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Quota allocation of coal overcapacity reduction among provinces in China

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A B S T R A C T

Laying down fair and economically viable policies to allocate quotas of coal overcapacity reduction to provinces has drawn great attention from both governments and enterprises. In this study, the production function method and panel variable coefficient model are used to estimate the boundary production function and coal capacities of 25 coal-producing provinces. The results predict that China's coal overcapacity will reach more than 0.803 billion tons by 2020. Then, a quota allocation model of coal overcapacity reduction among the provinces is proposed based on nonlinear programming, with the aim of minimizing the total cost of national overcapacity reduction. The results show that the total cost of national overcapacity reduction based on the optimal allocation scheme is 56.6695 billion yuan less than that based on the government allocation scheme. The Gini coefficient of the optimal allocation scheme is smaller than 0.3, indicating that this plan considers effectiveness and fairness. Furthermore, we calculate the optimal proportions for the provinces to reduce coal overcapacity based on different capacity utilizations and different national coal production control targets. The results show that the optimal proportions for most provinces are approximately the same under different conditions, which means the optimal allocation scheme is robust and efficient.

1. Introduction

China is the world's largest producer and consumer of coal. In 2015, it accounted for approximately 47% and 50% of the global total production and consumption, respectively; in addition, coal accounted for 72% of China's energy production and 64% of its energy consumption (Tang and Peng, 2017; Wu and Zhang, 2016; Yuan, 2018). However, since the 2008 global financial crisis, the coal oversupply in China has become increasingly prominent, and the problem of overcapacity has become more serious. Such problems are attributed to the combination of an economic downturn, market failure, system distortion, and energy transformation (Song et al., 2017; Sun et al., 2017; Tang et al., 2018; Wang et al., 2018). The China National Coal Association estimates that, by the end of 2016, China's coal production capacity was 5.7 billion tons, while the actual production was only 3.41 billion tons, a capacity utilization of less than 60%; moreover, under ecological constraints, China's coal production is expected to fall below 3.7 billion tons by 2020. However, it is worth noting that there is still a large number of projects under construction in the coal industry and the tendency for overcapacity is increasing. Without effective measures, China may face economic fluctuations, vicious market competition, serious resource waste, corporate profit decline, coal price distortion, environmental pollution aggravation, and other problems. Finally, the lack of such measures may also affect the healthy development of the coal industry and even of the whole national economy.

Studies show that it is difficult for market forces to make effective adjustments in a short time when the industry has serious overcapacity, so the solution to this problem relies greatly on the central administrative government's control measures (Yang and Wu, 2016). Therefore, in recent years, the Chinese government has implemented a series of measures to solve coal overcapacity.[1] In 2016, the National Development and Reform Commission (NDRC) issued the *Thirteenth Five-Year Development Plan of Coal Industry*, proposed the reduction target of 0.8 billion tons of coal capacity by 2020, and determined the subtasks of 25 provinces. However, in practice, the implementation of relevant policies and measures is not ideal, which brought about higher prices but failed to avoid the recurrence of increasingly worse overcapacity. From a regional perspective, many provinces do not actively participate in the capacity reduction, with some provinces seriously lagging. Many provinces have even adopted the superficial measure of reducing the authorized capacity to fulfill the capacity reduction goal perfunctorily. In addition, many enterprises, including some large state-owned

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[1] For example, the State Council issued *Several Opinions on Restraining Overcapacity and Redundant Construction in Some Industries and Guiding the Healthy Development* in 2009, *Guidance on Resolving Serious Contradiction of Overcapacity* in 2013, and A *Suggestion on Restraining Overcapacity and Meeting Anti-poverty and Development Goals* in March 2016.

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enterprises, may oppose controlling measures while seeming supportive of the practice. In April 2016, for example, the NDRC and National Energy Bureau jointly conducted a special inspection of 146 illegal construction of coal mines and found that although some large coal enterprises eliminated small- and medium-sized mines with a capacity of less than 600,000 t, the new coal capacity from their reconstruction or expansion of the main mines through technical transformation is much higher than the capacity reduced. In short, despite the rapid rise in coal prices since July 2016, this price change is unsustainable. From the aspect of supply and demand, there is no fundamental improvement in China's severe coal overcapacity and oversupply. With the decline of China's energy consumption intensity and, especially, the rapid development of renewable and clean energy, it is difficult for coal market demand to have absolute growth space. Therefore, the expanding supply capacity whilst contracting demand clearly indicates the significance of structural reform in China's coal industry (Yuan, 2018).

Given the serious impacts of overcapacity on the sustainable development of the coal industry, many motivated researchers in both the academia and industry have focused on coal overcapacity governance and have made great strides in the causes and mechanisms (Dagdeviren, 2016; Wang et al., 2014), measurement methods (Arfa et al., 2017; Ray, 2015), and governance policies (Goh and Effendi, 2017; Wu and Li, 2015; Zhang et al., 2016) of overcapacity. The discussion on the exit strategy of coal overcapacity mainly focused on two aspects: eliminating backward production capacity (Li and Nie, 2017) and resource integration (Cao, 2017). For example, the *Thirteenth Five-Year Development Plan of Coal Industry* has clearly set the targets of reducing of 0.8 billion of coal capacity and eliminating in 1–3 years mines with a capacity of less than 300,000 t per year, as well as mines with a capacity of less than 150,000 t per year. However, in practice, due to local officials' GDP-oriented performance evaluation, as well as to employment pressure and other factors, the closure policies for small coal mines have not been effectively implemented in some areas (Jia and Nie, 2017); moreover, some regions with a single economic structure tend to cope with the economic impact of small coal mine closures by expanding the capacity of large coal companies, which weakens the effect of such policy (Andrews-Speed et al., 2005). In addition, the merger and reorganization of coal enterprises has gradually become an important way to reduce coal overcapacity, because such merger and reorganization integrates coal resources and is conducive to enhancing mining technology and financing ability, and controlling the excessive growth of coal capacity (Zhang et al., 2011). Some scholars believe that, under local government intervention, the merger and reorganization is likely to exacerbate the coal overcapacity (Zeng et al., 2016; Zhang et al., 2017).

In other words, the Chinese government has implemented a set of measures to solve overcapacity in the coal industry from economic, environmental, technological, safety, and other perspectives. In addition, many scholars have explored the exit strategy for overcapacity. However, studies on quota allocation of coal overcapacity reduction among provinces remain limited, even though quota allocation is a key process of overcapacity governance. It would be insufficient to study the regulation strategy of overcapacity and the realization of the target only from a macroeconomic perspective. This is because China has a vast territory, and there are large differences in the economic development level, coal production conditions, industrial structures, and resource-carrying capacities among provinces (Wang et al., 2017). The economic and social development levels in the eastern region (e.g., Beijing, Shandong, Jiangsu, and other provinces) are significantly higher than those in the central and western regions (e.g., Shanxi, Gansu, the Inner Mongolia Autonomous Region, and other provinces); moreover, compared with the eastern provinces, central and western provinces depend more on the coal industry, having more employees and greater investment in fixed assets in the industry, and these factors determine the costs of coal overcapacity reduction for each province. In fact, the fundamental reason for the slow progress of overcapacity reduction in China is the high cost of production; especially, the high resettlement cost of surplus workers has seriously hindered the enthusiasm of local governments.[2] Therefore, governments at all levels are concerned about formulating an economic viable and equitable allocation scheme of coal overcapacity reduction, and such scheme is a major factor in whether China's coal overcapacity can exit smoothly. In view of this problem, from the perspective of national optimization, we build a quota allocation model of coal overcapacity reduction based on nonlinear programming, determine the minimum total cost of coal overcapacity reduction for the whole country, and propose an optimal allocation scheme of overcapacity reduction quotas for the different provinces.[3]

2. Methodology

2.1. Estimation of coal boundary production function based on panel variable coefficient model

The production function method is the most widely used method for estimating potential output. Based on the theory of economic growth, this method can reveal the relationship between inputs and outputs for the analysis of the contribution of capital, labor input, and technological progress to output. Moreover, this method requires easily accessible data (Klein and Preston, 1967). Therefore, we select the production function method to measure the potential output of the coal industry in China. The main steps of the estimation are as follows. First, the basic form of the boundary production function is determined, and the concrete form of the production function is estimated using the ordinary least square (OLS) method. Second, the difference between the observed value of the output in the sample interval and the estimated value of the corresponding average production function is calculated, and the concrete form of the boundary production function is obtained by taking the maximum value of the difference and adding it to the constant term of the average production function. Finally, the potential output is calculated according to the concrete form of the boundary production function.

Since the data used in this study's empirical analysis are panel data for 25 coal-producing provinces in China from 1986 to 2015, the model form should be set before the regression analysis. In general, the panel data model can be divided into four categories: hybrid, fixed effect, random effect, and variable coefficient models. Due to the obvious heterogeneities in coal resource endowment, economic development level, and technology level among the provinces of China, the invariant coefficient model not only fails to describe the variation of the parameters of explanatory variables over different sections or time, but also affect the validity of the model coefficient estimation. Therefore, it may overestimate or underestimate coal capacity. Hence, we adopt a panel variable coefficient model to estimate the concrete form of the coal production function.

In this study, the boundary production function is set as the most widely used Cobb-Douglas production function, and its basic form as

[2] The Chinese government has established a 70 billion yuan (RMB) resettlement fund to provide resettlement fees and subsidies to laid-off coal workers. The British Financial Times believes that, although the fund helps alleviate the societal pressure, compared with China's rising cost of living, around 55,000 yuan in laid-off subsidies per capita is obviously on the low side.

[3] The main reasons why we discuss quota allocation of overcapacity reduction on a provincial scale are as follows: firstly, since 1980, China's coal industry management system has undergone a series of changes, the current management system can be divided into the four levels known as central, provincial, municipal and county levels, in which the provincial government, as a substantive executive body of policies and regulations, plays the most important role in the process of overcapacity reduction. Secondly, with the large quantity of coal enterprises, the concentration level of China's coal industry is still very poor. In practice, it is hard for the government to allocate reduction quota to each coal enterprise. Thirdly, because the allocation model involves numerous parameters, enterprise-level data is difficult to obtain.