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Evaluating coal bed methane investment in China based on a real options model

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ABSTRACT

In this paper, a real options based binominal lattices model for the investment of coal bed methane (CBM) is conducted. CBM prices and market demand are incorporated into the model as the predominant uncertain factors and it is solved by using the bidimensional binominal lattices approach. Then the model is employed to evaluate the investment in CBM projects in China, and the effect of related policies is analyzed. The empirical results demonstrate that the model can be used to offer a better explanation of why the CBM industry has developed slowly in China from an investment perspective. It is found that the current policy environment is not positive enough to attract investment in the CBM industry. Among various factors, CBM prices yield the most significant effect on stimulating investment in CBM development. Increasing the price subsidy is also an effective policy to stimulate investment and promote the development of the CBM industry in China.

Introduction

Coalbed methane (CBM) is an unconventional natural gas found in coal seams. As a relatively clean energy source, CBM is an important supplement to natural gas supply in China. The exploitation of CBM has the potential to be very beneficial. The greenhouse effect caused by methane is nearly 20 times that of CO_2; therefore, large scale utilization of the CBM has the potential to significantly reduce greenhouse gas (GHG) emissions. In addition, the exploration and exploitation of CBM could decrease the risks associated with coal mining. Therefore, expansion of the CBM industry is of great importance to energy security, coal mine safety, and climate change mitigation.

China possesses abundant CBM resources, being third largest in volume in the world, behind only Russia and Canada. The methane-bearing area is $41.54 \times 104\ km^2$ under the buried depth less than 2000 m in 45 coal-accumulating basins and the geological reserves is $36.8 \times 10^{12}\ m^3$ (Liu et al., 2010), which is equivalent to conventional gas reserves. According to the China's 11th Five-Year Plan, great efforts should be undertaken that are designed to increase the surface drainage production capacity and production volume so as to reach 7 billion m^3 and 5 billion m^3/year. The proven geological deposit was slated to increase 300 billion m^3 during the 11th Five-Year Plan. However, these targets were not achieved at the end of the 11th Five-Year Plan. In 2010, the production capacity and production volume of CBM reached only approximately 3.1 and 1.5 billion m^3, and the proven geological deposit reached only 198 billion m^3. Therefore, it is important to explore the reason why the CBM industry developed so minutely from 2006 to 2010 in China. How can China attract more investment in CBM development and promote the CBM industry in the near future?

There have been some discussions regarding the developmental obstacles faced by the Chinese CBM industry and the prospective solutions to the issues it faces. Qin (2006) discussed some technical problem faced during exploration for CBM. Liu (2009) created a systematic summary detailing the policy system (subsidy, tax, price, management of exploration rights) to promote CBM industry development. Yuan (2009), Zheng et al. (2009) and Zhao et al. (2011) summarized the foreign experience of the CBM industry and illustrated the problems that exist in the policy and management. Xie (2009) introduced the discounted cash flow (DCF) method used to evaluate investment in the CBM project. Zhang (2009a) concluded that the economic benefit, environmental benefit and the social benefit should be incorporated into the evaluation of the CBM project. Luo et al. (2010), using the DCF method, conducted an economic evaluation of the CBM target areas in China and made an analysis of the policy affecting the CBM investment return.

The studies referred to above discuss the possible factors (technology, regulation, investment policy, etc.) that could potentially affect the development of the CBM industry in China. However, these discussions focused mainly on the qualitative analysis of the problem, and few gave quantitative analysis of the

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problem from an investment perspective (Xie, 2009; Luo et al., 2010). These few quantitative studies were conducted using the traditional DCF method. However, the traditional DCF method cannot consider the uncertainty and dynamics of factors that significantly affect the investment behaviour and therefore the investment flexibility tends to be ignored. As a consequence, this method cannot serve to create an objective evaluation of the investment, nor can it solve the investment timing optimization problem. As a result, it fails to explain why the CBM industry developed slowly from the perspective of the CBM investment decision and cannot offer a solution to this problem.

A CBM exploitation project requires huge investments to be made and with it comes a long-term lifecycle and high risks. The validity of investments in CBM projects and the resulting investment decisions are affected by many uncertain factors, such as resource conditions, capital requirements, maintenance costs, product prices, market demand, and applicable taxes, to name a few. Confronted with these uncertainties, investors have the option to invest immediately or to delay their investment decisions, which is similar to the financial option, and potential investors will not execute the option until there are more obviously favourable conditions. This option increases the expected project value by avoiding the possibility of irreversible loss (Sabour, 1999; Samis et al., 2005). Consequently, the investors in a CBM project have the option to delay the investment (McDonald and Siegel, 1986; Ingersoll and Ross, 1992; Sabour, 2001) when circumstances are not favourable enough, causing the development of the industry as a whole to slow. Real option methods have the advantage of describing and solving this problem with the characteristics referred to above. Van der Maaten (2010) investigated the effect of a Dutch government subsidy program on investment in a solar hot water system based on associated market priced risk. Lee and Shih (2010), using the real option methods, quantitatively evaluated the policy value provided by developing renewable energy (RE) in the face of uncertain fossil fuel prices and RE policy-related factors. Fleten et al. (2011) investigated whether uncertainty in terms of the introduction of a market for green certificates affected the timing of investments in small hydropower plants in Norway from 2001 to 2010 using real options theory and a multivariate discrete choice model. In the latter study, it was found that real options models provide better explanation of investors' behaviour compared to traditional net present value analysis.

A project value evaluation was conducted using the Han Cheng CBM target area in Shanxi province as a case study based on the real option analysis, and the effect of the related policies (such as subsidy, tax, and price) on the project value and stimulating effect on the investment behaviour were analyzed. Based on this analysis, we attempt to answer the following questions: why is the CBM industry in China still developing slowly under current conditions (technological, infrastructural and regulatory)? How the policies need to be adjusted and improved to encourage investment? A policy mix to stimulate investment in the CBM industry is then proposed.

Methods and model

Uncertain factors

The source of uncertainties

A CBM project requires big investments that feature long-term durations and possess high risks. For a potential investor, the yield of an investment in a CBM project has the potential to be affected by many uncertain factors, including resource conditions such as the CBM reserve itself, technological conditions, which are closely related to capital costs and production, maintenance costs, policy environment factors, such as taxes, subsidies, and market conditions such as product price and market demand. The evaluation of a project under these uncertainties is a complicated job, which may lead to making a wrong decision by managers and stockholders. Therefore, at first, the engineers must recognize the important mining uncertainties before carrying out the project evaluation (Dehghani and Ataee-pour, 2012). In general, most uncertainty regarding the resource conditions can be clarified before the potential investors make big investments through previous exploration. As for concerns regarding technological conditions, the uncertainty can also be analyzed through comparisons with similar CBM projects that have been studied, as is done in this paper. In China, a consensus has been reached that preferential policy should be adopted to stimulate the development of CBM. What concerns potential investors is not whether the policy environment would be improved, but instead *to what extent* the policy would be improved. And once established, the policy would remain unchanged for a long period. Therefore, the uncertainty in regards to policy could be resolved through sensitivity analysis. According to the current conditions, gas price is one of the most important and uncertain factors referred to above, especially when the natural resource pricing mechanism is under market-oriented reform (Dong et al., 2010). Finally, the basic infrastructure of the CBM pipeline in China is imperfect (Liu and Yu, 2005; Li, 2009), and as such, the production of CBM is mainly used to satisfy local needs (Zhang, 2009b). The development of the pipeline and the related infrastructure is an uncertain factor that will affect the long term CBM market volume. Therefore, market demand is another important uncertain factor that affects the project value and ultimately investment decisions. As a consequence, the CBM price and the market demand uncertainties are incorporated into the model and the other factors are specified exogenously according to current technology and market conditions and prospects of future expectations.

Modelling uncertainties

Current gas prices in China are relatively low, but are expected to increase in the future (National Development and Reform Commission (China), 2010). Gas consumption is also expected to increase in the future, along with industrialisation and urbanization in China. Although the trend is clear, both factors are uncertain. Therefore, it is assumed that the evolution of CBM prices and the market demand will follow the Geometric Brownian Motion (GBM) process:[1]

$$dP_t = \alpha_p P_t \, dt + \sigma_p P_t \, dW_t{}^P \tag{1}$$

$$dD_t = \alpha_D D_t \, dt + \sigma_D D_t \, dW_t{}^D \tag{2}$$

$$dW_t^P dW_t^D = \rho \, dt \tag{3}$$

where P_t and D_t denote the CBM price and the market demand, α_p, α_c stand for the expected growth rate of the price and the market

[1] According to the historical trading prices on most futures markets for natural gas, a mean reversion process is more suitable for depicting the behavior of gas prices on deregulated markets in long run. However, a GBM model is applied to CBM prices in China for several reasons. First, the gas market in China is not mature so far and gas prices are regulated by the government, current natural gas prices are much lower than international markets and other alternatives. The market-oriented gas pricing reform is being conducted and it is expected the gas prices will increase gradually in the future, but it will take a long time according to the experience of the oil pricing reform. Second, there is huge uncertainty with gas prices in China along with the gas pricing reform, and it does not seem there exists a market power driving prices back to the mean or trend, thus it might be more suitable to take the price behavior in China as a Geometric Brawn Motion process. Third, there is no trading prices data available for estimating the relevant parameters of the mean reversion process. Therefore we assume the evolution of gas prices in the future is a GBM process. But it should be mentioned that a GBM process may result in more volatiles than a mean reversion process.