Forecast and analysis of the “roof effect” of world net oil-exporting capacity

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Abstract: Oil is extremely crucial to the development of the modern economy. It is important to forecast the oil supply capacity due to its scarcity and non-renewability. This paper attempts to forecast and analyze thirty-five current and potential net oil-exporting countries. Integrating both qualitative and quantitative methods, the oil production and consumption are predicted based on historical data, so that the world net oil-exporting capacity can be obtained. The results show that the “roof effect” of the world net oil-exporting capacity may appear before 2030. Unconventional oil will play an important role in the future world oil market. The competition and cooperation relationships between OPEC and non-OPEC will last for a long time.

Key words: Oil production, oil consumption, net oil-exporting capacity, roof effect

1 Introduction

Oil, known as the life-blood of industry, is an important commodity and strategic resource. It is widely used in various sectors, such as transport, petrochemical industry and so on. According to the statistics of U.S. Energy Information Administration (EIA), oil accounts for 34.8% of the world's primary energy consumption in 2008, showing that oil plays an important role in promoting the development of the global economy.

In the 21st century, with the soaring oil price and its significant fluctuation worldwide, the value and scarcity of oil is highlighted, attracting many academic organizations and scholars to study the supply of oil. On the one hand, different researchers have obtained different results. According to the study of Jan and Filip (2009), the short supply of crude oil will last for a long time. Some researchers forecast that the production of conventional oil will suffer an irreversible decline somewhere between 2004 and 2037, by 22 to 42 billion barrels per year (John et al, 2004a; 2004b). Some believe the global oil production will most likely peak at 4.2-4.7 billion tonnes a year in 2020-2030 (Kontorovich, 2009). The “International Energy Outlook 2009” (EIA, 2009) also forecasts the world's future oil consumption and production, and suggests that the oil consumption will keep increasing, the oil production will be affected by oil price and oil demand, and the non-OPEC will play an important role in the future incremental oil production. On the other hand, different mathematics models are applied. The Hubbert model and modified Hubbert models are commonly applied worldwide

to forecast oil production and consumption (Hubbert, 1949; 1962; 1967; Aleklett, 2006; Deffeyes, 2002; Maggio and Cacciola, 2009; Zhang et al, 2009). Chinese researchers instead prefer the Generalized Weng Model and their self-developed mathematics model (Weng, 1984; Chen, 1996; Hu et al, 1995; Feng et al, 2006; 2008; Tang et al, 2009; Zhao and Yang, 2009).

In general, almost all the current studies focus on oil production or oil consumption, rather than oil-exporting capacity in certain countries or areas. Furthermore, the methods used for predicting the future oil production and consumption are mostly based on pure mathematic models. The qualitative analysis and quantitative models are not combined together, and unconventional oil production is not taken into account, either.

Tong et al (2009) propose the concept of “net oil trading volume” for the first time and forecast the trend of world net oil trading volume. This paper is a further study based on the academic achievements of Tong et al (2009). In this paper, the “net oil-exporting capacity” means the difference between oil production and oil consumption for each oil-producing country during a specific time. By combining the qualitative and quantitative methods, taking the reserve-production ratio, policy of oil-producing countries and other practical factors into consideration, this paper investigates thirty-five current and potential oil-exporting countries, with their oil production including unconventional oil and oil consumption, to forecast the net oil-exporting capacity from 2010 to 2030 and takes this as reference scenario. Meanwhile, we set the scenarios of “the supply of conventional oil” and “OPEC limiting production and price maintenance” as the benchmarks to make the results more comprehensive.

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2 Data and methodology

2.1 Data

This paper aims to predict and analyze the world net oil-exporting capacity to the year 2030. Thirty-five countries are selected as the current and potential oil-exporting countries shown in Table 1, including thirty-four current oil-exporting countries and one potential oil-exporting country, Brazil. For each country, we forecast its oil production and consumption, and then obtain the oil-exporting capacity. The world net-exporting capacity can be obtained through summarizing all the thirty-five countries. The oil production and consumption data of the thirty-five countries between 1980 and 2009 comes from “BP Statistical Review of World Energy 2010” (BP, 2010) and EIA web site (see U.S. Energy Information Administration(EIA). <http://www.eia.doe.gov/>), while the future growth rate data of oil consumption between 2010 and 2030 is cited from “International Energy Outlook 2009” (EIA, 2009) as reference.

2.2 Methodology

The method used for forecasting the oil production and consumption is the integrated qualitative and quantitative method.

2.2.1 Method for forecasting oil production

The world's oil producing countries in this paper are classified into three types: policy-oriented countries, resource-constrained countries, and semi-resource-constrained countries which is between the two former types. The methods for forecasting oil production are shown in the Table 2. The policy-oriented countries means that these countries are rich in resource, and their oil production will not be restrained by the resource before 2030, so that their oil production will not decline before 2030, but is mainly influenced by the governments' energy policies.

Table 1 Selection of net oil-exporting capacity countries

Units: million tonnes

Countries	Net oil exporting capacity in 2009	Countries	Net oil exporting capacity in 2009
Canada*	58.8	Saudi Arabia	337
Mexico	61.9	Syria	6.2
Argentina	11.5	United Arab Emirates	98.7
Colombia	25.3	Yemen	7.0
Ecuador	15.3	Algeria	63.6
Trinidad & Tobago	5.04	Angola	84.4
Venezuela*	97.4	Chad	6.1
Azerbaijan	47.9	Republic of Congo (Brazzaville)	13.7
Denmark	4.72	Egypt	3.75
Kazakhstan	66.0	Equatorial Guinea	15.1
Norway	98.6	Gabon	10.7
Russian Federation	369	Libya	65.5
Turkmenistan	4.96	Nigeria	87.1
Iran	118	Sudan	20.1
Iraq	93.9	Brunei	7.50
Kuwait	102	Malaysia	8.82
Oman	33.5	Brazil**	-3.95
Qatar	49.7		

Notes: *The oil in Canada and Venezuela consists of unconventional oil and conventional oil;

** Brazil is a potential oil-exporting country.

Table 2 Methods for forecasting oil production

No.	Country-type	Description	Criteria	Method	Countries
I	Policy-oriented	Before 2030, the oil production will not be restrained by the resource and hence not decline	The reserve-production ratio is more than 60 in 2009	(1) <i>Qualitative analysis</i> : Making qualitative judgment on energy policy because the oil production is more influenced by the governments' energy policies (2) <i>Quantification</i> : Oil production increases by a certain percentage	Canada, Venezuela, Kazakhstan, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, Libya
II	Semi-resource-constrained	Before 2030, the oil production will increase first, and then may decline because of the constrained resource by the end of 2030	The reserve-production ratio is between 10 and 60 in 2009	(1) <i>Decline point</i> : When the reserve-production ratio is reduced to 10, the oil production enters the decline period (2) <i>Before decline</i> : the highest goodness-of-fit curve, obtained by the curve-fitting method based on historical data, is used to forecast the oil production (3) <i>After decline</i> : the reserve-production ratio is kept to be 10 and to forecast the oil production based on the remaining reserve.	Mexico, Argentina, Ecuador, Trinidad & Tobago, Azerbaijan, Russian Federation, Oman, Syria, Yemen, Algeria, Angola, Chad, Republic of Congo (Brazzaville), Egypt, Equatorial Guinea, Gabon, Nigeria, Sudan, Brunei, Malaysia, Brazil
III	Resource-Constrained	Since 2009, the oil production has declined because of the constrained resource	The reserve-production ratio is less than 10 in 2009	The oil production is calculated by a fixed decline rate. The decline rate is an average value in the decline period	Colombia, Denmark, Norway, Turkmenistan

These countries are mainly the OPEC countries. Resource-constrained countries are those whose oil production will decline after 2009. The oil production of these countries is restrained by the oil resource. Semi- resource-constrained countries means that the oil production in these countries has not declined so far, but may decline before 2030. In our work, when the reserve-production ratio is reduced to 10, the oil production of the country is assumed to enter the decline period. Before the decline period, the oil production is forecast with the highest goodness-of-fit curve, which is obtained by the curve-fitting method based on historical data; In the decline period, the reserve-production ratio is assumed to be 10 so as to forecast the oil production based on the remaining reserves. This assumption about the reserve-production ratio of 10 is proposed by John et al (2004).

The remaining oil reserves is forecast as follows:

$$r_t = r_{t-1} + \Delta r_t - p_t$$

where, r_t is the remaining oil reserves of t year, r_{t-1} the remaining oil reserves of the $(t-1)$ year, Δr_t the increment of remaining oil reserves of t year, and p_t the oil production of t year.

When forecasting the remaining oil reserves of the current year, we take the remaining reserves of last year plus the incremental increases in oil reserves of current year minus the production of the current year. The method for forecasting the incremental oil reserves of t year is as follows: First, the highest goodness-of-fit curve, obtained from historical data, is used to forecast the future incremental oil reserves; then qualitatively judge the reasonableness of the fitting curve according to the further potential petroleum resources to make corresponding revisions.

2.2.2 Method for forecasting oil consumption

The method for forecasting the oil consumption is shown in Fig. 1.

Fig. 1 Method for forecasting oil consumption

The method follows two steps:

First, forecast the trend of oil consumption using the highest goodness-of-fit curve obtained from historical data;

Second, the curve fitting method is feasible in a short-term, but the forecast error will continually rise in a long-term, so for a long-term, the forecast value of oil consumption need to be corrected. The principle of correction is to take the smaller value between the growth rate from the fitting curve and the forecast growth rate supplied by EIA as the revision value.

3 Results and discussion

3.1 The “roof effect” of the world net oil-exporting capacity appearing by 2030

With the methods and data mentioned above, the net oil-exporting capacity of each oil-exporting country can be forecast. The sum of the net oil-exporting capacity of the 35 countries will be a reference to the world total net oil-exporting capacity. The forecast result is shown in Fig. 2.

Fig. 2 Forecast result of world total net oil-exporting capacity

As shown in Fig. 2, the “roof effect” of the world net oil exporting capacity may appear in 2028. The net-exporting capacity will reach its highest point of 2.40 billion tonnes, followed by a gradual decrease. This phenomenon is known as the “roof effect” of world net oil-exporting capacity. In this paper, the “roof effect” of world net oil-exporting capacity means that the world oil consumption increases continually but the oil production begins to decline at a time in the future due to the limitation and non-renewability of oil resources, causing the world net oil-exporting capacity decline. The world net oil-exporting capacity will increase by 9.1% from 2.2 billion tonnes in 2009 to 2.40 billion tonnes in 2030, with the oil production increases by 14.7% from 3.13 billion tonnes in 2009 to 3.59 billion tonnes in 2030 and the oil consumption increases by 32.2% from 0.93 billion tonnes to 1.23 billion tonnes. The rise of consumption is higher than that of production. The increased oil demand is mainly from the developing countries.

3.2 Structural change of world net oil-exporting capacity and analysis of world's major oil-producing countries

The net oil-exporting capacity of thirty-five countries in 2009 (actual value) and in 2030 (forecast value) are shown

Fig. 3 Comparison of net oil exporting capacity of thirty-five countries in 2009 (actual value) and in 2030 (forecast value)

3.3 Unconventional oil as an important part of world oil export

In order to investigate the role of unconventional oil in the future world oil export, this paper sets the scenario of “net conventional oil export”. The world net oil-exporting capacities including and excluding unconventional oil are shown in Fig. 4. The unconventional oil mainly refers to oil sand and heavy oil. Since Canada and Venezuela are both rich in unconventional oil, the unconventional oil is mainly from Canada and Venezuela. Their conventional oil production are cited from EIA’s (EIA, 2009) forecast data.

As shown in Fig. 4, if the unconventional oil is not taken into consideration, the roof effect of world net oil export will appear in 2023, five years ahead of the time suggested in reference scenario. After 2023, the world net oil export will decrease at the rate of 0.31%. While in the reference scenario,

in the Fig. 3. It can be seen that by the year of 2030, the net oil exporting countries will decrease from thirty-four to thirty worldwide, the oil production of Mexico, Denmark, Turkmenistan, Syria, and Egypt will no longer meet their domestic consumption. Thus, these four countries will become net oil-importing countries. Brazil, the net-importing country in 2009, is expected to become a net-exporting country soon with an exporting capacity of 67 million tonnes in 2030. In 2009, the largest two oil exporting countries are Russia and Saudi Arabia. Although the net oil-exporting capacity of Russia will decrease by 26.5% by 2030, the absolute volume of its net export will be still large enough. Saudi Arabia will still hold its unshaken position in terms of world net oil-exporting capacity. Rich in oil resources, Iraq will become the third largest oil-exporting country behind Saudi Arabia and Russia. However, with the world’s fastest net export growth rate of 167%, Iraq has a great potential to catch up with or even surpass Russia in net oil export. The net oil-exporting capacity of Venezuela and Canada will increase by 56.2% and 138% respectively. Such a large increase is due to the production of unconventional oil resources. Among the thirty-five countries, twenty countries’ oil-exporting capacity will decrease at different extents, contributing directly to the “roof effect” of world net oil-exporting capacity.

the decrease rate of the world net oil export is only 0.05%. In the reference scenario, the proportion of unconventional oil in world net oil export will increase from 3.9% in 2009 to

Fig. 4 The world net oil-export under the scenario of “the supply of conventional oil” and reference scenario

11.6% in 2030, indicating that unconventional oil will play an important role in future net oil exports, and will bring challenge and difficulty for the petroleum refining industry.

3.4 Competition and cooperation between OPEC and non-OPEC countries

In the reference scenario, the oil production of OPEC countries will increase from 1.57 billion tonnes in 2009 to 2.15 billion tonnes in 2030. the non-OPEC oil production will remain 1.45 billion tonnes level, with a slight fluctuation in the study period. However, the oil consumption of the non-OPEC countries will increase rapidly by 25.5% from 0.6 billion tonnes in 2009 to 0.751 billion tonnes in 2030. In order to investigate the role of OPEC countries in world oil export, this paper sets the scenario of “OPEC limiting production and price maintenance” as the benchmark. Assuming that OPEC countries take the limiting production and price maintenance policy to reduce the production by 10%, the forecast of world net oil-exporting capacity is shown in Fig. 5.

As shown in Fig. 5, if the production of OPEC countries decreased by 10%, the “roof effect” of world net oil-exporting capacity would not come ahead of the time suggested in reference scenario. It fully proves that non-OPEC countries will take certain positions and have an influence on world oil exports. Russia has the greatest influence among those countries. Although Russia’s oil production continuously decreases, the proportion of its oil export in the world will still account for 11% in 2030. The forecast result also shows that if the OPEC countries do not limit their productions, the proportion of OPEC oil export in the world oil export would continuously increase from 61.7% in 2009 to 69.5% in 2030. However, if they limit their production by 10%, the proportion of OPEC oil exports in the world oil exports would still increase from 58.5% in 2009 to 66.5% in 2030. In other words, OPEC countries are still the main contributors to the future oil exports. Among the OPEC countries, Saudi Arabia retains the most powerful influence and the proportion of its oil export in the world total will maintain at 18%.

Fig. 5 World net oil export under the scenario of “OPEC limiting production and price maintenance” and reference scenario

4 Conclusions and limitations

4.1 Conclusions

Oil plays an important role in the development of

the world economy. Forecasting world net oil-exporting capacity has a crucial significance to China’s relevant policy formulation and implementation. This study makes a systematic research on the production and consumption of thirty-five net export countries by 2030. It also analyzes the net oil-exporting capacity of each country in detail and comparatively. Study was made concerning world net oil-exporting capacity under different scenarios. The conclusions are as follows:

1) With the development of global economy, this paper considers that oil consumption will continuously increase to the year of 2030. Meanwhile, the limitation of oil resource will lead to the “roof effect” of world net oil-exporting capacity. The forecast conclusion indicates that the “roof effect” of world net oil-exporting capacity may appear in 2028. In the study of thirty-five countries, the oil export capacity of twenty countries will decline at various degrees, and the number of net exporting countries will reduce by five. That is to say, the world remaining oil reserves will be concentrated in a few countries, thus improving their influence on the oil price and the oil market.

2) Contrast analysis shows that unconventional oil will delay the time of the “roof effect” of world net oil-exporting capacity and slow down the decline rate after reaching “roof effect”. It is thus clear that unconventional oil will play an important role in future oil exports. The authors consider that the unconventional oil resources are very rich and are not yet being fully utilized. Thus, developing unconventional oil can provide sufficient energy to guarantee the development of the world economy effectively by covering the conventional oil demand gap.

3) Through predictive analysis, if OPEC countries adopted limiting production and price maintenance policies, the time of “roof effect” of world net oil-exporting capacity would not be affected. It shows non-OPEC countries have certain influences on the world oil exports. However, the influence of OPEC countries cannot be discounted. The proportion of OPEC net oil-exporting capacity in world total will increase continuously and OPEC countries are still the main contributors to future supply. The authors hold the view that China should strengthen the contact with OPEC countries and establish long-term cooperation relations in order to guarantee China’s energy supply to support continuous economic development.

4.2 Limitations

The future development worldwide is full of uncertainties. The main limitations of this paper are as follows:

1) The paper did not take the emergence of other new oil production countries into consideration. Oil production country with export capacity is one of the important factors influencing the world oil export capacity. Pushed by the technology progress, a number of new oil production countries may appear. For example, according to “the Statesman” of Ghana, along with more and more companies conducting exploration and drilling operations, more oil resources will be discovered in Ghana. Ghana will become the representative of new oil production countries. New oil production countries will delay the forthcoming of “roof effect” of net oil-exporting capacity. But the probability of emergence of larger oil production countries is quite small. In

that case, the impact on the stability of analysis results could not be significant.

2) The paper did not take the discovery of new large oil and gas fields into consideration. The discovery of new large oil fields can effectively enlarge world net oil-exporting capacity. With the development of petroleum exploration technology and the rise of global oil prices, more and more oil fields are being discovered. According to the assessment report of the United States Geological Survey (USGS) in 2008, Arctic takes 13% of the global unproved oil reserves. With further exploration and development of oil and gas resources, the pressure of world oil shortage might be relieved. But the exploitation of Arctic oil and gas resources faces significant challenges concerning technology and costs, and the huge uncertainty still remains.

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