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Comprehensive efficiency evaluation of coal enterprises from production and pollution treatment process

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ABSTRACT

Environmental problems caused by coal enterprises have drawn increasing attentions. In order to address this problem, in this paper, the production chain of coal enterprises is divided into production process and pollution treatment process, and accordingly a scientific input–output index system is built as well. In addition, by using the non-radial, non-angular slacks-based measurement (SBM) model, a comprehensive assessment for the operational efficiency of 36 Chinese coal enterprises based on the data from 2006 to 2011 is presented. The production efficiency and environmental efficiency of each enterprise are measured, and the input redundancy and output deficiency of these enterprises are analyzed as well. This helps to provide scientific analysis for enterprises to make their decisions in resource utilization and environmental protection.

1. Introduction

With the gradual elimination of barriers of global trade and investment, the world has increasingly integrated into a big market. Due to the economic globalization, elemental resources flow rapidly among countries. This makes resource allocation complicated and difficult in many countries. In the global production chain, China has always been at the bottom of the industry chain and producing low value-added products with small profit margin. Meanwhile, the intensive chemical industry with heavy pollution has seriously damaged the ecological environment in China. As a result, this has been severely threatening Chinese sustainable development. Due to the weak environmental regulation, some of the developed countries have moved their polluting enterprises to China, which makes China become a shelter from polluting their own countries. This consequently deteriorates the ecological balance in China. The good news is that the world has realized the importance of the negative impacts of climate change and environment protection (Oberheitmann, 2013). The development of green economy, that is, the economic growth is separated from the increasing emissions of pollution, thus, is highly demanded (Yang, 2012). In China, the government has been gradually constructing a resource-saving and ecology-friendly society. China has made many policies and taken a lot of actions to reduce pollution.

Coal, as the major resource of energy in China, has accounted for about 70% of the primary energy in many years. Such situation will be kept for a long time. Coal industry is a basic industry in China, which is directly related to economic lifeline and energy security in China. Thus, we should pay more attention to it in order to realize the sustainable development of China. At present, because of the huge consumption of coal and less treatment on emission, coal industry is becoming a major source caused the environment pollution in China. Moreover, due to the limitation of the technology and equipment for coal utilization, a large amount of coal is used only for direct combustion, which has largely reduced the efficiency of coal utilization in China.

In order to solve these problems, this paper investigates the performance of coal enterprises and provides scientific analysis and suggestions for efficient operations of enterprises. We divide the coal production chain into production process and pollution treatment process, and then extract the input and output indexes based on the micro-data of 36 coal enterprises from 2006 to 2011. The efficiencies of coal enterprises are evaluated by using an extended data envelopment analysis (DEA) method. In addition, the input redundancy and output deficiency are analyzed accordingly, in order to provide benchmark for coal enterprises to control the cost and reduce environmental pollution as well.

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The rest of this paper is organized as follows. The related work in the literature is reviewed in Section 2. In the following section the environmental efficiency DEA model and index data are introduced. The measurement of environmental efficiency and the results of coal enterprises are analyzed in Section 4. Policy recommendations and discussions are given in Section 5, and the concluding remarks are drawn finally.

2. Literature review

In order to realize the sustainable development, many countries have paid increasing attention to environment protection. Many academics have done a lot of studies at enterprise level on energy saving and cost control, including cost control in polluting industries, technology improvement and management innovation. Altman (2001) built a behavioral model to analyze the X-efficiency and technology change of some enterprises that were related to environmental problems. The author found that enterprises with more environmental-friendly consciousness were more competitive on cost and profitability. However, it is impossible that private entrepreneurs would accept green economy policy spontaneously. Khanna and Anton (2002) discovered that responsibilities on environment, high cost of obeying the environmental rules, and pressures from market and the public were able to push enterprises to build a more comprehensive environmental management system so as to reduce the pollution emissions from production. Costantini and Crespi (2008) examined that environmental regulation was a significant source with comparative advantages. Besides, strict environmental regulation based on National Innovation System was also a vital driving force for developing energy technology. Igari et al. (2009) indicated that strict law and historical high interest rates could improve the implementation of environment protection and agricultural policy after analyzing opportunity cost and environmental protection of the industrialization of agriculture in Sao Paulo state in Brazil. After quantitatively analyzing the relationship among environment performance, environmental protection cost and national wealth, Salomaa and Watkins (2011) found that biochemical oxygen demand (BOD) was closely related to a wealth state of a country. Testa et al. (2012) carried out case study on 25 Italian constructional chemical manufacturers and 28 Irish pharmaceutical companies, and drew a conclusion that direct regulation was still the main driving force for companies to reduce industrial pollution and increase production efficiency.

The social economic problems of polluting enterprises have been widely studied as well. Jayaraman and Lanjouw (2004) put forward that strict environmental regulation might cause the termination of production and operation in small-scale companies with serious environmental pollution problems, and result in more low-income people in society. Tong (2007) studied some local government officials and company executives from six cities in China, and concluded that their concerns about environmental problems only stayed on conceptive level instead of on practical policy level. Banyte et al. (2010) discussed environmental protection problems from the perspective of consumers. The authors indicated that if the public paid more attention to environmental protection and only chose environment-friendly products, enterprises had to concern more about their social responsibility on the environment. Dong et al. (2010) analyzed the game between local governments and polluting enterprises, and elaborated their orientations by using the game theory. Dam and Scholtens (2012) studied the impact of environmental regulation in the host countries on multinational corporations with pollution problems. Although the impact was not significant, it was still a factor greatly influenced by pollution haven and resource curse.

Studies on the environmental management accounting (EMA) of polluting enterprises have also drawn intensive attention of many scholars. Jasch (2006) pointed out that environment-related cost increased continuously because of environment disclosure pressure. As the rising environmental performance might bring potential economic benefits, traditional accounting practices could not provide enough information for environmental management and decision-making analysis. Gale (2006) presented that the EMA method proposed by the United Nations Division of Sustainable Development would help the enterprises not only to carry out cost control, but also to promote clean production processes. Similarly using EMA as a tool, Burritt et al. (2009) investigated a rice processing enterprise in Philippines and addressed how to reduce the enterprise's negative influence on environment while enhancing its total efficiency at the same time. Papaspyropoulos et al. (2012) indicated that though EMA had provided some useful results to policy makers, further additional accounting system was also necessary.

Although there have been a lot of studies on environmental issues on polluting enterprises, the analysis on Chinese enterprises, especially coal enterprises, is rare. It has been found from many countries that the consensus on environmental regulation could promote the development of enterprises and countries (Hryshchenko et al., 2012). The environmental cost and competitiveness among the polluting enterprises in China have been little studied. In this paper, in order to enhance the production efficiency of coal enterprises, the operational processes of coal enterprises is divided by using the EMA method, and the environmental efficiency is measured by using the Slacks-Based Measure (SBM) model.

3. Model and data

3.1. DEA model

The data envelopment analysis (DEA) approach has already become an important method to measure the efficiency of Decision Making Units (DMUs) with multiple inputs and multiple outputs. The first DEA model was proposed by Charnes et al. (1978). Since then, some important works, such as the BCC model which is named by the first alphabet of its three authors, have been established through continuous improvement and development by many scholars (Banker et al., 1984). When using the DEA model to evaluate the production function, we firstly take production status of other economies into consideration, and then estimate and predict production output after obtaining the production efficiency of evaluation unit through comparative analysis. Fig. 1 illustrates the example firstly used in Cook and Seiford (2009). The horizontal axis "*X*" represents "input" and the vertical axis "*Y*" represents "output". In Fig. 1, it is supposed that there are 7 decision making units with single input and single output. One point signed by an

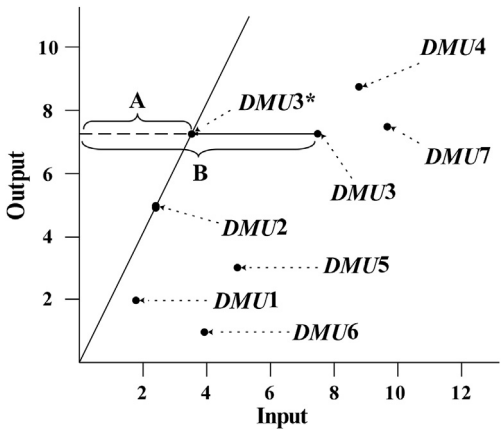

Fig. 1. One-dimensional description of production efficiency.

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