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Exploring the future of shale gas in China from an economic perspective based on pilot areas in the Sichuan basin—A scenario analysis

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ABSTRACT

Although there have been discussions regarding the commercial prospect of shale gas in China, no quantitative and convincing analysis regarding its economic viability has been reported. This research aims to explore the future of the shale gas industry in China using a single-well model. This model is established with the DCF (Discounted cash flow) method aiming at getting an average or representative reflection of the economic viability of shale gas. In the model based on data mainly from pilot areas in Sichuan Basin, three scenarios are conducted to discuss the current economy, the short-term prospect, and the future of the shale gas industry. Under the current technological and economic conditions, China's shale gas resources are not worth an investment. However, in the near future, several sweet-spots are promising, particularly with the expectation of higher gas prices and lower drilling and completion costs (D&C costs). Although the sweet-spots are promising, it is difficult to achieve the goal of large-scale development according to the known information if mainly relying on current policy, unless there are sufficient sweet-spots. Hence, we hold a cautiously optimistic attitude towards the future of the shale gas industry. We suggest that the government should spend more on supporting resource surveys and exploration in the initial stages. After identifying the resource status, a more comprehensive development plan with systemic policies conformed to the resource status is warranted, including encouragement of technical innovations, a system for mature shale gas technical service markets, and a market-oriented price.

1. Introduction

China's nature gas consumption is expected to triple by 2035 (Odgaarda and Delmanb, 2014), and the security of the supply is a challenge that the government will confront. Expanding native energy sources is the most effective way to increase supply, and fortunately, shale gas provides such an opportunity for China. An assessment by China's Ministry of Land and Resources (MLR) announced that China has potentially recoverable resources of 25 trillion cubic meters of shale gas, which is larger than those of the U.S. (Zhang et al., 2012). China's huge shale gas deposits and growing energy consumption have encouraged and even obliged the government to turn to shale gas as a way to meet the surging clean energy needs in China, and additionally, as a way to decrease air pollution created by burning coal. According to the *shale gas development plan* (2011~2015) issued by China's National Development and Reform Commission (NDRC), the production of the whole country is projected to be 6.5 billion cubic meters by 2015 (NDRC, 2012). To achieve this, some incentive policies including a price subsidy have been introduced. As expected, the state push and the growing market make it an alluring target for oil companies (SBR, 2014). Many investors have focused on China's shale gas, including local state-controlled companies, such as CNPC and Sinopec, and foreign companies, such as Royal Dutch Shell, ConocoPhillips, and Exxon Mobil (ASIACHEM, 2013).

China's shale gas industry seems promising, but it has not developed as quickly and smoothly as most investors expected. Though Sinopec, the leader of China's shale gas industry, has recently announced a yearly production capacity plan of ten billion meters in the Fuling shale play in Chongqing, which seemingly

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indicates the forthcoming commercial development, the quoted well head price is given at 2.68 Yuan/m^3. This price is much higher than the current gas price in the market and is hardly accepted by users. That means making a profit from shale gas is not yet easy. Moreover, the Fuling shale play already has many advantages, such as good geology similar to that of the Barnett shale play in the USA, convenient transportation, and a short distance to the market. For other plays that are not superior to the Fuling play, it is harder to achieve business goals. Hence, the commercial prospect of China's shale gas is far from clear.

Controversial views about the commercial prospect of shale gas in China are available. Some persons with gloomy views suggest that shale gas should not be given priority over other unconventional gas (e.g., Cui and Zhang, 2013; Lian, 2013; Wan et al., 2014), such as coal-bed methane and tight gas. The main reasons given by these persons are the complicated geology, uncertain reserve volumes, immature local development technologies, and man-made barriers. Jia Chengzao, the Chief Geologist of the CNPC and an academician of the Chinese Academy of Sciences, is one representative of this perspective. He announced that CNPC will focus on tight gas within the next 5–10 years, instead of the shale gas, because extracting shale gas is more difficult and expensive (Wang, 2012). The optimists similarly agree with the pessimists on these obstacles, but remain optimistic about the prospect of shale gas (e.g., Zhao and Yang, 2011; Hu et al., 2013). They believe that with supportive policy from the state and learning from the successful experiences of and the technologies from the US companies, the obstacles can be overcome and the industrialization progress of China's shale gas can be accelerated. Accordingly, the optimists suggest that shale gas should be prioritized. Additionally, some analyses provide a listing of the advantages and disadvantages of shale gas development in China without proposing an outcome (e.g., Hu and Xue, 2013; Wang et al., 2014a,b; Zhao et al., 2013).

Thus, the future of the shale gas industry in China remains unclear. That is a large concern among investors and the government. Almost all of the publicly available economic analyses about China's shale gas are broad qualitative analyses or from geological or technological perspectives as described above. The conclusions drawn from a qualitative analysis usually fail in persuasiveness, and the commercial prospect ultimately depends on the economic viability of shale gas. For this reason, this study makes an attempt to quantitatively explore the future of shale gas from an economical and policy perspective. Due to the uncertainty of influencing factors, a scenario analysis is employed, and the scenarios consider not only the current situation but also situations that may arise in the future.

The data used in this research is mainly from the pilot areas located in the Sichuan Basin (considered as the most promising region (Liu et al., 2010)) that belong to the Sichuan province and Chongqing municipality, collected from both public articles and personal interviews. Among the pilot areas, some resources are identified as sweet-spots and are defined as the most productive areas and often the target of development (Haley, 2009).

2. Methods and data

DCF analysis is widely used for the economic analysis of shale gas projects (e.g., Gülen et al., 2013; Kaiser, 2012; Weijermars, 2013) and is also used in this research. According to the DCF analysis, all cash inflows and outflows are discounted to some base or beginning point in time called the present at an interest rate that is generally a minimum attractive rate of return (Sullivan et al., 2009). When DCF analysis is conducted, the NPV (net present value) and the IRR (internal rate of return) are the most popular indicators (Kaiser, 2012), which are included in our analysis.

The NPV is the sum of the present discounted values of the future amounts of cash flows. A positive NPV for a project mean a profit over the minimum amount required by investors. The formula is written as:

$$NPV = (CI-CO)_0(1+i)^0 + (CI-CO)_1(1+i)^{-1} + (CI-CO)_2(1+i)^{-2} + \ldots + (CI-CO)_t(1+i)^{-t} + \ldots + (CI-CO)_T(1+i)^{-T} = \sum_{t=0}^{T}(CI-CO)_t(1+i_0)^{-t} \quad (1)$$

where CI is cash inflows; CO is cash outflows; t is an index for each analysis period 0,1,2 … T (the period is 1 year in this research); i_0 is the discount rate, and also called the minimum attractive rate of return; and T is the number of periods in the planning horizon.

The IRR reflects the rate of return on an investment or project. It can also be regarded as a breakeven discount rate, at which the NPV is zero (Fig. 1).

To calculate the NPV or IRR, all annual cash inflows (CIs) and cash outflows (COs) from the shale gas exploitation should be estimated. For a shale gas evaluation in China, the COs consist of acquisition costs, exploration and development costs, operating costs and taxes; the CIs consist of gas sales revenue and government subsidy revenue. The development costs may be subdivided into three categories: drilling, completion and facilities (Bonakdarpour et al., 2011).

In general, the cash flows of a shale gas exploitation project are based on an overall development plan, which describes the drilling

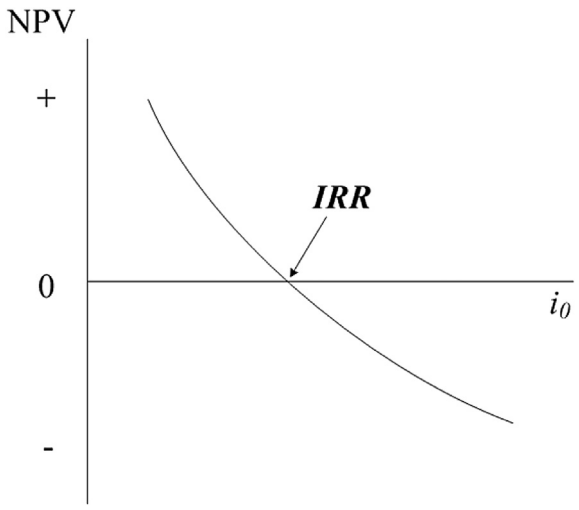

Fig. 1. Relations between NPV and IRR.