Energy Policy 79 (2015) 99–103

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Short Communication

R&D status and the performance of domestic firms in China's coal mining industry

Sizhong Sun [a], Sajid Anwar [b,c,*]

[a] School of Business, James Cook University, Townsville QLD 4811, Australia
[b] School of Business, University of the Sunshine Coast, Maroochydore DC QLD 4558, Australia
[c] Shanghai Lixin University of Commerce, 2800 Wenxiang Road, Shanghai, China

HIGHLIGHTS

- R&D status affects firm performance in China's coal mining industry.
- Coal mining firms that conduct R&D are, on average, 0.2717% more productive.
- Coal mining firms that conduct R&D experience an increase in sales.
- Increase in foreign investment decreases the market share of coal mining firms.

ARTICLE INFO

Article history:
Received 5 September 2014
Received in revised form
9 December 2014
Accepted 3 January 2015
Available online 22 January 2015

Keywords:
R&D activities
Coal mining industry
Productivity
Coarsened exact matching
China

ABSTRACT

Coal use accounts for a very large proportion of electricity production in China. Using a recently developed coarsened exact matching (CEM) technique, this paper examines the impact of research and development (R&D) activities on the performance of firms in China's coal mining industry. Our empirical results reveal that firms in China's coal industry that conduct R&D are more productive and their sales are higher. However, as far as the firm profitability and market shares are concerned, whether or not a firm in China's coal industry conducts R&D makes no difference. We find that foreign direct investment in China's coal mining industry leads to a significant decrease in the market share of domestic firms and its impact on productivity, sales and profitability of domestic firms is insignificant. The empirical results presented in this paper suggest that policies that encourage domestic firms in China's coal mining industries to conduct R&D can increase domestic production thereby reducing reliance on imports. Furthermore, productivity gains arising from R&D activities can also help Chinese mining firms to improve their competitive position in the international market. However, there is a need for restricting foreign direct investment in China's coal mining industry.

1. Introduction

During the past few decades, China's economy has experienced phenomenal growth. As a result of this growth, China's demand for natural resources such as coal has significantly increased.[1] Coal is a major source of electricity generation. The rising demand for coal is being satisfied through an increase in domestic production and imports.[2] An increase in China's demand for coal has implications for the environment. In order to build an innovation-based economy, the Chinese government is encouraging research and development (R&D) in all sectors of the economy, including sectors that contribute to energy sources (China Daily, 2013). Table 1 shows the estimated pair-wise linear correlation coefficients involving GDP, production and import of coal. The top panel of

* Corresponding author.
E-mail addresses: Sizhong.Sun@jcu.edu.au (S. Sun), SAnwar@usc.edu.au (S. Anwar).

[1] Using industry level data, Bloch et al. (2015) conclude that coal use has contributed to China's economic growth but it is also associated with increase in pollution. In an earlier study using Vector Error Correction methodology, Bloch et al. (2012) have shown that coal consumption in China causes significant increase in pollution.

[2] From 1996 to 2010, the average annual growth of GDP and coal production respectively was 9.87 and 6.01 per cent. During the same period, the imports of coal grew on average by 50.55 per cent. From 1995 to 2010, the GDP index of China registered more than a four-fold increase and during the same period, there has been a rapid increase in coal production. There seems to be a close link between China's economic growth and consumption of natural resources (China Mining, 2013). Coal is widely used for electricity production in China and hence China's rapid economic growth depends heavily on coal production and imports.

http://dx.doi.org/10.1016/j.enpol.2015.01.004
0301-4215/

Table 1
Correlation of GDP, Coal production and coal imports.Source: Author calculations using data from the National Bureau of Statistics.

	GDP	Coal production	Coal imports
Level			
GDP	1		
Coal production	0.98	1	
Coal imports	0.88	0.85	1
Growth rate			
GDP	1		
Coal imports	−0.02	0.11	1

Table 1 is the correlation between level variables while the bottom panel shows the correlation between the growth rates. The top panel shows that there is a strong relationship between (i) coal production and GDP and (ii) coal imports and GDP. The bottom panel suggests that the growth rate of imports is negatively related to GDP but this relationship is very weak.

While a number of existing studies have explored the impact of R&D on productivity in China, relatively few studies have focused on China's coal mining industry.[3] This paper examines the impact of R&D spending on productivity in China's coal mining industry. Analysis of the impact of R&D spending on firm performance in China's coal mining sector allows one to develop a better understanding of production and import of coal in China. An increase in the production of coal can reduce its dependence on imports. The analysis presented in this paper is based on a recently developed coarsened exact matching technique, which allows one to isolate the impact of R&D on firm performance. The technique involves matching firms that are involved in R&D activities with firms that are not involved in R&D activities. As a result of the matching, an appropriate control group is created, which allows a relatively more accurate comparison of firm performance based on their R&D status. We consider four indicators of firm performance in China's coal mining sector; productivity, sales, profitability and market share.

The rest of the paper is organized as follows. Section 2 contains a review of the related literature. Section 3 contains a discussion of the methodology. Empirical results are presented in Section 4. Section 5 includes a discussion of the empirical results. The last section contains some concluding remarks and policy implications.

2. Review of the related literature

A number of previous studies have focused on various aspects of coal mining industry in China. One strand of the existing studies focus on the demand for coal in China. Using income, price and relative size of the heavy industry as the main determinants of demand, Chan and Lee (1997) attempted to forecast the demand for coal in China. Cattaneo et al. (2011) considered the coal demand at the provincial level. Their work suggests that on average demand for coal in China will increase by 2 per cent per year.[4]

Li and Leung (2012) examined the impact of coal consumption on economic growth in China. They find that coal consumption Granger causes the GDP in both Coastal and Central China. Due to its importance and the significant pollution it generates, some studies explore the environmental aspect of coal consumption. Shi (2011) suggests that coal consumption can be reconciled with the environment via declined emission intensity. After reviewing the development of clean coal technology in China, Chen and Xu (2010) report that China has achieved some success in these technologies. Zhang et al. (2011) believe that a coal-resource integration project in Shanxi Province of China has contributed to energy saving and emission reduction.

Few available studies appear to have focused on the production side. Wang et al. (2011), Lin and Liu (2010) and Wang et al. (2013), among others, attempt to forecast China's coal production. Shen et al. (2012) highlight the importance of appropriate policy development in China's coal industry. In summary, earlier studies on China's coal mining industry mostly focus on the demand side. This paper focuses on the supply side—specifically, the supply from domestic sources.

3. Methodology and data

In order to examine the impact of R&D activities on firm performance in China's coal mining industry, we employ a recently developed coarsened exact matching (CEM) technique. This technique is particularly useful when some independent variables are subject to endogeneity problem. A brief description of this technique is presented below.

Let an indicator variable $drd_{it} \in \{0, 1\}$ denote whether a firm conducts R&D, which takes a value of one if firm i conducts R&D at time t and zero otherwise. We can measure the effectiveness of R&D as the impact it exerts on the firm performance, which in turn can be defined as

$$\pi_{it} = p_{it}^1 - p_{it}^0 \tag{1}$$

where p_{it}^1 is the performance of firm i at time t that conducts R&D and p_{it}^0 is the performance of the same firm if it does not conduct R&D.

Eq. (1) measures the net improvement in the performance of firm i due to R&D spending at time t difference. In empirical studies, whether or not a firm conducts R&D can be measured by a dummy variable drd_{it} that takes a value of 1 if the ith firms conducts R&D and zero otherwise ($drd_{it} = 0$). However, Eq. (1) is not identified in that in real life a firm either conducts or do not conduct R&D. In other words, in real life, eitherp_{it}^1 or p_{it}^0 will be observed. Following the existing studies, in order to overcome this difficulty, we focus on the average treatment effect (see for example, Heckman et al., 1997; Dehejia and Wahba, 2002) as follows:

$$E\{p_{it}^1 - p_{it}^0 \big| drd_{it} = 1\} = E\{p_{it}^1 \big| drd_{it} = 1\} - E\{p_{it}^0 \big| drd_{it} = 1\} \tag{2}$$

In Eq. (2), the average performance if firm i does not conduct R&D, $E\{p_{it}^0 \big| drd_{it} = 1\}$, is unobserved. After controlling for possible self-selection bias due to factors that affect both the R&D decision and firm performance, namely with an appropriate counterfactual comparison group, we can estimate $E\{p_{it}^0 \big| drd_{it} = 1\}$ by $E\{p_{it}^0 \big| drd_{it} = 0\}$.

We construct the comparison group by making use of CEM proposed by Iacus et al. (2011). Under the unconfoundedness assumption, i.e., conditional on observable factors, the outcome (i.e., firm performance) is independent of the treatment (R&D). The CEM algorithm first coarsens each factor and groups the factor into categories in which the factor has substantively indistinguishable values.[5] In the next stage, the algorithm stratifies the data by

[3] For example, the empirical work of Jefferson et al. (2006), Li et al. (2007) and Yang et al. (2010) suggests that R&D spending has a positive impact on productivity in China's manufacturing sector. In a recent study, Sheng and Song (2013) re-estimated the total factor productivity (TFP) of firms in China's iron and steel industry.

[4] Crompton and Wu (2005) used a vector autoregression model to investigate the energy consumption in China. Their work suggests that demand for coal in China would increase on average by 3.3 per cent per year over the period 2004–2010.

[5] Within the context of this paper, matching involves dropping some information from the dataset so that there is a better balance between firms that conduct R&D and firms that do not. Matching tends to reduce the confounding