Analysis of Embedded Non-safety Regulation Games in China's Two Types of Coal Mines through Safety Performance Disparity, 1980-2014^{*}

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Abstracts: China has an appalling record of fatalities in its coal mining industry. Moreover, the fatalities observed in township and village coal mines (TVCMs) is much more terrible than that in state-owned coal mines (SOCMs). The safety performance of coal mines is influenced not solely by governmental safety regulation, but by their embedded non-safety regulation games with their internal and external related industries. Therefore, to better understand the safety performances disparity in SOCMs and TVCMs, an embedded non-safety regulation game analysis of the two types of mines is introduced. The paper traces China's safety records of SOCMs and TVCMs, and then analyzes their embedded non-safety regulation games respectively. The result shows that the SOCMs are mainly embedded into non-safety regulation games with the national electric power enterprises, railway sectors, and coal transportation and marketing enterprises; and the TVCMs are mainly embedded into non-safety regulation games with some local government officials and related groups (e.g. local gangdom and journalists). Moreover, in the above embedded games, the SOCMs and TVCMs are often placed in a weaker bargaining position. Besides, the SOCMs and TVCMs also play internal games on coal output and safety. Overall, the SOCMs and TVCMs are embedded into a plurality of different non-safety regulation games which, at least in part, affect their safety investment decisions differently and lead to safety performance disparity eventually.

Keywords: Non-safety regulation; Fatalities; Embedded games; Township and village coal mines; State-owned coal mines

1. Introduction

China is the largest coal producer in the world, producing an estimated 3.87 billion tonnes of coal output in 2014 (the State Administration of Coal Mine Safety, 2014). It is also the largest coal consumer in the world (Niu, 2014). According to China's *National Energy Development Strategy Plan (2014-2020)*, the coal will continue to dominate the energy strategy accounting for more than 60% of China's energy. The coal-dominated strategy is unlikely to be changed during the 13th Five-Year Plan Period (2016-2020). However, China has an appalling record of fatalities in the coal mining industry. Fatalities in Chinese coal mines account for about 70% of the global coal fatalities (Liu, et al., 2015). The frequent coal mine accidents have long been considered as one of the most significant outstanding problems in China (Liu and Li, 2014). Those accidents not only led to huge loss of lives and properties damage, but also had negative influence on society. Therefore, Chinese government reformed its coal mine safety management system between 1998

^{*} This work was supported by the National Science Foundation for Post-doctoral Scientists of China under Grant 2015M580498 and the National Natural Science Foundation Projects of China under Grant 71271206.

and 2000 (Song and Mu, 2013; Liu and Li, 2013). The outcome of the reform process was the new coal mine safety inspection system, namely “State inspection, Local regulation, and Enterprise responsibility” (Liu and Li, 2013). The State Administration of Coal Mine Safety (SACMS) and local regulation departments of coal mine safety share the task of administrative enforcement on coal enterprises’ safety production.

Although the safety performance of coal mines has improved year after year since the reform of coal mine safety management system shown in Figure 1, the improvement of different types of coal mines in China differ quite widely. The safety performance observed in township and village coal mines (TVCMs) is much more terrible than that in state-owned coal mines (SOCMs). For instance, according to the statistics from the State Administration of Coal Mine Safety (SACMS), in 2011, the number of fatalities and fatality rate per million tonnes in TVCMs are 1391 and 1.10 respectively. If we compare to SOCMs in the same period, we get 582 and 0.26 respectively. The comparison demonstrates that the fatality rate per million tonnes in TVCMs is 4.2 times higher than that in the SOCMs.

Fig.1. China’s total number of fatalities and fatality rate per million tonnes in coal mine from 1949 to 2015.

Note: The People’s Republic of China was established in 1949.

Source: China Coal Industry Statistical Yearbook (2013) and the website of the State Administration of Coal Mine Safety (SACMA).

When exploring the underlying causes of China’s appalling record of coal mine fatalities, the complicated geological condition, the backward technology and equipment, the insufficient skills of miners, the inadequate safety investment and poor safety management are all the factors that contribute to the frequency and catastrophic nature of China’s fatal coal mining accidents (Wright, 2004; Wang, 2006; Liu, et al., 2016). Furthermore, it suggests that problems with governmental coal mine safety regulatory regime might be contributing to China’s bad safety performance (Andrew, 2009; Liu and Li, 2013; Liu, et al., 2015). Scholars from China and elsewhere have studied the existing problems of China’s poor coal mine safety performance from the perspective of governmental safety regulation to explain the high incidence of accidents. Some scholars argued that coal mine safety performance, such as accident frequency and extent of injury in work place, possess obvious correlation with the strength of governmental safety regulation and that the government should strengthen the safety regulation on coal mines (Lewis-Beck and Alford, 1980; Gray and Scholz, 1993; William, 2001; Gray and Mendeloff, 2005; Lu and Shang, 2005; Xiao, et al., 2008; Liu and Li, 2013; Qin, 2013). However, some other scholars put forward objections and

argued that the governmental safety regulation is ineffective and even hinder the development of the coal industry (Viscusi, 1979; Baggs, et al., 2003; Wright, 2004). In the existing literatures, many researches have focused on the study of high incidence of accidents from the perspective of governmental safety regulation games with the government regulators, such as American's Mine Safety and Health Administration (MSHA), China's State Administration of Coal Mine Safety (SACMS) whose predecessor is the Ministry of Coal Industry (MCI), etc. (Keise, 1980; Scholz, 1991; Fu and Liu, 2007; Hu and Liu, 2008; Shen and Mei, 2010; Feng and Ma, 2011; Song and Guo, 2011; Liu and Li, 2013; Liu, et al., 2015). These studies provide a promising foundation to explain the high incidence of coal accidents. However, the safety performance of coal mines is influenced not solely by the governmental safety regulation, but, to some extent, by their embedded non-safety regulation games with their internal and external related industries. The non-safety regulation game is relative to safety regulation game. It is the games between coal mine and coal mines' internal and external related industries, such as the national electric power enterprises, railway sectors, etc. not the government regulators.

The embedded non-safety regulation games of TVCMs and SOCMS differ quite widely due to their different mine ownership, mine objectives, and coal pricing. Research is also needed to explain the above large disparity in terms of safety performance in the TVCMs and SOCMS. Therefore, to help address the gaps in the research, this paper describes the analysis of embedded non-safety regulation games in China's two types of coal mines through safety performance disparity (1980-2014). The remainder of this research is organized as follows. In Section 2, we trace China's two types of coal mines and their safety records from 1980 to 2014. In Section 3 and Section 4, we analyze the characteristics of TVCMs and SOCMS, and then explore their embedded non-safety regulation games respectively. In Section 5, we analyze the non-safety regulation games between SOCMS and TVCMs. Finally, we conclude this work in Section 6.

2. China's two types of coal mines and their safety records disparity

Reports from the State Administration of Coal Mine Safety (SACMS) reveal that within the 26 provinces, autonomous regions, and municipalities that produce coal, 15071 and 12722 coal mines were in operation in 2007 and 2008 respectively (SACMS, 2008, 2009). Although the number of mines has declined due to the closure or consolidation of some small mines, these numbers are perhaps the largest among the main coal producers in the world (Wang, et al., 2014).

Coal mines in China have been historically classified into SOCMS (state-owned coal mines) and TVCMs (township and village coal mines) based on their ownership, subordination, and product distribution. The SOCMS are run or managed by the state, which played a key role in China's energy supply. They have the responsibility of earning social benefits and multiple objectives from all facets of public needs and political pressures. Moreover, the state has the complete right to dominate the SOCMS and assigned an output quota (allocated coal) to the SOCMS which filled the quota and sold to the state at the fixed price (Shen, et al., 2012). The output, which beyond the allocated coal output, could be sold at free market price in the open market. Differently, the TVCMs were owned and controlled by a variety of private companies and agencies or local township and village governments. They usually have small size on coal output, but also have played a significant role in China's energy supply. Furthermore, they mostly distribute and locate in remote areas with low degree of mechanization and automation, which provide a basis for the local employment and economy development. A summary of safety

production statistics for SOCMs and TVCMs are shown in Table 1.

First, according to Table 1, the Figure 2 below demonstrates the trends of coal outputs in SOCMs and TVCMs during the period 1980 to 2014. It can be clearly seen that the coal outputs in SOCMs and TVCMs followed the same trend. In 1980, the figures stood at 515 in SOCMs and 105 in TVCMs, and moderately increased to 759 and 615 million respectively in 1996, before falling to 683 in SOCMs in 1999 and 246 in TVCMs in 2001. But after 2001, the figures began to grow markedly and continued on this upward trend. Furthermore, the coal outputs in SOCMs and TVCMs stood at 2728 and 1142 in 2014 respectively.

Second, the Figure 3 below demonstrates changes in the number of fatalities in SOCMs and TVCMs from 1980 to 2014. It is clear that the number of fatalities in SOCMs experienced a downward trend with slight fluctuation, but the figure in TVCMs fluctuated dramatically. During the period 1980 to 1982, the number of fatalities in TVCMs remained steady at around 1750, follow by a sharply rose to the peak of 5191 in 1990. The figure then fluctuated during the period 1991 to 2002 and reached the peak again in 2002, and then fell sharply over the following years. What's more, it is found that the annual number of fatalities in TVCMs is more than twice as many as that in TVCMs in the recent thirty years.

Third, if the fatalities are considered as a function of production, namely fatality rate per million tonnes, then the changes of fatality rate per million tonnes in SOCMs and TVCMs can be shown in Figure 4 below. During the period 1980 to 2014, there was a sustained decline of fatality rate per million tonnes in SOCMs from 6.59 in 1980 to 0.16 in 2014. By contrast, the figures in TVCMs fluctuated sharply. Especially in 2001, the figure peaked at 14.82, whereas that number is 2.12 in SOCMs, namely 7 times as many as that of SOCMs.

Table 1 Safety production statistics for SOCMs and TVCMs from 1980 and 2014.

Year	SOCMs			TVCMs		
	Output (million tonnes)	Number of fatalities	Fatality rate per million tonnes	Output (million tonnes)	Number of fatalities	Fatality rate per million tonnes
1980	515.27	3396	6.59	104.86	1769	16.87
1981	495.07	3311	6.68	126.56	1768	13.97
1982	520.31	3066	5.89	146.01	1739	11.91
1983	544.43	3463	6.36	170.10	1968	11.57
1984	572.34	3271	5.72	216.89	2427	11.19
1985	588.30	3274	5.56	283.98	3385	11.92
1986	607.97	2731	4.49	286.07	4005	14.00
1987	614.85	2377	3.87	313.24	4520	14.43
1988	643.62	2447	3.8	336.25	4304	12.80
1989	656.15	2451	3.73	398.00	5174	13.00
1990	673.44	2282	3.39	405.86	5191	12.79
1991	665.96	2187	3.28	418.32	4225	10.10
1992	671.83	1919	2.85	442.72	4073	9.20
1993	656.90	1941	2.95	494.47	4203	8.50
1994	649.96	1975	3.04	579.57	4822	8.32
1995	700.67	1933	2.76	591.51	4809	8.13
1996	759.27	1650	2.17	614.81	4734	7.70

1997	754.75	1926	2.55	570.50	4815	8.44
1998	700.53	1452	2.07	531.98	4575	8.60
1999	683.32	1519	2.22	360.31	4666	12.95
2000	729.97	1592	2.18	269.20	3933	14.61
2001	859.64	1825	2.12	245.95	3645	14.82
2002	981.78	1927	1.96	433.53	5068	11.69
2003	1115.39	1773	1.59	612.48	4661	7.61
2004	1255.10	1670	1.33	742.25	4357	5.87
2005	1358.55	1554	1.14	792.77	4384	5.53
2006	1449.77	1315	0.91	882.01	3431	3.89
2007	1563.16	886	0.57	960.26	2900	3.02
2008	1656.65	855	0.52	995.78	2360	2.37
2009	1920.59	874	0.45	1091.92	1757	1.61
2010	2048.61	733	0.36	1199.72	1700	1.42
2011	2238.27	582	0.26	1259.96	1391	1.10
2012	2380.16	419	0.18	1279.84	965	0.75
2013	2557.90	486	0.19	1142.10	581	0.51
2014	2728.10	440	0.16	1141.90	491	0.43

Note: The TVCMs was developed in the late of 1980s.

Source: China Coal Industry Statistical Yearbook (2012) and the website of the State Administration of Coal Mine Safety (SACMA).

Fig.2. China's coal output in two types of coal mines from 1980 to 2014.

Source: Based on Table 1.

Fig.3. China's total number of fatalities in two types of coal mines from 1980 to 2014.

Source: Based on Table 1.

Fig.4. China's fatality rate per million tonnes in two types of coal mines from 1980 to 2014.

Source: Based on Table 1.

Overall, the safety performance observed in TVCMs is much more terrible than that in SOCMs. Specifically, the TVCMs, which account for approximately one third of the total production, are responsible for over 70% of the death toll before 2013. The large disparity is impacted by various factors, such as the strength of government regulation, the mine complicated geological condition, the mine backward technology or equipment, the insufficient skills of miners, the mine inadequate safety investment and poor safety management (Wright, 2007; Andrews-Speed et al., 2005; Liu and Li, 2013). What's more, the TVCMs and SOCMs are embedded into a plurality of different non-safety regulation games which, at least in part, affect mines' safety investment decisions differently and eventually lead to safety performance disparity. Therefore, the following sections analyze the TVCMs' and SOCMs' embedded non-safety regulation games respectively to explain their safety performance disparity.

3. SOCMs' characteristics and embedded non-safety regulation games

3.1. Characteristics

The SOCMs play a key role in China's energy supply. They have the responsibility of earning social benefits and multi-objectives from all facets of public needs and political pressures. These objectives involve consideration of social stability, labor employment, regional equality, income distribution, and national sovereignty. However, the reforms that have opened China to market have had an enormous impact upon SOCMs (Wang, 2006). After the SOCMs entered the market, their backward ideas, management system, marketing methods, product mix, and staff quality were not fit the market, resulting in serious waste of labor, many redundant staff, and repeated investment which greatly increased the production costs (Zhang, et al., 2011). Moreover, although a host of SOCMs have reformed their enterprises in the name of company, they have not formed standardized corporate governance structure and converted their operation systems fundamentally. They just "change the liquid but not the drugs" -- a superficial reform.

Besides, the SOCMs have to make a trade-off between pursuing economy profit and obeying governmental safety regulations. Before 1988, much of the safety investment in SOCMs came from the state budgetary allocation. After 1988, this cash allocation disappeared and was replaced

by a so-called “maintenance charge”. Furthermore, when the coal price was gradually liberalized after 1993, the SOCMs had to compete on markets. The competition forced them to reduce production costs and increase productivity. Therefore, pressures to reduce production costs and improve productivity on the one hand and to comply with governmental safety regulations on the other were deemed contradictory under such circumstances.

In addition, the SOCMs lack economic autonomy and bargaining power for a long time. They are run by the state which has the complete right to dominate them. Specifically, there is a “two-tier pricing” system in coal industry before 2013, which consisted of two sets of prices, namely the fixed price and the market price. The market price is higher than the fixed price. Furthermore, the state assigned an output quota (allocated coal) to SOCMs which filled the quota and sold it to the state at the fixed price. To encourage the SOCMs’ coal output, any output beyond the allocated coal output could be sold at free market price on the open market. The distortion in coal sale prices reduced SOCMs’ income and profits which is not conducive to their accumulation of safety investment.

3.2. *Embedded Non-safety Regulation Games*

Due to SOCMs’ ownership, subordination, and product distribution, they are mainly embedded into three non-safety regulation games with the national electric power enterprises, railway sectors, and coal transportation and marketing enterprises respectively (Lei, et al., 1999; Yang, 2007; Bai and Wang, 2009; Dong and Xu, 2009; Li, 2009; Zhu, 2009; Song and Li, 2011; Jiang, et al., 2013; Wan, 2013; Zhang, 2013), as shown in Figure 5 below. These non-safety regulation games have a direct impact on the economic benefits of coal industry, thereby affecting the SOCMs’ safety investment.

Fig.5. The embedded non-safety regulation games of SOCMs.

(1) Game with the national electric power enterprises

In recent decades, the thermal power generation has been accounting for about 80% of the total sources of electricity in China and its consumption of coal accounted for 50% of total coal output per year (Yang et al., 2013). As the biggest coal consumer, the thermal power generation has a major impact on coal industry. In order to guarantee the sharp growth demand of power by the surging national economy, the supply of thermal coal has been relying on governments’ allocation in a way of allocated coal to SOCMs instead of market. Moreover, to meet the demands of thermal coal, the government drives down the price of thermal coal when coal is in short supply triggered by the gradual liberalization of coal market, which formed the aforementioned “two-tier pricing”

system in coal industry. The SOCMs have to sell the allocated coal to the national electric power enterprises at the fixed price which is much lower than the free market price. Meanwhile, the national electric power enterprises have a direct importance in the development of economy and society. Consequently, they can purchase coal at the low fixed price with the help of administrative ways from the government. The distortion in coal sale prices made SOCMs greatly lose money and even become bankrupt. One choice of SOCMs is to speed production to seek more output that beyond the allocated coal, which set the scene for potential risk in turn.

(2) Game with the railway sectors

Most of the coal resources in China are distributed in the inland provinces of North China and Northwest China, especially in Inner Mongolia, Shanxi, Shaanxi, and Xinjiang which account for 79.5% of the total coal resources (Song, 2013). However, a multiple of industrial centers and big coal consuming provinces are concentrated in the east and south of China. This geographical asymmetry in coal production and consumption leads to the phenomena of “west coal transported eastwards” and “north coal transported southwards”. Furthermore, for most of SOCMs located in inland provinces, the railway transportation is their primary tool for external transportation of coal. In recent decades, the railway bears most of the coal transportation of SOCMs, which accounts for more than 58% of its total freight gross (Jiang, et al., 2013). Therefore, the railway sectors directly determine the coal sale of SOCMs and play a major role in SOCMs’ access to markets. But for a long time, the railway is monopolized by the state with a serious shortage of capacity, reflected in the coal circulation process is that the railway transport capacity of coal is far behind the growth of coal needed to transport, thus becoming the “bottleneck” of restricting the development of SOCMs. So, in order to obtain the access to transport capacity, it is arduous for SOCMs to form the bargaining power in the front of monopolistic railway sectors. Conversely, the railway sectors even set rent illegally and raise the shipping cost, which affect the profit of SOCMs.

(3) Game with the coal transportation and marketing enterprises

In the industry chain of SOCMs, some local government not only has a monopoly on SOCMs but makes the mining, and coal transportation and sales operated by different enterprises, thereby causing the imparity of upstream and downstream relationship between production and marketing. According to the *Coal Law of the People’s Republic of China* (Articles 46, 47), the SOCMs have the right to sell their coal directly, and coal trading should reduce intermediate links and even cancel the unreasonable intermediate links. However, in practice, some local coal transportation and marketing enterprises possess a monopoly on their territorial coal transportation and sales, and squeeze down coal buying price from SOCMs, which gives rise to SOCMs’ reduction of profit. What’s more, when the national electric power enterprises purchase coal, their real contractor is the coal transportation and marketing enterprises not the SOCMs. Besides, there are many intermediate links in the coal trading with large rise in price, but the SOCMs benefit little. Just as the folk song goes, “mining no better than coal transportation, coal transportation no better than coal dressing, coal dressing no better than coal selling.” In a word, the SOCMs are embedded into the non-safety regulation game with the coal transportation and marketing enterprises and often be placed in a weaker bargaining position.

In conclusion, the SOCMs are mainly embedded into the non-safety regulation games with the national electric power enterprises, the railway sectors, and the coal transportation and marketing enterprises. In the above embedded games, the SOCMs are often placed in a weaker bargaining position, which affect their profit and make against safety investment and eventually, at least in

part, affect their safety performance.

4. TVCMs' characteristics and embedded non-safety regulation games

4.1. Characteristics

Before China's economic reform, coal enterprises were largely state-owned and exempted from market competition. There were few TVCMs operated by a variety of private companies and agencies. However, in the late 1980s and the early 1990s, the state encouraged all types of coal enterprises, including the private enterprises, to exploit coal resources to meet the fast growing demand for energy. As a result, the coal output of TVCMs grew drastically from 105 million tonnes in 1980 to 580 million tonnes in 1994 when the output of TVCMs accounted for 47.1% of the total coal output. However, in the late 1990s, the economic slowdown following the Asian financial crisis resulted in a dramatic drop in the demand for energy, which particularly affected the coal output. Therefore, the state launched a campaign in 1998 to shut down about 25,800 illegal and irrational TVCMs by the middle of 2000 (Shen and Andrews-Speed, 2001). During the period of 2002 through 2014, as the economy boomed, the energy demand for coal quickly recovered and the coal price soared, thereby a host of previously closed TVCMs reopened legally or illegally.

Over the last thirty years, the TVCMs no doubt played a significant role in China's fast growing economy. Besides, they provided a basis for local employment and economy development in many poor and remote areas in China. Yet at the same time they have had substantial negative impacts, such as a high fatality rate amongst miners, the terrible wastage of coal resources, and a wide range of environmental damage (Song and Mu, 2013). As an example, in 2002 a total of 6995 miners were killed in workplace, 72.5 percent of which occurred in TVCMs. Therefore, the TVCMs are the heavy disaster areas of mine accidents. A summary of safety production statistics for TVCMs are shown in Table 2.

Table 2 Safety production records of TVCMs from 1980 to 2014.

Year	Output (MT)	Output/Total output	Number of fatalities (one)	Number of fatalities/Total number of fatalities
1980	10486	16.9%	1769	34.2%
1981	12656	20.4%	1768	34.3%
1982	14601	21.9%	1739	35.7%
1983	17010	23.8%	1968	36.2%
1984	21689	27.5%	2427	42.6%
1985	28398	32.6%	3385	50.8%
1986	28607	32.0%	4005	59.5%
1987	31324	33.8%	4520	65.5%
1988	33625	34.3%	4304	63.8%
1989	39800	37.8%	5174	67.9%
1990	40586	37.6%	5191	69.5%
1991	41832	38.6%	4225	65.9%
1992	44272	39.7%	4073	68.0%
1993	49447	42.9%	4203	67.3%
1994	57957	47.1%	4822	66.6%

1995	59151	45.8%	4809	69.6%
1996	61481	44.7%	4734	71.2%
1997	57050	43.0%	4815	68.0%
1998	53198	43.2%	4575	72.6%
1999	36031	34.5%	4666	72.1%
2000	26920	26.9%	3933	67.9%
2001	24595	22.2%	3645	64.3%
2002	43353	30.6%	5068	72.5%
2003	61248	35.4%	4661	72.4%
2004	74225	37.2%	4357	72.3%
2005	79277	36.9%	4384	73.8%
2006	88201	37.8%	3431	72.3%
2007	96026	38.1%	2900	76.6%
2008	99578	36.2%	2360	73.4%
2009	109192	36.2%	1757	66.8%
2010	119972	36.9%	1700	69.9%
2011	125996	36.0%	1391	70.5%
2012	1279.84	35.0%	965	69.7%
2013	1142.10	30.9%	581	54.7%
2014	1141.90	29.5%	491	52.7%

Note: The TVCMs was developed in the late of 1980s.

Source: China Coal Industry Statistical Yearbook (2012) and the website of the State Administration of Coal Mine Safety (SACMA).

The TVCMs mostly widely distributed and located in remote poor areas, which increases the difficulty of governmental safety regulation. It is also relatively more expensive for TVCMs to comply with governmental safety regulations than SOCMs. In this sense, they small size does not allow them to make the same efforts in improving occupational safety as SOCMs. They invariably skimp on their safety standards and worker training. Besides, there are many migrant workers with low education who have transferred from agriculture. The low level of safety consciousness among migrant workers in TVCMs does make some contribution to high accident rate. Moreover, because of the paramount role of TVCMs in local economic development, especially in areas with few other sources of income, powerful forces work for the survival of unsafe small mines. The problem of safety in TVCMs will not be solved until China's rural population has other, better and safer, ways to increase their family incomes so that they have the option to refuse to risk their lives (Wright, 2004).

Furthermore, the TVCMs are the “life-blood” in remote underdeveloped areas and were closely linked to local governments, which result in the prevalence of local protectionism. The county or township level cadres often tolerate the illegal reopening of mines, or even give licenses to mines that do not meet the criteria. Moreover, a host of illegal TVCMs in remote areas run through a system of corruption and local officials even held shares in them. In short, the bribery, corruption, and the networks of local protectionism that permeate TVCMs lie behind much of their appalling record of fatalities. What make things worse is that the government policy towards TVCMs has swung between encouraging when there is a supply shortage and suppressing in time of

over-supply (Wright, 2007; Andrews-Speed et al., 2005). The policy uncertainties discourage TVCMs from taking on long-term investments but encourage them to embrace some short-term rent-seeking behaviors as they do not know how long they can produce before they are forced to shut down.

4.2. Embedded Non-safety Regulation Games

The TVCMs are invested by township collective or private agencies, whose production of coal are mainly sold at free market price on the open market. They basically adopted contract system, contracted and operated by individuals. Therefore, the TVCMs, unlike the SOCMS, are mainly embedded into the non-safety regulation games with some local government officials and related groups (e.g. local gangdom and journalists) (Zhang, 2010; Feng, 2014).

(1) Game with local government officials

The TVCMs are embedded into the non-safety regulation game with local government officials. Firstly, there are multiple of principal-agent levels between TVCMs and central government (Andrews-Speed, et al., 2003; Xiao and Zhao, 2009; Cao, et al., 2011). As an example, a mine owner from TVCMs concentrated area said, “coal production and sales in TVCMs are nothing compared to making dealings with a host of charge departments, and a legitimate mine may be managed by more than a dozen governmental departments”. Moreover, the TVCMs are usually the “life-blood” in some remote underdeveloped areas and are closely linked to local governments. Secondly, the government policy towards TVCMs swung between encouraging and suppressing. The policy uncertainties discourage TVCMs from taking on long-term investments but encourage them to embrace some short-term rent-seeking behaviors. Moreover, it is also relatively more expensive for TVCMs to comply with governmental safety regulations than SOCMS. Thirdly, due to the low acquisition cost of coal resources and huge profits in TVCMs, the mine owners could use their economic resources to seek rent and evade governmental regulation (Xu, 2007; Zhang, 2010; Zhang, et al., 2013; Feng, 2014). In sum, the TVCMs are embedded into the non-safety regulation game with local government officials, especially in the field of safety regulation.

(2) Game with some related groups

The TVCMs are also embedded into the non-safety regulation game with some related groups, such as journalists and local gangdom. In recent years, when the media become a crucial way to surveil the safety of coal mines, the journalists also become the target of bribery in TVCMs (Zhang, 2010). Some journalists who should represent the social conscience and be responsible for supervision by public opinion even join the ranks of blackmail and impose exactions on TVCMs. As an example, on January 10th, 2007, a journalist from Shanxi reporter stations of China Trade News was beaten to death in a small coal mine in Datong, Shanxi province, which dredged up some inside stories and hidden rules of the game between TVCMs and journalists. Besides the journalists, the local gangdom also game with TVCMs in some poor public order areas. The local gangdom usually extorts and blackmails the TVCMs in the name of collection protection money. In short, the TVCMs are involved in some non-safety regulation games actively or passively with the journalists and local gangdom.

In any one of the above non-safety regulation games, the TVCMs need to pay great energy and financial resources, which make TVCMs who originally possess little motive power to comply with safety regulation standards transfer these non-safety production costs by reducing their safety investment. In conclusion, the TVCMs are mainly embedded into the non-safety regulation games

with the local government officials and related groups (e.g. local gangdom and journalists). In the above embedded games, the TVCMs are often placed in a weaker bargaining position, which affect their profit and make against safety investment and eventually, at least in part, leads to their appalling safety performance.

5. Non-safety regulation games between SOCMs and TVCMs

As the regulated, the SOCMs and TVCMs also play games on their safety investment and coal output, namely they are embedded into non-safety regulation games with each other. Moreover, the games are kinds of a typical Prisoners Dilemma game. As the two sides of the games, the SOCMs and TVCMs are likely to both exist the incentives for production under unsafe conditions. And each side believes that their unilateral safety production cannot improve the whole safety performance fundamentally in the case of opposite side's production under unsafe conditions, but increase their production costs and impact their market competitiveness. Or each side believes that their unilateral illegal production will not have decisive impact on the whole safety performance in the case of opposite side's production complying with safety regulation standards. Finally, the results are the Tragedy of the Commons. The above large disparity in terms of coal mine safety performance may lie in issues of the organizational conditions, technical conditions, and societal conditions which differ quite widely in SOCMs and TVCMs.

For the SOCMs, they are run and invested by the state with scale production and high degree of mechanization and automation. Besides, they also have multiple objectives from all facets of public needs and political pressures. In contrast, the TVCMs are owned and invested mostly by a variety of private companies and agencies. They mostly widely distributed and located in remote areas with low degree of mechanization and automation. It is relatively more expensive for TVCMs to comply with safety regulation standards than SOCMs. In this sense, they small size on coal output does not allow them to make the same efforts in improving occupational safety as SOCMs. Besides, there are multiple of migrant workers with low education. Furthermore, the TVCMs are the "life-blood" in some remote underdeveloped areas where have few other sources of income. The county or township level cadres often tolerate the illegal reopening of mines, or even held shares in illegal mines. The bribery, corruption and networks of local protectionism that permeate TVCMs lie behind much of their appalling record of fatalities. What make things worse is that the government policy towards TVCMs has swung between encouraging and suppressing, which discourage TVCMs from taking on long-term investments but encourage them to overexploit coal resources as they do not know how long they can produce before they are forced to shut down. All of the above factors, to some extent, contribute to the large disparity between SOCMs and TVCMs in terms of coal mine safety performance.

6. Conclusions

With the continuous improvement of the coal mine safety inspection and regulation system, the overall situation of China's coal mine safety performance is improving noticeably, but the improvement of different types of coal mines in China differ quite widely. The safety performance such as facilities and fatality rate per million tonnes observed in TVCMs is much more terrible than that in SOCMs. The safety performance of SOCMs and TVCMs is influenced not solely by the governmental safety regulation, but, to some extent, by their embedded non-safety regulation games with some internal and external related industries. Therefore, the embedded non-safety

regulation games in China's two types of coal mines are analyzed. The result shows that the embedded non-safety regulation games of SOCMs and TVCMs differ quite widely due to their different ownership, subordination, and product distribution. Specifically, the SOCMs are mainly embedded into non-safety regulation games with the national electric power enterprises, railway sectors, and coal transportation and marketing enterprises. Differently, the TVCMs are involved in non-safety regulation games actively or passively with the local government officials and related groups (e.g. local gangdom and journalists). Moreover, in the above embedded games, the SOCMs and TVCMs are often placed in a weaker bargaining position and are always the loser of the games. Furthermore, the SOCMs and TVCMs have to pay great energy and financial resources, which causing a drop in safety investment at least in part. Besides, the SOCMs and TVCMs also play games on their coal output and safety investment. The games are kinds of a Spatial Prisoners Dilemma game and their final results are always the Tragedy of the Commons. In conclusion, the SOCMs and TVCMs not solely play the safety regulation games with the government regulators, but are embedded into a plurality of different non-safety regulation games which, at least in part, affect their safety investment decisions differently and eventually lead to safety performance disparity.

Acknowledgements

The authors gratefully acknowledge the funding support from the National Science Foundation for Post-doctoral Scientists of China under Grant 2015M580498 and the National Natural Science Foundation Projects of China under Grant 71271206, and the support of the Sustainable Minerals Institute of the University of Queensland for resources necessary to complete this research.

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