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Investment opportunity in China's overseas oil project: An empirical analysis based on real option approach

Bao-Jun Tang[a,b,c,*], Hui-Ling Zhou[a,b,c], Hao Chen[a,b,c], Kai Wang[d], Hong Cao[a,b,c]

[a] Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing 100081, China
[b] School of Management and Economics, Beijing Institute of Technology, Beijing 100081, China
[c] Collaborative Innovation Center of Electric Vehicles in Beijing, Beijing 100081, China
[d] Research Institute of Petroleum Exploration & Development, China National Petroleum Corporation, Beijing 100083, China

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ABSTRACT

China's overseas oil investments uphold national energy security. Located in the complex international economic and political environment, the benefits of overseas oil projects are affected by various uncertainties. Oil companies call for a set of evaluation method dealing with these uncertainties, especially when encountering low-oil-price conditions. It is much more crucial to answer when to optimally invest rather than whether to invest. This paper analyzes the investment opportunity of an oil project in the development and production phase considering uncertainty, irreversibility and management flexibility. The decision-making process combines Discounted Cash Flow (DCF) method and the trinomial tree model of Real Option Approach (ROA). For practical purposes, tools of hurdle price, cumulative probability and decision tree are adopted. In addition, results of the case project show the economic feasibility at present and optimal start-up timing at the end of 2016. Besides, the lower cost parameters generally make it easier to meet the opportunity. The scenario analysis suggests the higher risk contributes to an earlier start-up. Furthermore, the issues of method applicability, investment signals and decision-lag effects are discussed.

1. Introduction

1.1. Investment opportunity is significant in overseas oil investment strategy

The exhaustible crude oil resource is closely related to the national interests and people's livelihood. China's crude oil dependency keeps increasing, as is shown in Fig. 1, and is predicted to reach 66% in 2020. Since Jun. 2014, international oil price plummeted. In anticipation of continuing low oil price, many projects have been on indefinite suspension. At the exploration stage, high oil price creates considerable pre-assessment values. While approaching production stage, the drop in oil price leads to a sharp decline in project value. Thus, project values vary widely at different assessment or investment timing. Under the current low-price conditions, the research on investment opportunity in the development and production stage will be a helpful reference for China's overseas oil development.

In this paper, investment opportunity refers to when and at what oil price to invest during the negotiated period of a development contract. From time perspective, opportunity occurs when it is more profitable to invest immediately than to defer. From price perspective, opportunity occurs when current oil price breaks through the critical price. Decisions on investment opportunity are subject to various factors. The oil price aforementioned is merely a direct one.

1.2. The main influencing factors of investment opportunity

Irreversibility, uncertainty and flexibility are the three main factors of investment opportunity at development and production stage. The irreversibility of investment costs mainly refers to the sunk-cost effect. A development contract will not be easily terminated on account of huge sunk costs in pre-exploration activities. The uncertainty of investment conditions refers to a generalized conception of risk, or the probability of gains and losses. China's oil projects are generally located in high-risk areas where Western countries' companies refuse to enter (Wei and Zhou, 2010). The fluctuations of oil price, exchange rate and political situation in host country cause instability of project revenues. However, the geological information such as reserve factor is relatively stable at this stage and will not be considered. The flexibility of management is reflected in the negotiated period covering from issue date to target date for field start-up. During this period, project parties could seize the optimal investment opportunity according to updated

* Corresponding author at: Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing 100081, China.
E-mail address: tbj@bit.edu.cn (B.-J. Tang).

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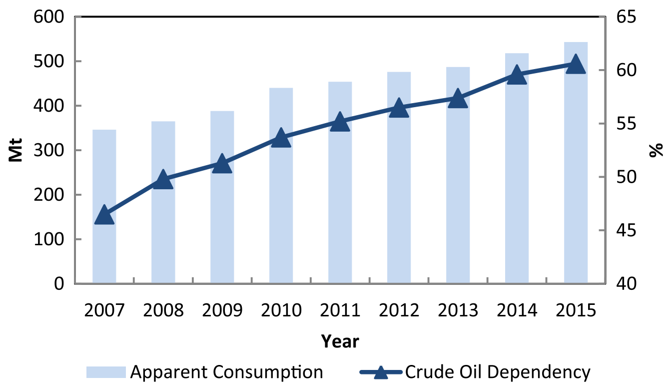

Fig. 1. China's crude oil consumption and dependency Data sources: National bureau of statistics, China's general administration of customs.

information (such as the investment environment, construction conditions, etc.). However, the negotiated period cannot extend indefinitely subjected to contract terms and the constraints of fixed cost.

The remaining paper proceeds as follows: Section 2 makes a literature review; Section 3 introduces the methodology; Sections 4 and 5 presents an applied case and conclusions are put forward in the last section.

2. Literature review

2.1. Oil project evaluation: Traditional methods and Real Option Approach

For domestic oilfield projects, conditions for investment and production are relatively steady. For the longest time, traditional methods, especially Discounted Cash Flow Model (DCF), have been capable in evaluating oil projects. For China's oil companies, the DCF method cannot satisfy the strategy of international expansion. The deterministic discount rate cannot capture the evolution of various overseas risks through projects, which involves a great deal of uncertainty and flexibility. At the same time, it generates a result bias because of lack of entirely reasonable assumptions (Grafstr and Lundquist, 2002). But up till now, practitioners extensively use the DCF method for reasons of simplicity (Kvalev, 2009).

Real Option Approach (ROA) is a promising methodology different from a deterministic DCF model. It is developed from financial option framework, and was introduced to be used in investment decisions on real assets (Myers, 1977). By parameter modifications, various uncertainties including complex overseas environment can be dealt with. In the evaluation process, project value will be obtained by incorporating option value into the NPV without flexibility (Monjas-Barroso and Balibrea-Iniesta, 2013). Thus, ROA is also known as the expanded NPV method, not the total negation but a further inheritance and development of traditional methods. It has the important characteristics of irreversibility and the possibility of delay that are inherent in most investments (Dixit and Pindyck, 1994). Furthermore, strategic evaluation by ROA can justify investing in projects for which traditional methods deliver a negative NPV but which present opportunities for competitive advantages (Monjas-Barroso and Balibrea-Iniesta, 2013). Therefore, it can provide a novel perspective under current low-oil-price situation.

Debates on the method selection have never stopped. Dickens and Lohrenz (1996) point out that the results of NPV method can avoid radical decisions in valuation of oil and gas resources, and better suited for valuation of upstream. Accordingly, they believe that the ROA is no panacea. Grafstr and Lundquist (2002) point out that values of DCF method and ROA at high oil price are quite similar. Kvalev (2009) also believes that ROA is more complicated and difficult to use compared with DCF method. Nevertheless, a moderate view is proposed that the relatively higher valuation by option pricing would lead some projects with poor efficiency to implementation, while those beneficial promising projects might be stranded when using DCF methods. Therefore, the study suggests an effective combination of the two methodologies and further standardization of ROA in the oil and gas industry.

Real options are categorized into different types, such as the option to defer (Carr, 1988; MacDonald, 1986; Paddock et al., 1988; Pindyck, 1988; Tourinho, 1979; Trigeorgis, 1993), the option to contract or expand (Pindyck, 1988; Trigeorgis, 1993), the option to abandon (Myers and Majd, 2001), etc. The investment irreversibility in oil project implies an option to defer, which is similar to American option in the financial options framework. Such option gives investors the flexibility to postpone investments during the negotiated period, that is, advance investment to start-up date. According to updated information, investors can "exercise" the option and capture the option value at any time during the period, and thus benefit from oil price fluctuations.

Black and Scholes (1973) propose a continuous model (also known as B-S option pricing formula) to price the value of European options. Following studies in the oil industry have adopted this model to solve investment values of projects (Armstrong et al., 2004; Brennan and Schwartz, 1985; Paddock et al., 1988; Siegel et al., 1987; Ucal and Kahraman, 2009). Some kinds of American option are subject to conditions of contract and the acts of exercising have time limits. As for issues of investment opportunity, the option to defer could only be exercised during a certain period. Continuous models cannot handle American option neither in the option value nor in its optimal critical value. On this occasion, discrete models (numerical methods) are more suitable (Yang and Luo, 2007), not merely because of the simplifications of continuous ones. N-ary trees, a representative of discrete models, are a good solution to investment timing owing to their flexible phased-tree structure.

Binomial tree (Cox et al., 1979) has become an applicable method to decide when to optimally invest in oil exploration and development (Ekern, 1988; Laine, 1997; Zettl, 2002). However, the only two states (rising and falling) in each period result in large calculation errors. Segmenting periods to get more states designed to reduce errors will otherwise lead to a surge in computations (Ding and Zeng, 2005). Trinomial tree model (Boyle, 1988) is proposed to improve the accuracy by increasing states in each period. Its n-step calculation is closer to the theoretical option value than that of 2n-step of binomial tree (Ding and Zeng, 2005). Therefore, trinomial tree performs better in flexibility and precision.

2.2. Investment opportunity analysis: Applications of trinomial tree model to energy projects

Trinomial tree model has been gradually applied to investment decisions of energy enterprise. In dealing with uncertainties, most studies adopt market variables. Correia et al. (2008) considered the impact that market variables (such as fuel prices and electricity prices, etc.) had on the power plant's behaviors of postponing or abandoning the stage investments. Except for electricity prices, Munoz et al. (2009) also consider wind regimes as well as investment and maintenance costs in a wind energy plant. Abadie and Chamorro (2014) stress the effect of different reward/support schemes on the option of an operating wind farm. Uncertainties are considered up to three sources: the electricity price, the level of wind generation, and the certificate (ROC) price. A trinomial lattice combined with Monte Carlo simulation is adopted for lack of data. However, it is likely to overestimate or underestimate risk by using traditional approaches, for example, Monte Carlo method (Mi et al., 2017). Zhang et al. (2014) analyze the investment timing in CCS (carbon capture and sequestration) retrofitting, with two typical types of power plants considered. Parameters reflect uncertainties in carbon prices, government incentives, annual running time, power plant lifetime and technological improvements.