

Research on effectiveness of coal mine safety supervision system reform on three types of collieries in China

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Received: 30 December 2013 / Revised: 6 August 2014 / Accepted: 10 August 2014 / Published online: 31 October 2014
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Abstract Coal mine safety supervision system plays an important role in the coal mine safety management in China. However, the current supervision system is established on the basis of learning the advanced experience from other developed countries. It needs to be further improved according to national conditions. Therefore, the effectiveness of coal mine safety supervision system reform on three types of collieries are assessed by using time series analysis method based on comparative analysis of the supervision system before and after the reform in this paper. The regression results show that the structural reform is not conducive to the improvement of coal mine safety situation in the short term, but conducive significantly in the long term. Specifically, the effects in township coal mines are more significant than state-owned key coal mines in the long run, but negative effects also exist in the short term. The negative effects in state-owned key coal mines are non-significant compared with township coal mines. Moreover, the regression results are analyzed from the aspects of the closure policy of illegal small township coal mines at the end of 1998 and shortage of the new supervision system. Finally, the suggestions on improving the new supervision system are put forward based on the above analysis.

Keywords Coal mine safety supervision · Time series analysis · Structural reform · Death rate per million tonnes · Effectiveness of supervision

1 Introduction

Coal accounts for more than 70 % of China's energy. The coal-dominated energy structure is unlikely to be changed for a long period because China is rich in coal, poor in oil and gas (Wang 2006). In recent years, frequent coal mine accidents not only caused huge losses of life and property, but also had a negative influence on the society. Although the data of total accidents, death toll and death rate per million tonnes from *China Coal Industry Statistical*

Yearbook have decreased year after year (Table 1), the coal mine safety situation is still very grim compared with some developed countries. Therefore, coal mine safety remains one of the most significant outstanding problems in China (Liu et al. 2011; Li 2012). The complex mining geological condition, backward technology and equipment, insufficient skills of miners, and weak safety foundation are the fact that does not dispute for the bad coal mine safety situation in China. But coal mine safety supervision system plays a dominant role in regulating collieries and bear great responsibility for China's bad coal mine safety situation. Consequently, China began to reform fundamentally the coal mine safety management system at the end of 1999 and established a new coal mine safety supervision system which is "State Supervision, Local Regulation and Enterprise Responsibility", namely the State Administration of Coal Mine Safety and the local coal mine safety regulation department share the task of administrative enforcement on

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Table 1 Safety situation after the coal mine safety supervision system reform in China

Time	State-owned key coal mines			Local state-owned coal mines			Township coal mines		
	Output (million tonnes)	Death toll	Death rate per million tonnes (%)	Output (million tonnes)	Death toll	Death rate per million tones (%)	Output (million tonnes)	Death toll	Death rate per million tones (%)
1998	503.49	542	1.02	242.02	910	3.76	531.98	4,575	8.60
1999	512.71	572	0.92	253.89	947	3.73	360.31	4,666	12.95
2000	535.74	765	1.44	201.22	827	4.11	269.20	3,933	14.61
2001	618.57	781	1.27	254.63	1,044	4.10	245.95	3,645	14.82
2002	714.58	904	1.27	267.10	1,023	3.83	433.53	5,068	11.69
2003	814.05	892	1.07	293.67	881	3.00	612.48	4,661	7.61
2004	938.79	854	0.93	301.11	816	2.71	742.25	4,357	5.87
2005	1,024.21	984	0.93	279.41	570	2.04	792.77	4,384	5.53
2006	1,119.56	704	0.63	319.90	611	1.91	882.01	3,431	3.89
2007	1,214.91	475	0.38	318.60	411	1.29	960.26	2,900	3.02
2008	1,377.81	454	0.33	246.01	401	1.63	995.78	2,360	2.37
2009	1,526.34	580	0.38	394.25	294	0.75	1,091.92	1,757	1.61
2010	1,624.16	478	0.29	519.73	255	0.49	1,199.72	1,700	1.42
2011	1,689.11	351	0.21	549.16	231	0.42	1,259.96	1,391	1.10

coal mine safety production (Liu and Li 2013). But how was the effectiveness of the coal mine safety supervision system reform?

Many scholars at home and abroad studied the current problems of China's coal mine supervision system from different aspects to explain the high occurrence of coal mine accidents. Wright (2004) have analyzed the regulation of China's township and village collieries, they pointed out that the current regulatory policy can't solve the problem fundamentally and a targeted regulation system should be set up. A number of studies have quantitatively analyzed the effectiveness of coal mine safety supervisions (Viscusi 1979, 1986; Lewis-Back and Alford 1980; Gray and Jones 1991), and the results showed that there exist significant correlation between coal mine accidents rate and the intensity of government supervision. Chinese scholar Xiao (2009, 2010) have empirically studied the effectiveness of China's coal mine safety regulation based on VAR model, and he drew the conclusion that China's coal mine safety regulation was effective in the long run. However, there is less research on quantitative study of China's coal mine safety supervision, especially on quantitative study of the three types of collieries, and most research to date has focused on qualitative analysis. Therefore, in this paper, the effectiveness of coal mine safety supervision system reform on the three types of collieries (state-owned key coal mines, local state-owned coal mines and township coal mines) are studied by using time series analysis method.

2 Materials and methods

2.1 Comparative analysis of the supervision system before and after the reform

China's coal administrative supervision system and coal industry production system had been repeatedly changed with the characteristics of frequently separating and integrating in turn after long intervals (Yan 2009). Premier Zhou firstly put forward the policy of "safety first" in the first national coal conference in 1949 and then the Ministry of Fuel Industry was established which managed coal, electricity and oil industry. In 1953, the Technical Supervision Bureau was established which was subordinate to the Ministry of Fuel Industry, it marked the initial formation of coal mine safety management system, "administrative management, trade union supervision and labor department inspection". In July 1955, the Ministry of Coal Industry and its subordinate Safety Supervision Bureau were established by withdrawing the Ministry of Fuel Industry in the second session of the first National People's Congress. But coal mine safety supervision had not been paid enough attention in the actual coal production, especially in the period of "Great Leap Forward" and "Cultural Revolution", which was interrupted (Wang 2004). In short, the management system was the "almighty management mode" in this period.

After the Third Plenary Session of the 11th Central Committee, China's coal mine safety management entered a new stage of recovery and development, and gradually

institutionalized, it showed a change from the “almighty management mode” to “supervision management mode”. In 1983, the Ministry of Coal Industry promulgated the *Regulations of Coal Mine Safety Supervision*. In 1993, the State Council proposed the coal mine safety management system which is “enterprise responsibility, state supervision, sectional management and public surveillance” according to the development of the reform of market system and state-owned coal mining enterprises. In 1998, the organ of the State Council reformed, and the Ministry of Coal Industry was canceled and its coal mine safety work was allocated to the Safety Production Bureau of State Economic and Trade Commission.

China began to reform fundamentally the coal mine safety management system at the end of 1999. On December 30 1999, the General Office of the State Council of the People’s Republic of China promulgated the “Circular on Printing and Distributing the Implementation Plan on the Reform of Coal Mine Safety Management System” and drafted the new *Regulations of Coal Mine Safety Supervision*, and began to establish a new coal mine safety supervision system which was vertical management (Zhang 2001). In 2001, the new coal mine safety supervision system was composed of 19 provincial administration of coal mine safety bureaus and 68 sub-administration of coal mine safety offices, which was three-level and vertical supervision system included the state, province and region levels. In March 2003, the State Administration of Work Safety (the State Administration of Coal Mine Safety) became the institutions directly under the State Council and was responsible for the comprehensive management of national safety production and coal mine safety supervision. In 2005, the State Administration of Work Safety was upgraded to a ministry-level agency, and the State Administration of Coal Mine Safety was set up separately and upgraded to a vice-ministerial level agency under the State Administration of Work Safety. In 2006, the general office of the State Council promulgated “Views on the Relevant Issues about Strengthening the Coal Industry Management” and transferred the functions related to coal mine safety from the State Development and Reform Commission to the State Administration of Coal Mine Safety. Since then, China’s coal mine safety supervision was dual leadership of the State Administration of Coal Mine Safety and the local government, and mainly by the State Administration of Coal Mine Safety (Wang 2010), namely the State Administration of Coal Mine Safety and the local coal mine safety regulation departments share the task of administrative enforcement on coal mine safety production, as shown in Fig. 1.

2.2 Model design and data

The time series analysis method was used in assessing the effectiveness of many policies by many scholars, and it has

improved continuously and has been proved to have strong explanatory power on assessing the effectiveness of structural reform (Zheng and Cui 2011). The basic idea of this method is that select a continuous period data which can reflect the safety situation and design the econometric model. Firstly, the econometric model was designed as follows according to the above comparative analysis of supervision system before and after the reform.

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 D_{1t} + \beta_3 D_{2t} + e_t$$

where Y_t is the variable used to represent the annual safety situation of coal mines; X_{1t} is the time variable, also called the trend variable and used to assess the time, value from 1 to N ; D_{1t} is the dummy variable, and given the value 0 before 2,000 and 1 after 2,000; D_{2t} is the dummy variable that assess the time, and given the value 0 before 2,000 and 1, 2, 3, ... after 2,000; β_0 , β_1 , β_2 and β_3 are the regression coefficient; and e_t is the residuals.

In the above model, β_0 and β_1 represent the safety level of coal mine and variation trend respectively, namely the intercept and slope of linear regression. And β_2 and β_3 represent the effects after the structural reform in 2000. Specifically, β_2 represents level effects, namely short-term effects; and β_3 represents trend effects, namely long-term effects. Therefore, the effectiveness of the structural reform can be obtained from assessing whether β_0 and β_1 are affected or not, namely detecting the statistical significance of β_2 and β_3 . If β_2 is significantly different from 0, then the supervision system reform has a short-term effects on the improvement of coal mine safety, and vice versa. And if β_3 is significantly different from 0, then the supervision system reform has a long-term effects on the improvement of coal mine safety, and vice versa. Finally, the effectiveness of the supervision system reform on state-owned key coal mines, local state-owned coal mines and township coal mines can be obtained by using the above econometric model.

In the econometric model, the value of X_{1t} , D_{1t} and D_{2t} have been given except Y_t . There are many indicators which can represent the annual safety situation of coal mines, such as the data of annual total accidents, death, et al. However, in this paper, we selected the death rate per million tonnes as the assessment indicator for the following considerations. Firstly, death is the most serious accident consequences in coal mine production. Secondly, the death rate per million tonnes has a high correlativity with other data and can reflect other data indirectly. Thirdly, it is more generic and not be affected by other factors, such as output of coal, death toll, et al.

The data of death rate per million tonnes in state-owned key coal mines, local state-owned coal mines and township coal mines are collected from *China Coal Industry Statistical Yearbook* and the website of State Administration of

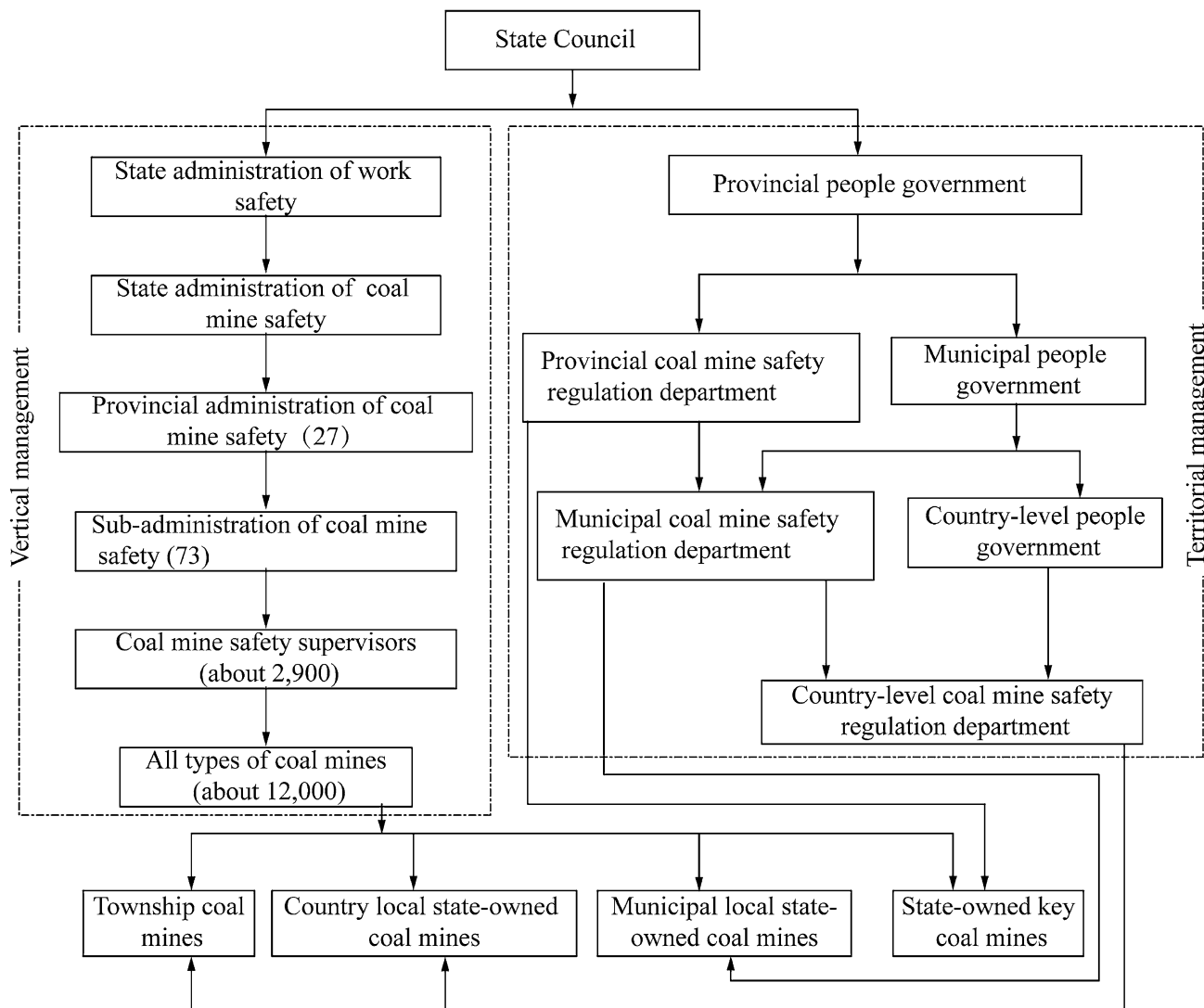


Fig. 1 Structure of coal mine safety supervisions system in China

Coal Mine Safety, and the sample interval is 1989–2011. The value of X_{1t} , D_{1t} , D_{2t} , and Y_t are shown in the following Table 2 based on the above analysis.

2.3 Empirical results

The regression coefficients of the econometric model are obtained by using the econometric analysis software EViews (Zheng and Cui 2011), and they are tested with F-test, t test, Heteroskedasticity test and Autocorrelation test. Furthermore, the model is modified continually until it passed all the tests at the significance level of 5%. Finally, the regression results of the model are sort out in Table 3.

The following results can be drawn from the Table 3.

(1) The structural reform has had a big influence on the safety situation of coal mines and its work is

effective on the whole. Specifically, the regression coefficients of C , X_{1t} , D_{1t} and D_{2t} are all significant under the significance level of 5%, and their symbols of t-stat are positive, negative, positive and negative respectively. And the results show that there are different degrees of improvement trend of safety situation in state-owned key coal mines, local state-owned coal mines and township coal mines.

(2) Coal mine safety situation in state-owned key coal mines is better than local state-owned coal mines, and local state-owned coal mines is better than township coal mines before the structural reform according to β_0 (state-owned key coal mines) $>$ β_0 (local state-owned coal mines) $>$ β_0 (township coal mines). This is correspond to actual situation that the state-owned key coal mines mostly have large production scale

and high equipment and technology level while the township coal mines mostly have small production scale, less investment and backward equipment and technology.

- (3) In the short term, the structural reform is not conducive to the improvement of coal mine safety situation, and negative effects are different in the three types of collieries. Specifically, the negative

- effects in state-owned key coal mines are non-significant compared with township coal mines.
- (4) In the long term, the structural reform is conducive significantly to the improvement of coal mine safety situation, and positive effects are also different in the three types of collieries. Specifically, the effects of the new supervision system in township coal mines are more significant than the effects in state-owned key coal mines. Therefore, the township coal mines have much room for improvement compared with the state-owned coal mines.

Table 2 Data of Y_t , X_{1t} , D_{1t} , and D_{2t} in 1989–2011

Time	Y_t			X_{1t}	D_{1t}	D_{2t}
	State-owned key coal mines	Local state-owned coal mines	Township coal mines			
1989	1.74	6.30	13.00	1	0	0
1990	1.43	5.00	12.79	2	0	0
1991	1.06	6.20	10.10	3	0	0
1992	1.01	4.50	9.20	4	0	0
1993	1.12	4.90	8.50	5	0	0
1994	1.19	4.82	8.32	6	0	0
1995	1.16	4.90	8.13	7	0	0
1996	1.17	4.02	7.70	8	0	0
1997	1.45	4.13	8.44	9	0	0
1998	1.02	3.76	8.60	10	0	0
1999	0.92	3.73	12.95	11	0	0
2000	1.44	4.11	14.61	12	1	1
2001	1.27	4.10	14.82	13	1	2
2002	1.27	3.83	11.69	14	1	3
2003	1.07	3.00	7.61	15	1	4
2004	0.93	2.71	5.87	16	1	5
2005	0.93	2.04	5.53	17	1	6
2006	0.63	1.91	3.89	18	1	7
2007	0.38	1.29	3.02	19	1	8
2008	0.33	1.63	2.37	20	1	9
2009	0.38	0.75	1.61	21	1	10
2010	0.29	0.49	1.42	22	1	11
2011	0.21	0.42	1.10	23	1	12

3 Results analyses

The regression results are mainly analyzed from the aspects of the closure policy of illegal small township coal mines at the end of 1998 and shortage of the new supervision system.

3.1 The closure policy of illegal small township coal mines at the end of 1998

The structural reform is not conducive to the improvement of coal mine safety situation in the short term, and this result can also be shown in Table 1, which the death rate per million tonnes fluctuated greatly in 1998–2002, especially in the township coal mines. This result is much more related with the closure policy of illegal small township coal mines at the end of 1998.

The closure policy has mainly brought two aspects of negative influence. Firstly, the closure of small coal mines was carried out in batches, so when a number of small coal mines was closed, other small coal mines would have a sense of crisis and then they would produce hastily and didn't pay attention to safety issues more before they were shut down, which lead to the increase of accidents. Secondly, the supply of coal decreased greatly and may

Table 3 Regression results

Explanatory variables	State-owned key coal mines			Local state-owned coal mines			Township coal mines		
	Coefficient	<i>t</i> -stat	<i>P</i> -stat	Coefficient	<i>t</i> -stat	<i>P</i> -stat	Coefficient	<i>t</i> -stat	<i>P</i> -stat
$C (\beta_0)$	1.436	13.236	0.0000	6.113	25.280	0.0000	11.177	9.109	0.0000
X_{1t}	-0.038	-2.393	0.0278	-0.227	-6.369	0.0000	-0.231	-1.274	0.0218
D_{1t}	0.549	3.815	0.0013	1.044	3.253	0.0044	6.037	3.811	0.0012
D_{2t}	-0.087	-3.858	0.0012	-0.157	-3.126	0.0058	-1.085	-4.508	0.0002
R^2	0.845			0.955			0.828		
<i>F</i> -stat	32.63			127.84			30.58		
<i>D</i> - <i>W</i> test	1.91			2.14			1.82		

even in short supply owing to closing many small coal mines, which would lead to high coal prices and profits and then many other coal mines would be possible to increase their outputs and ignore the safety issues. Many illegal small township coal mines couldn't be completely shut down. Some of them still recovered production behind closed doors, and they produced hastily and didn't pay attention to safety issues more for compensating the considerable loss in their rectification period. In short, the negative effects from the closure period and recovery period greatly lead to the safety record worsened in the short term.

3.2 The shortage of the new coal mine safety supervision system

The regression results show that the structural reform is conducive significantly to the improvement of China's coal mine safety situation in the long run and its effect is significant at the significance level of 5 %, but the goodness of fit of the data are not very good. From the aspect of the shortages of the new coal mine safety supervision system, the reasons are as follows.

- (1) The vertical supervision system has caused unclear rights and responsibilities between the State Administration of Coal Mine Safety and the local coal mine regulation departments. Because of lacking effective coordination mechanisms, the two kinds of department act of their own free will for their interests, and even some central supervision departments and local regulation departments are the one department in some areas and they undertake the function of supervision and management at the same time (Zhen 2009).
- (2) The Administration of Coal Mine Safety is short of independence and authority. In the process of law enforcement, they have no independent power of penalty and compulsory right to execution on local regulation departments' illegal enforcement or coal mines' illegal production (Xiao 2010).
- (3) The local coal mine safety regulation departments are of serious malpractice on regulating their territorial mines. The local government has great law enforcements in the coal mine safety supervision and regulation work, but in order to develop its local economy, it often ignore national interests and long-term interests and cause the prevalence of local protectionism.

In short, the above shortages of the new coal mine safety supervision system have weakened its supervision effects, and this also increased the probability of accidents to a large extent.

4 Conclusions and suggestions

In this paper, we studied the effectiveness of coal mine safety supervision system reform on state-owned key coal mines, local state-owned coal mines and township coal mines by using time series analysis method. The regression results show that the structural reform has had a big influence on the safety situation of coal mines and its work is effective on the whole. In the short term, the structural reform is not conducive to the improvement of coal mine safety situation, and negative effects are different in the three types of coal mines. Specifically, the negative effects in state-owned key coal mines are non-significant compared with township coal mines. In the long term, the structural reform is conducive significantly to the improvement of coal mine safety situation, and positive effects are also different in the three types of coal mines. Specifically, the effects of the new supervision system in township coal mines are more significant than the effects in state-owned key coal mines. Therefore, the Administration of Coal Mine Safety should take measures to perfect its supervision system on the basis of the above conclusions and analysis. (1) Ensure the independence and authority of the Administration of Coal Mine Safety, and establish effective supervision system to avoid its abuse of power at the same time; (2) avoid frequent changes of supervision organization and coordinate its relationship with the legislation departments, administration departments and justice department; (3) stabilize the policy on the township coal mines and encourage long-term legal business, and also periodically inspect the township coal mines which have passed the security acceptance; (4) weaken the beneficial relations between local government and township coal mines. The tax from the township coal mines can be mostly submitted to central government and then return to local government according to their different demands, and the rest can be used as safety fund for granting appropriate subsidies to the legitimate township coal mines.

Acknowledgments This work was supported by the National Natural Science Foundation Projects of China under Grant 71271206; and Innovation Project of Graduate Education for Jiangsu Province under Grant KYZZ_0377.

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