A comparative study on the production efficiencies of China's oil companies: A true fixed effect model considering the unobserved heterogeneity

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ABSTRACT

With the promotion of 'One Belt, One Road' (OBOR) initiative, China's oil companies have speeded up the pace of 'Going Global Strategy' to expand their business internationally. The efficiency problems of China National Petroleum Corporation (CNPC) and Sinopec Group, which determine the international competitiveness, have drawn ever-increasing attention from both the general public and from decision makers. The wide variation in cultural, economic and institutional characteristics of different international oil companies may result in a large amount of unobserved heterogeneity. Distinguishing the time-invariant unobserved heterogeneity from time-variant inefficiency could avoid heterogeneity bias and thus ensure consistent efficiency estimates. Considering that the production efficiencies of the sample oil companies are influenced by various heterogeneous factors, this paper evaluates the production efficiencies of the world's 10 biggest oil companies during 2003–2013 based on the stochastic frontier analysis (SFA) method and the true fixed effect (TFE) model. Results suggest that: (1) estimation techniques that do not account for unobserved heterogeneity would produce biased efficiency estimates; (2) compared with other oil companies, the production efficiencies of CNPC and Sinopec Group were relatively improved after the global financial crisis; (3) China's state-owned oil companies should be further enhanced with the ability of internationalization management.

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1. Introduction

With the promotion of establishing a comprehensive Eurasian infrastructure network under the land-based "Silk Road Economic Belt" and the "Maritime Silk Road of the 21st Century", more cooperative agreements between China and countries around Southeast Asia, the Persian Gulf, and the Horn of Africa are expected to be established, the market integration is expected to be accelerated to ever-deeper levels, and the resource allocation would be more efficient (Du et al., 2016a). Meanwhile, the establishment of Asian Infrastructure Investment Bank (AIIB) also

indicates the accelerating pace of the implementation of the Go Out Policy (also referred to as the Going Global Strategy) of central State-Owned Enterprises (SOEs) of China, especially China's two biggest oil companies named China National Petroleum Corporation (CNPC) and Sinopec Group (or China Petroleum & Chemical Corporation).

At the end of 1990s, the Chinese government implemented the strategic restructuring policy of the petroleum industry by cancelling the Ministry of Petroleum and establishing the two super large petroleum and petrochemical enterprise groups. The reform aimed to make the two companies the mainstays of the petroleum industry, which would be in charge of most petroleum activities in China. The production capacities as well as scales of the two oil companies increased substantially after more than a decade of development. In 2001 and 2007, both of them were the top listed

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companies in the stock market of China. Additionally, they listed as the world's top 10 companies in revenues over the last decade in the Fortune Global 500. Considering the typical facts of unbalanced distribution of oil resources and economic globalization, competing in international markets, winning the marketing war, and striving for overseas oil and gas resources, have become important missions for China's oil companies. The OBOR initiative provides easier accesses to ports and new sources of energy, which thereby provides good opportunities for China's two biggest oil companies to play more important roles in the global energy market.

Considering that the international oil companies have comparative advantages in the possession of oil and gas resources, the employment of high quality talents and the accumulation of management experiences, the road of "Go Out" for CNPC and Sinopec Group may not be smooth. Therefore, the most important approach for China's state-owned enterprises to gain the competitive advantage in the management of internationalization is enhancing the production efficiencies (Lu et al., 2002). Data showed that the output scales of CNPC and Sinopec Group have expanded rapidly over the past years. However, opinions about the production efficiencies of the two oil companies are divergent. One argument is that, as the most important state-owned enterprises, CNPC and Sinopec Group are supported by the Chinese government in both scientific research and resource allocation; therefore, they have advantages in terms of the overall efficiency (Jiang et al., 2011). Meanwhile, they also have other advantages including the product structures of oil and gas production and oil refinery, and technologies in the upstream area such as the resource exploration (Wang and Chen, 2007). More importantly, CNPC and Sinopec Group can receive various types of subsidies from the government and take the absolute share in domestic market under the long-term monopoly (Wang et al., 2014). Under the progressive effects of many non-market forces, CNPC and Sinopec Group should have strong competitive advantages and abilities to achieve sustainable development; and their production efficiencies should also rank top among the international oil companies, just like their top-ranked values of outputs.

An alternative view holds that state-owned enterprises are unable to establish an effective corporate governance structure (Xia and Fang, 2005). In addition, the monopolistic environment of CNPC and Sinopec Group, which lacks of withdrawal mechanisms and competitive pressures, may lead to problems such as the heavier policy burden, unclear property rights, deficiencies in management incentives and the soft budget constraint, and would finally result in the loss of stimulation mechanism of enterprises management (He, 2012; Zhang et al., 2015a,b). Lin and Li (2004) also pointed out that the policy-related burdens of the state-owned enterprises would cause the problems of moral hazard and soft budget constraint, thus would result in the low efficiencies of the enterprises. These factors made market investors lack confidence in the CNPC and Sinopec Group with regard to their operational strengths. Compared with the market values in 2007 when China's stock market index raised to peak, the market values of CNPC and Sinopec Group have shrunk dramatically in recent years. Therefore, based on the above opinions, there are great controversies in the literature surrounding production efficiencies of CNPC and Sinopec Group. What method can be used to reasonably evaluate the production efficiencies of Chinese petroleum enterprises? What are the production efficiencies of CNPC and Sinopec Group compared with other international oil companies? The above questions are the major concerns of this paper.

2. Literature review

Based on the importance of efficiency improvement, a great number of scholars have conducted research on the efficiency measurement (Odeck, 2007; Fenn et al., 2008; Zhou et al., 2012; Zhang and Choi, 2013a; Zhang et al., 2014; Arjomandi and Seufert, 2014; Zhang, 2015; Lin and Long, 2015; Song et al., 2016b; Song and Wang, 2016b). During the recent years, the method of stochastic frontier analysis (SFA) has been widely used to evaluate the production efficiencies of enterprises in China. For instance, Zheng et al. (1995) used the SFA method to study the efficiencies of industrial enterprises located in the coastal areas of China, and measured the changes of technical efficiency, allocation efficiency, technological progress and productivity of these enterprises. Yao and Zhang (2001) measured the technical efficiencies of Chinese enterprises, and then compared the technical efficiencies of state-owned enterprises (SOEs) with those of non-state-owned enterprises (NSOEs). Based on the annual data of large and medium-sized industrial enterprises, Tu and Xiao (2005) used the SFA method to decompose the total factor productivity and found that technical efficiency played an important role in promoting the productivity growth. As a parametric analysis method, the SFA method captures the deviation of individuals from the frontier of production, and separates the non-efficiency from individual heterogeneity (He, 2012). Some limitations and possible problems may encounter in conducting a study based on the SFA method. For instance, the absolute level of technical efficiency is quite sensitive to distributional assumptions, while rankings are less sensitive; the SFA requires using of large number of DMUs; the SFA suffers from endogeneity of regressor and it partially violates the monotonicity conditions. Therefore, these limitations should be kept in mind when choosing to use the SFA method. Some papers also developed alternative methodology named deterministic parametric approach (Zhang and Wang, 2015; Du et al., 2016b) to overcome the above mentioned limitations.

Among studies that used the SFA method to evaluate the production efficiencies of enterprises, the common methods proposed by Battese and Coelli (1992, 1995) may overestimate the inefficient term, which would result in the estimated results of efficiency lower than the actual situations. Based on the above issues, Greene (2004; 2005a; 2005b) focused on the impact of the heterogeneity among enterprises on the measurement of production efficiencies. Based on the World Health Organization's (WHO) panel data set on health care delivery, Greene (2004) compared the efficiencies of health care service providers of 191 countries and concluded that it is necessary to distinguished between heterogeneity and inefficiency. Followed Greene (2005a), Farsi et al. (2005) applied a number of stochastic cost frontier models to a panel data set and compares their abilities to distinguish unobserved heterogeneity from inefficiency variation among firms. Empirical results from Abdulai and Tietje (2007) also indicate that controlling correlations between unobserved heterogeneity and the explanatory variables could avoid heterogeneity bias and thus ensure consistent efficiency estimates. More and more studies in recent literature have emphasized the importance of heterogeneity in estimating efficiency. For instance, Wang and Ho (2010) indicated that if there is no sufficient control for individual heterogeneity, the effect of heterogeneity would be incorporated into the invalid rate term and even substitute the technical inefficiency in the measurement of inefficiency. Čechura (2010) showed that only those model specifications allowing for the capture of time-invariant firm heterogeneity may provide consistent estimates of technical efficiency. Considering that the heterogeneity of production technologies among provinces in China may cause difficulties for unbiased evaluation of energy efficiency, Wang et al. (2013) used a meta-frontier data envelopment analysis (DEA) approach to measure energy efficiency by