Dynamic analysis on market structure of China's coal industry

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ABSTRACT

According to industrial organization theory, market structure is a crucial factor to market performance. Based on the VAR model and the data from 1994 to 2014, we revealed the dynamic response route of the market structure to these factors and the change process of contribution rate of these factors to the market structure. It shows that market structure is inertial adjustment; technology advance and industry policy have continuous effects on improvement of market concentration ratio; market size and production scale have sustained negative effects on market concentration ratio; fixed capital has barrier effect, which is mainly the entry barrier effect at the beginning, and then the exit barrier effect continues to play a leading role. Therefore, the government has no need to introduce special policies to encourage merger or expansion on the capacity as enterprises would do it spontaneously; it is necessary to make market access system stricter, to improve exit compensation mechanism and to promote technological innovation; all these policies need dynamic adjustment based on the stages of economic cycle.

1. Introduction

As China's basic energy, coal plays an important role in China's economic development and national energy security. Throughout the history of China's coal industry, the market structure of low concentration has been a major obstruction for the development of the coal industry. As the state had actively developed small coal mines from the early 1980s to the middle of 1990s, state key coal mines, local state coal mines, and small coal mines of all types were accounted for 36.6%, 16.3% and 47.1% of the total output and concentration ratio of the top eight companies was only 11% (Fig. 1), belonging to decentralized competitive market structure in 1997. Since then, China coal industry has become the "small, scattered, chaotic" market structure. Since the late 1990s, low concentration brings about increasingly serious negative effects, including frequent accidents, low technology, disordered production and surplus production driven by a large number of small mines especially illegal ones. With the outbreak of the Asian financial crisis in 1997, China's coal industry was seriously threatened with massive overcapacity and a loss of 400 and 1800 million yuan respectively in 1998 and 1999. With the booming coal demand from 2002 to 2012, coal enterprises had made increased profit gradually. However, the low concentration and decentralized operation led to unordered competition, dramatically increasing coal production and enormous waste of resources, which damage the basis of the long-term development in the coal industry (Wang, 2012). At present, as China's coal market has turn into a rapidly descending channel, the excessive

competition in this market structure has generated price-cutting among coal enterprises, which in turn results in a sharp decline in coal prices and profit with the negative profit growth rate from 2012 to 2015, especially −65% in 2015. In conclusion, the market structure of low concentration has a negative effect on market performance, including lower technology and safety level and excessive competition, which in return caused dramatically increasing production in economic boom and price-cutting among coal enterprises in economic recession.

Furthermore, as the core topic in industry organization theory, there are abundant researches on the relationship between market structure and market performance. Since the hypothesis, the former depends the latter, was put forward in 1959 (Bain, 1959), the positive relationship of concentration ratio, a common indicator of market structure and market performance is verified in banking, insurance, manufacturing and so on (Rhoades, 1982; Frame and Kamerschem, 1997; Maudos, 1996; Bajtelsmit and Bouzouita, 1998; Jacquemin et al., 1980; Conyon, 1995; Gerard et al., 1999), but instability causal, non-monotone linear or negative relationship is found in a few researches (Zaralis, 1991; Yoon, 2004; Bloch, 1994). As for China's coal industry, current researches have a consensus on the benefit of higher concentration ratio to market performance. Chen and Zhou (2010) conclude this positive relationship and the profits from efficiency rather than market power by CDW. Li et al. (2007) finds that higher concentration ratio has significant and positive effect to improve the performance of profit and safety. Chen (2013) further measures the optimal concentration ratio with CR_8 of 53% based on the
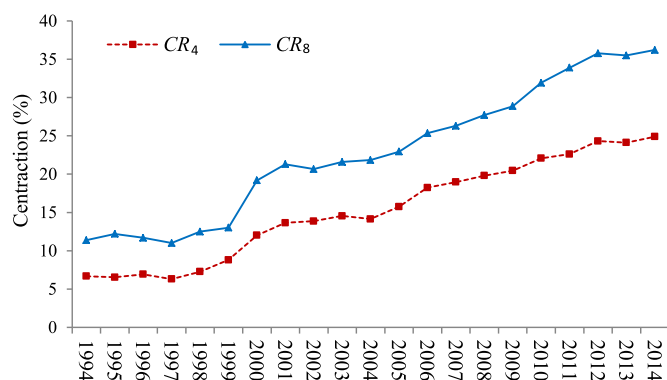
Fig. 1. China's coal market concentration ratio in 1994–2014.
Source: calculation of data from China coal industry yearbook (1982–2013) and China coal industry website (http://www.coalchina.org.cn/).

goal to meet national economic development and enterprise profit maximization, implying there is a long way to rise for China's coal market concentration due to under 40% now. These results show higher concentration is beneficial to better market performance at present and for some time in the future.

Therefore, the state issued a series of policies aimed at the promotion of market concentration and the optimization of the market structure, but the market structure of low concentration never changes. The state forced to close mines and depress output, especially small mines in 1998, and focused on large coal bases development since 2003. These policies have promoted market concentration ratio (Fig. 1), but the competitive market structure of China's coal industry still never changes. Therefore, the excessive competition caused by the market structure of low concentration is still a major barrier for the development of China's coal industry. The reasons are that existing policies mainly focus on the cultivation of large- and medium-sized coal enterprises and the close of small coal mines, but the factors of market structure is complicated, which also includes market size, barriers to entry, production scale, technical innovation level, etc. (Wang and Li, 2012; Chen, 2013). As a consequence, it is the key of the transformation from competitive to monopolistic market structure to reveal the key factors of the market structure in China's coal industry.

As for China's coal market structure, its factors studied include barriers to entry (Li and Shen, 2013; Liu and Zhou, 1998), market size (Li and He, 2000; Wang and Li, 2012), lagging concentration (Wang and Li, 2012), geographical factors (Li and He, 2000), industrial policy (Chen, 2010), etc. Methods adopted are qualitative and quantitative analysis method, such as multivariate regression and gray correlation among which the most common is multiple regression. These methods belong to the static equilibrium analysis, by which it is difficult to reveal influencing strength, functional path and dynamic contribution to the improvement of market structure at different years from each factors although it is easy to get the long-term equilibrium relationship between market structure and its factors. Thus, this limits the reference value for policy which may is implemented more uncertainly and blindly. Specifically, as policy effect changes with time, governments may enhance the efforts of implementation blindly when the policy has not yet worked fully, resulting in a drastic fluctuation in coal economy and market structure in the later year. More dangerously, the policy tends to have a more drastic fluctuation when the policy has a negative effect on the optimization of market structure in short term and a positive effect in the long term.

Furthermore, there may be endogenous and non-stationary in the model of multiple regressions, which destroys the basic hypothesis of classical linear regression model with inconsistent estimation and then affects the credibility of policy advice based on the researches (Chen, 2010). Therefore, it is an urgent need to introduce a dynamic and systematic model to study China's coal market structure to provide reference on the dynamic effects of policy.

The contribution in this article is that dynamic adjustment of market structure driven by its factors and the change of the contribution rate of its factors are revealed by impulse response function and variance decomposition and the deficiency in the multiple regression equation model effectively can be make up for by introducing VAR model (Pervukhina et al., 2014). Those results can be a support for not only the practical and feasible policy design on market structure but the dynamic adjustment of policy in strength in later stages. Therefore, the result is beneficial to the adaptation and the feedback of policies for external environmental changes and the decrease of tentative or choppy reforms, which promotes the upgrade of market structure and the growth of China's coal industry with steady steps.

2. Methodology and data

2.1. VAR model

Vector autoregressive (VAR) was adopted for following reasons. (1) The traditional structural equation describes the relationship between variables based on economic theory. However, current industrial organization theory is not enough to provide a rigorous support for the dynamic relationship between market structure and its factors, and endogenous problem may make the estimation more complex due to the probable mutual causal relationship between market structure and its factors. As a nonstructural equation model, VAR can solve the above problems by the construction of simultaneous equations including the market structure and its factors in current period and lag periods (Pervukhina et al., 2014). (2) Using VAR model, we can analyze the dynamic effect of market structure from its factors shocked by policy with impulse response function and the contribution of its factors to the change of market structure in later periods with variance decomposition.

The mathematical expression of general VAR (P) model is as follows:

$$y_t = \phi_1 y_{t-1} + \dots + \phi_p y_{t-p} + H x_t + \varepsilon_t \quad t = 1, 2, \dots, T \quad (1)$$

Where y_t is a $n*1$ vector of endogenous variables, p is the lag order, $k*k$ matrix, $\phi_1, \dots, \phi_p$, and $k*d$ matrix H are coefficient matrixes to be estimated.

We will identify a specific VAR model and test its stability after choosing reasonable variables of influencing factors, testing stationarity of each sequence and co-integration relationship and determining the lag order below.

Based on the existing results and the characteristics of China's coal industry, there are proxy variable of market structure and possible factors as follows.

(1) Market structure, measured by an indicator of market concentration ratio, CR_8. It can be calculated by dividing the raw coal production of the top eight enterprises by the total coal production in China. The reasons why raw coal production is used are as follows. ① The coal production of coal enterprises determines their market share and market power and can truly reflect their market position and competitiveness. Furthermore, with universal diversification of coal enterprises, coal production can distinguish coal section from total scope of business. ② As an popular and standard indicator in the world, CR_8 is convenient not only to measure market structure by current classification method, but compare with those of other countries (Bain, 1959).
(2) Minimum efficient scale. If the average costs down with expansion of scale, companies will continue to increase production, until the situation where average cost in long-term reaches or closes to the minimum. This scale level is also known as the minimum efficient scale, which realizes economy of scale. On the proxy variable, the average scale of enterprises is adopted instead of minimum efficient scale (Comanor and Wilson, 1967; Greer, 1971; Guth,