exogenously given crude oil reserves, R (t) ≥ 0, n is the exogenously given crude oil production cycle, r is the level of market interest rates, so maximization objective function of the future profit is:

$$\max(\pi) = \max \int_{t=0}^{n} [P_t Q_t - cQ_t] e^{-rt} dt \tag{2}$$

From the above objective function,we can get Hamilton function:

$$H(t) = P_t Q_t - cQ_t - \lambda Q_t \tag{3}$$

λ is the dynamic shadow price of oil output[2].

According to the Hamilton function, a perfectly competitive firm's first-order conditions are:

$$\partial H/\partial Q = p_t - c - \lambda = 0 \tag{4}$$

$$\partial H/\partial R = \lambda' - r\lambda = 0 \tag{5}$$

$$\partial H/\partial \lambda = R' = -Q_t \tag{6}$$

After settling those,the optimal price path is $\overline{P}/P = r(1 - c/p)$, this is the famous Hotelling Rule. It shows that the optimal price path of manufacturer is the net price of oil resources changes with interest rates, that is, changes in interest rates affect the price changes[3].

3.2 China's oil most superior mining model predictions

Through the above model and the results, we can obtained that the interest rate through the impact on oil prices, and ultimately determine its optimal exploitation path. Based on this, the paper takes interest rates as a variable, introducing the superior mining Bellman theory [4], to predict the future 20 years China's oil extraction.

At present, our country oil reserves are about 4 billion barrels, accounted for only 2.3% of the world total, and only 20.6 years of age can be exploited, far below the world average life of 42.8 years. Assumed that China's oil mining life of 20 years, we take every five years as a period, then 20 years can be divided into four stages, to determine the beginning of each extraction, so as to makes utility maximization. For a country with GDP as a utility, that is, that discounted value of GDP per year is maximum. Derived:$\max(J) = \max \sum_{t=1}^{4} \frac{GDP_t}{(1+r)^{5(t-1)}}$,

$$\text{S.T.}: S_{t-1} = S_t - C_t, S_1 = 40, \ldots\ldots, S_5 = 0$$

Select our country of 1970 $\sim$ 2010 GDP and oil consumption data, using SPSS software for regression analysis with two sets of data, the output is as follows:

From the table's statistics result, fitting degree is higher, we can conclude that the logarithmic function is existed between China's *GDP* and oil consumption Q, that is, $GDP = a + b\ln(x)$. As China's oil consumption in large part from imports every year, assumed that the government control oil, referencing to historical data, annual oil consumption accounted for the proportion of oil, wittern as θ is 0.6. So, the relationship between *GDP* and the amount of oil is still logarithmic function, namely:$GDP = a + b\ln(0.6Q) = a + B\ln Q$.

Table 1: China's GDP and oil consumption Q of regression analysis

Model	Regression Coefficients		Inspection results		Coefficient determination
Model	a	b	F	P	R^2
Y=a+bln(x)	-970864.12	102336.6	612.97	0.0000	0.975

With reference to the Bellman optimization theory, that is to say,if we want the whole period to be best, the whole period can be divided into two sections, first find the optimal of the next stage, and then find the optimal of first period, then use recursive functional equations, to solve each period function.

As $S_4 = C_4$, $S_5 = 0$, we use function $J(s_t)$ as the utility and maximum in t period, $J(s_4) = \max \frac{GDP_4}{(1+r)^{15}}$, so the forth period of utility maximization is mining the remaining oil to consume, that is $J(s_4) = \frac{a+B\ln(s_4)}{(1+r)^{15}}$.

For the third period, we use the recursive equation, get:$J(s_3) = \max\left[\frac{GDP_3}{(1+r)^{10}} + J(s_4)\right]$, as $S_4 = S_3 - C_3$, $J(s_4) = \frac{a+B\ln(s_3-c_3)}{(1+r)^{15}}$, substitute into$J(s_3)$, $J(s_3) = \max\left[\frac{a+B\ln c_3}{(1+r)^{10}} + \frac{a+B\ln(s_3-c_3)}{(1+r)^{15}}\right]$, to find the optimal value of $J(s_3)$, we should make C_3 derivative at the right of equation, then order the first derivative is zero. We can see:$(1+r)^{-5}c_3 = s_3 - c_3$, then get $c_3 = k_3 s_3 = \frac{s_3}{1+(1+r)^{-5}}$. Substitute into$J(s_3)$,

$$J(s_3) = \frac{a + B\ln k_3 s_3}{(1+r)^{10}} + \frac{a + B\ln(1-k_3)s_3}{(1+r)^{15}}.$$

By analogy, we can get $J(s_2)$,$J(s_1)$, from the results we see that coefficient k_1, k_2, k_3 is associated with interest rate r. According to the actual and trend of China's economic development, rates are selected as 0.03, 0.04, 0.05, substitute into the above formula, then obtain each period country's optimal oil extraction under different rates.

Table 2: China's optimal oil extraction under different level of interest rates (barrels / year)

Period	i=0.03	i=0.04	i=0.05
The first period	2.462	2.622	2.781
The second period	2.124	2.152	2.178
The third period	1.832	1.774	1.704
The forth period	1.581	1.456	1.343

4 Conclusion

By establishing the profit maximization function model, concludes that the interest rate movements decided the optimal exploitation of oil prices, that is, the net oil price changes with the interest rates; Based on the impact of interest rate effect on oil prices, by building the Bellman superior mining model on the basis of China's existing oil reserves, and through empirical analysis, we can obtian China's oil production of per period in next 20 years. The results showed that:the greater of interest rates, the more of the number of mining, but each period of extraction is reduced. However, Only 20 years mining life of existing oil can not meet China's future economic development, as an oil-importing country, oil prices will directly affect China's oil industry and the overall macroeconomic development. Therefore, our country should actively implement oil and gas resources sustainable development strategy, and constantly improve our oil price system, guaranteeing our country's economic health.

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