

**“Blood Coal”: A Flawed Development Strategy  
behind the Death Toll in Chinese Coal Mines**

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*For My Wife Zhengrong Song*

## Abstract

Today, China has the World's worst coal mine safety record. According to one account, the number of deaths per million ton in China is about 100 times of that of the U.S., 30 times of that of South Africa, and 10 times of that of India. Although coal mining is considered one of the most dangerous industrial occupations, the fact that fatality rate remains so high for so long (for at least two decades) suggests that something is fundamentally wrong with the Chinese coal industry.

To answer the question, "Why fatality rate remains so high for so long in Chinese coal mines", this paper studies China's industrial policy with regard to the coal industry and the impact such a policy had on economic and institutional development. We find that the decentralization development model, often credited with having successfully transitioned China out of planned economy, may be responsible for a larger share of coal mine safety problem than some other popularly accepted factors. In other words, the structural cause of coal mine disasters is a case of flawed development policy.

## Abbreviations

CDO	China Data Online (中国数据在线)
CESY	China Energy Statistical Yearbook 2004 (中国能源统计年鉴)
EIA	(U.S.) Energy Information Administration
MOC	(India) Ministry of Coal
SACMS	(China) State Administration of Coal Mine Safety (国家安全监管总局)
SDO	Singularly Disqualifying Offense (一票否决)
SOE	State-owned enterprises
TVE	Town-village enterprises
WCI	World Coal Institute

## Introduction

Coal mining has always been one of the most dangerous occupations. Even among the developed countries, mining claims a disproportional share among all types of industrial accidents (OECD 1990). Still the accident rate and death rate<sup>1</sup> in Chinese coal industry stands out among all nations. According to official statistics, China produces 35 percent of the world's coal but contribute to 80 percent of the fatal accidents of the world's coal mining industry (Congress 2005). As seen in Table 1, when compared to other major coal producers of the world, China's mining death data tells a disturbing story: not only the rate of fatal accidents in China is extraordinarily high, but they remain high in every year we have data for.

**Table 1 International comparison of coal mine fatality rates (measured by number of deaths per million ton)**

	China	USA	S. Africa	India	Germany
1990	6.1	0.07	0.24	0.28	0.54
1991	5.21	0.07	0.12	0.24	0.63
1992	4.65	0.06	0.49	0.23	0.69
1993	4.78	0.06	0.28	0.25	1.18
1994	5.15	0.05	0.15		0.75
1995	5.03	0.05	0.32		0.54
1996	4.67	0.04	0		0.48
1997	5.1	0.03	0.6	0.54	0.19
1998	5.02	0.03		0.47	0.19
1999	5.3	0.03	0	0.45	
2000	5.86		0.13	0.46	
2001	5.13		0.08	0.45	
2002	4.64	0.03		0.29	
2003	4.17			0.33	
2004	3.08			0.27	

Source: Wang, S. (2006). "Regulating Death at Coalmines: changing mode of governance in China." *Journal of Contemporary China* 15(46). 2004 data compiled from WCI, regulatory sources in China (SACSM) and India (MOC)

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<sup>1</sup> In this paper, death rate is measured by number of miners killed for every million metric tons of coal produced.

Such a consistently high level of fatality rate suggests something is fundamentally wrong with China's coal industry. In this paper, we categorize potential causes as either exogenous or endogenous to mining safety management. The exogenous factors include China's dependency on coal and the poor geological properties of Chinese coal mines. The endogenous factors include insufficient investment in production safety, lack of regulatory framework and enforcement resources and so on.

Although the exogenous factors are important as they define a perimeter for our discussion, the main focus of this paper remains at the endogenous factors, particularly those associated with institutional arrangement and policy design. We choose to do so for two reasons. First, we do not believe that the exogenous factors can explain all the differences in death rates between China and the rest of the world. For example, on average, coal mines in India are shallower and easier to extract. However, while the difference in average mine depth in China and India is significant (465 meters vs. 150 meters), the difference in death rate is staggering (10 to 1). What is more, not all Chinese coal mines have the same fatality rate. In general, the larger, state-run mines have 5-10 times better safety record than the smaller, non-state-run mines, even though some of them operate side by side. This fact further suggests that factors other than geological condition also play a large role in mining safety.

In this paper, we have identified four main actors: the central government, the local government, large state mines and small local mines.<sup>2</sup> The state mines are the legacy of the Soviet style industrialization. They are larger, better equipped, centrally managed and safer than the smaller mines. However, until recently, a large portion of their output is distributed by the central government at a lower-than-market price.<sup>3</sup> In addition, despite being reorganized as corporations, many state mines are still on the hook to provide their employees' with housing, healthcare and pension, in a way that the old "work unit"<sup>4</sup> used to.

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<sup>2</sup> Pertaining to the coal industry worldwide, there is no inherent linkage between ownership type and size of operations. It is entirely a legacy matter that in China, large coal mines are almost all owned by the state and operated by the central or provincial government. And small mines are largely owned and operated by collective, private or mixed ownership entities. In this paper, we are more interested in the size of mines than in the ownership. For convenience, and to put reference in correct context, we may use the ownership type and size interchangeably.

<sup>3</sup> This portion is called "tong pei mei" or 统配煤 in China.

<sup>4</sup> 单位

Just as the state mines are products of the 1950s, the local mines are that of the 1980s. When Deng Xiaoping initiated economic reforms in the late 1970s, the central government opened up the coal industry and encouraged local governments and collectives to enter. As a result of this policy change, the next 15 years witnessed phenomenal growth of the small local mines. In the mid 1990s, 50% of China's total coal production comes from those small mines. Today, China has more mines than the rest of the world combined. As we will describe in greater detail later, this structural change in the coal mining industry is a product of the decentralization strategy—one that the government actively pursued in order to transition China out of planned economy.

Coupled with the growth of small mines is the deepening involvement in coal mining by local governments. Once centrally managed, coal mine operations have become increasingly localized and fragmented. Complicating matters even further, since 1994 the central government has adopted a series of tax reforms that weakened local government's fiscal standing and resulted in constant, if not perpetual, budgetary shortfalls (Wong and Bird 2008). In this context, the TVE coal mines have become an important source of revenue and, to some corrupt officials, personal wealth.

We argue that, together with an adverse supply-demand condition, the decentralization strategy has created a distorted political economy that has trapped the coal mine fatality rate at a stratospheric level for decades. We believe coal mining is a capital intensive industry and safety is best served by scale and level of sophistication of mining operations. In this paper, we will examine safety and production data from China's coal industry and draw the conclusion that, to the extent local interference is a factor in high death rate, it is not as significant as the size of mining operation. However, the decentralization policy creates an incentive structure that effectively blocks industry consolidation and management centralization, thus leaving a lasting, adverse impact on coal mine safety. For the same reason, we challenge those who consider regulation the answer to the safety problem. From our research, we are convinced that, first, regulation does not work well in a fragmented industry. Secondly, some regulations are not aligned with the incentive structure created by the decentralization policy, hence are not credible.

The rest of the paper is organized as such: after the introduction, we will start our discussion with a review of literatures on China's coal industry. Coal mine safety is a very complex issue. Some study it as a workplace safety case; others use it as a case to make a broader argument. We consider the safety issue as closely related to industrial development policy, which reflects the contemporary political economy in China. Therefore, our literature review will focus on the relations between institutional design and economic development. We are particularly interested in the area of economic Federalism and decentralization development model.

The next section contains an overview of China's energy structure and the coal industry. By comparing China's natural endowment with other countries, we try to bring in some perspective on the challenges facing China's coal industry.

After the energy review, we will give a brief account of the history of China's coal industry with special attention trained to the decentralization efforts in the early 1980s. This push to decentralize coal industry significantly lowered barrier to enter the coal industry and resulted in explosive growth of small coal mines. We will show that, in the context of a transitional economy, such a policy has achieved its goal of introducing market force into the coal industry. However, it also created the safety problem we are left with today.

As mining fatalities worsened, the central government tried to regulate the industry through various disciplinary powers at its disposal. However, despite some high visibility efforts, regulation has largely failed to achieve its goal. In the section that follows, we will enlist some of the majors efforts launched by the central government, and analyze why they have been ineffective so far.

In the last section before the conclusion, we will show that some of popular notions explaining high coal deaths cannot be sustained by empirical evidence. Instead, we find stronger support linking safety performance to the scale and productivity of mines. Based on those findings, we will bring forth an alternative interpretation of institutional factors in China's coal mine disasters.

## **Research Design and Methodology**

This paper focuses on China's coal mining industry as unit of study. Given the complexity of the industry and the limited access to data from outside of China, this paper uses a mixture of comparative and investigative analysis. As different countries have vastly different natural endowments, mining history and energy consumption patterns, we use cross-country comparisons only when such comparisons are reasonable and sensible. More often, we compare the same subject across different periods because a main focus of this study is to reveal the impact of the decentralization policy on institutions and industries.

The investigative portion relies on some statistical analysis to support our arguments. Most of the data are related to industrial output and regional economy. Some of the important sources are: safety reports found in SACSM archives and economic statistics found in CDO and coal industry statistics found in CESY.

We deem the data largely reliable because they are from official sources and have been widely used. There have been cases where we found inconsistency in data. None of those cases involved data we used in this paper. However, we stand corrected if newer or cleaner sources emerge in the future.

## **Literature Review**

This paper benefits enormously from prior researches on China's coal industry by many scholars. Roughly speaking, writings on Chinese coal mine disasters may be grouped into three categories: those from the mass media, those by specialists and administrator in China and case studies by social scientists.

Inside China, there is an abundance news reports and analysis on coal mine disasters. Compared to other incidents of disaster coverage—most notably the SARS outbreak in 2003, news media in China enjoys considerable freedom in reporting on coal mine. Even official media outlets such as Xinhua news agency and People's Daily have special-topic sections dedicated to coal mine disasters. This reality can be explained by two recent developments in China. First, the

government is becoming more sophisticated in managing public opinion after crisis.<sup>5</sup> Secondly, Chinese media has undergone an existential transformation: from its party propaganda machine past, it has become a commercial industry that has acquired significant autonomy.<sup>6</sup>

The quality from media reports varies. However, what is striking is the quantity of reports and the forcefulness of opinions expressed in those reports. This observation is important to our study: because of media transparency and the public scrutiny it generates, we assume that the accounting of coal mine disaster is reasonably accurate (because there is little chance for cover-ups) and that public officials will be held accountable in high profile cases.

The opinions expressed by experts and bureaucrats are more measured and technical than those in mass media. They tend to treat coal mine disaster as a workplace safety issue. Finding solution largely means finding the gap between the normative and the actual: what are the rules on the book and why they have not been properly implemented. Occasionally, there are suggestions of policy changes, such as using insurance mechanism to compel mine owners to improve safety (李炎杰 2007).

Not surprisingly, political scientists view coal mine disasters as a case of a broader issue. Tim Wright has been following Chinese coal industry for years and has written extensively on the subject. A political economist, Wright is particularly interested in the labor movement, or the lack thereof, in Chinese coal industry. He concludes that mining safety will not improve until Chinese laborers are economically and politically empowered (2004). However, as Wright himself notes, the privately owned coal mines are the worst offenders, and many operate in pre-industrial mode: small, un-mechanized and manned by peasants. Wright fails to consider whether labor movement is even possible where coal production is fragmented and primitive.

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<sup>5</sup> In 2005, the central government issued a clear set of rules on disaster reporting. Although it contains tough sanctions against “false reporting” that resulted in “disruption of public order”, it makes rules public and thus open to contention. In our research, we have also found a spike of interest in “crisis management” in Chinese academia in recent years. A few think tanks have been established in prestigious universities to study this topic.

<sup>6</sup> For a more detailed discussion on Chinese media, please refer to (Lee 2000)

Others look beyond traditional political economic parameters and show more interest in coal mine as a case study of public governance. This is also the angle we position our study in this paper.

Apparently, the abysmal fatality rate in Chinese coal mines make it an easy case for critics of the Chinese government. They point to the government's failure to close down unsafe and illegal coal mines as an example of the state's weakening capacity to fulfill its social obligations. The "deficits" in governance, they argue, is ultimately responsible for the breakdown of public order and social welfare, a development "symptomatic of a ... predatory state" (Pei 2006).

However, many others are not ready to concede on this point. They counter that a state behaving predatorily at times is fundamentally different from a predatory state: the Chinese state is not constitutionally structured to divert public resources to benefit one entrenched class as in some African states.<sup>7</sup> Instead, many of the problems China experiences now, they suggest, stem from an imperfect political economy that has yet to shed its central planning past and to embrace a properly regulated free market.

According to their narrative, the economic reforms instituted in the late 1970s are not as much as a property ownership transfer as it is a governance transformation: the Chinese state turned from running the economy to regulating at arms length. In his authoritative study of the early reform era, Barry Naughton documents how the government drastically lowered barriers for non-state entities to enter key industries used to be dominated by SOE. Unlike what happened in Russia during the 1990s, where the economic transition was marked by wholesale auction of state assets, China adopted a gradualist approach and encouraged local collectives (at township or village level) to take over production gaps left by a retreating state-run economy.<sup>8</sup>

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<sup>7</sup> Here I am influenced by Migdal's critique of Robert Bates' work. Bates' study in "*Markets and States in Tropical Africa*" portrays a typical predatory state in which the political leaders choose to deprive the welfare of the state for their own benefits. This seemingly contradictory behavior is in fact "rational" as the political institutions are designed to reinforce the ruling class' interests, according to Bates. See (Migdal 2001; 242-246)

<sup>8</sup> For the early efforts to ease state's control on economy and to lower barriers for non-state participation, see Naughton (1995; 137-168). C. Wong's research also suggests that, beyond lowering barriers, the state played even a more active role than many assumed in the early stage of rural industrial development. For a summary of her contribution, see Whiting (2000; 40-42). For the role rural enterprises played in the post-Mao economy, see Oi (1989; 1995)

The success of China's economic reforms further stimulates discussions among social scientists as to what can be learned from China's experience. Statist theorists see China's success as yet another example of state's intervention and leadership. In her study of rural enterprises, Oi borrows the concept of corporatism, popular in the East Asian Miracle literature,<sup>9</sup> and coins the term "local state corporatism" to describe an activist state actor, albeit at local levels (Oi 1998). The notion that localized economic decision-making was key to China's economic growth is shared by a group of neo-institutionalists. Believing the protection of property rights is fundamental to a free-market economy, they advocate Federalism as a constitutional design that effectively checks on political elites' predatory instincts. Although China is not a Federalist polity, nor has it declared constitutional guarantee of property rights, the Federalist suggest that economic decentralization achieves the same effect: when central government relegate itself to relying on local governments' tax revenue, the constraint on the central government's political power is credible enough to assure market participants.<sup>10</sup>

If there were still questions in the early 1990s within China as to whether decentralization was the right strategy, the debate is largely settled today. The question now turns to how to manage the externalities resulted from rapid development. Many scholars believe those issues can be managed by expanding the state's regulatory capacity. They point to past turbulences in recent years (e.g. 1997 Asian financial crisis) as proof of Chinese state's perseverance and increased capacity to govern (Naughton and Yang 2004; Yang 2005).

China's coal industry is cited more than once as a case for improved regulation (Su 2004; Wang 2006). In general, the authors' accounts share a similar pattern: the 1980s decentralization spurred coal production. In the 1990s, a slew of problems emerged of which safety issue loomed

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<sup>9</sup> For example, Robert Wade's comprehensive study of the rise of East Asian economies—particularly that of Taiwan, cites "corporatist political arrangements have contributed to East Asia's fast growth" (Wade 1992; Ch. 10)

<sup>10</sup> The most prominent Federalist advocate is Barry R. Weingast. In a series of articles in the mid-1990s, he laid the theoretical ground work for the "market preserving Federalism" (Weingast 1995). Subsequent work by Montinola et al further refines its application in Chinese economic reform. Acknowledging that the local-central relationship in China is quite different from Federalism in the West, the authors coin the term "Federalism, Chinese style" to capture the uniqueness of the Chinese system (Montinola, Qian et al. 1996). In addition, there is a rich literature on this subject. For a review of different branches within this school of thoughts, see a comprehensive review by Zheng Yongnian (2005).

large. Subsequently, the central government initiated a series of regulatory changes that clearly demonstrate the maturity and determination of the administrators.

However, as we will show later, our research has found abundant evidence that cast doubts on their conclusions. For example, Su claims that the problem of overproduction from local mines is largely under control. However, as Wright points out in his review of Su's work (2005), Su may be too ready to accept official accounts from the Chinese government. The actual coal output as calculated by independent sources tells a very different story.

As to Wang's confidence in "China's transition from state socialism has ... [resulted] in a new regulatory state which exerts controls over a wide range of economic and social affairs via standard setting, supervision, monitoring, and enforcement", we think he may be overly optimistic as far as coal mine safety is concerned: although most of the regulatory initiatives started in the 1990s, ten years or more later, the death rates in coal mines have yet to improve qualitatively.<sup>11</sup>

So why have the regulations not worked? Is it really because the state cannot mobilize sufficient political support? Or is the state losing its credibility to deter undesired behaviors? We do not believe one can parlay the failed safety efforts in the coal industry into such generalized assertions. After all, the Chinese government has a track record of successful campaigns in many other areas.<sup>12</sup>

The reason that regulatory efforts have been largely ineffective, we believe, is that the decentralization policy has created a fragmented production base. What makes the situation so difficult to change is, first, fragmentation slows productivity growth, worsens the supply-demand dynamics and leaves little room for fundamental industry restructuring. Second, local mines have

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<sup>11</sup> For example, in 1994 China's death rate (measured by number of fatalities per million ton of production) is 7 times higher than that of India. Ten years later, the same rate is 50% lower in China, but it is actually 12 times that of India in the same year.

<sup>12</sup> Some of the success stories include: the anti-smuggling efforts in the late 1990s and the banking reform in the 2000s (Yang 2005); the anti-inflationary measures (Huang 1996); and improved safety records in the airline industry (PASZTOR 2007).

become an important source of revenue for local governments, who are reluctant to relinquish control.

What we like to emphasize is, today's fragmented coal industry did not come about by itself. It is the product of a development strategy that worked so successfully in many other industries in China. However, the coal industry has its own logic and the decentralization policy proves to be a mismatch. We further argue that, as the coal safety case illustrates, once a flawed development strategy takes hold, it can interact with other factors to create a self-reinforcing eco-system that is extremely resistant to change—even with all the regulatory power a state has at its disposal.

We will start by examining the larger economic context the decentralization policy operates within. Although some factors are exogenous to coal mine safety management, they are nevertheless important for us to understand the evolution of the coal industry and its current predicament.

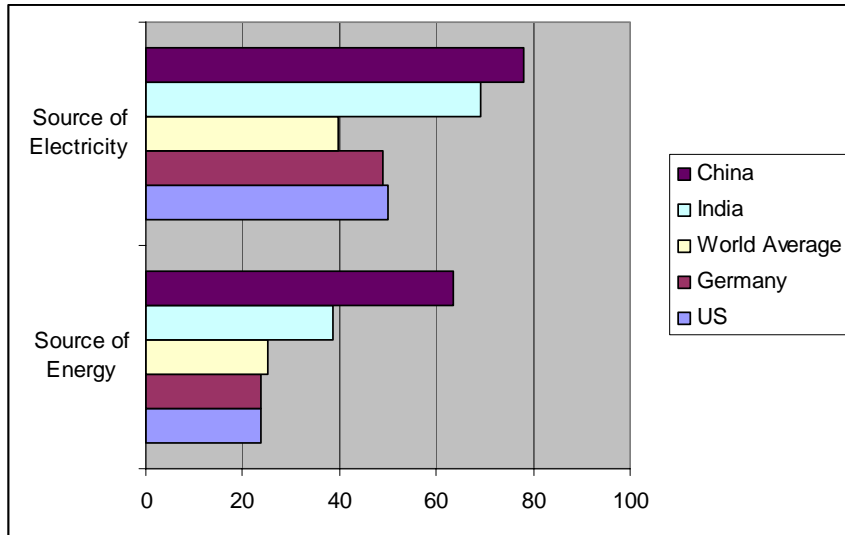
## **Coal as a Critical Source of Energy**

To put it simply, in the near term, coal is the only viable source that can meet China's needs of economic growth and energy security. However, when compared to other major coal producing regions, Chinese coal deposits are deeper, thinner and harder to extract.

China has a long history of coal mining. Today, even as China is investing heavily in other energy sources, such as oil and gas, coal is still China's most important fuel. As measured by coal's share in energy consumption and electricity generation, China is more dependent on coal than other major economies and coal producers (see Figure 1). In recent years, China's robust economic growth adds even higher demand pressure on coal production, and the production can barely keep pace. Between 2001 and 2006, China's total coal output grew by an average of 12% annually, making the country the world's largest coal producer by a wide margin (the second largest, the U.S., produces only at 50% of China's level). Yet even at this pace and scale, production still lags behind consumption: since early 2007, China has become a net coal importer. It remains to be seen, however, how much relief China can find on the world's coal market. As oil and gas prices surging in recent month, more and more countries are turning to

coal as a viable source of energy (ROSENTHAL 2008). In the end, China may have to turn inward to squeeze out more supply.

**Figure 1 Coal’s weight in total energy consumption: China and other countries**



*Sources: Compiled from online sources from WCI, an industry trade group and United Nations Development Programme (WCI 2006; UNDP 2008)*

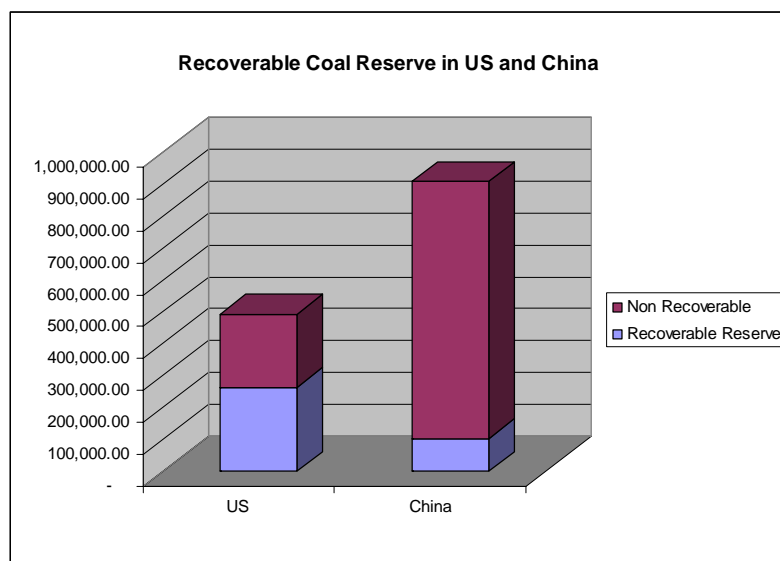
Besides the pressure from the energy demand, the makeup of energy supply also tilts toward a coal-dependent economy. First of all, compared to oil and natural gas, China claims a much larger share of the world’s coal reserve (11.6% versus 1.3% for oil and gas).<sup>13</sup> Secondly, China’s entire industrial infrastructure is built for a coal-based economy. For example, nearly 80% of electricity generation comes from coal and forty-five percent of China’s national railway capacity is utilized for coal transportation (Lester and Steinfeld 2007). Such an infrastructure in turn makes coal mining more cost-effective than oil and gas exploration. This effect can be seen by comparing marginal return on investment in the two energy sources: for every additional yuan invested in fixed assets, return from coal (in terms of energy generated) is almost five times as high as that from oil and gas (see Figure 7 in Appendix).

Even as China’s reliance on coal tightens while its economy grows in double-digits year after year, mining production is severely complicated by the poor geological properties associated with a large share of Chinese coal mines. For example, the average depth of Chinese coal mines

<sup>13</sup> Data compiled from EIA online database. Visit: <http://www.eia.doe.gov/>

is 465 meters while India's mines average between 150-200 meters.<sup>14</sup> As seen in Figure 2, while China's proven coal reserve is 85% higher than that of the U.S., only 11.25% of it is considered recoverable (the rest is either too dangerous or not economically profitable to extract), compared to 53.71% the U.S.<sup>15</sup>

**Figure 2 Recoverable coal reserve: the U.S. and China**



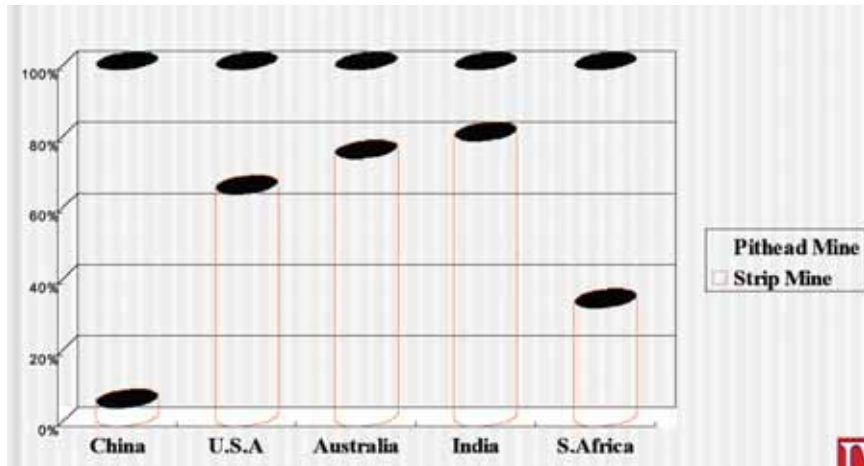
Source: Compiled from EIA online database (<http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html>, accessed on May 15, 2008)

One indicator of the accessibility of a country's coal reserves is the portion of surface mining in coal production. Surface mining allows greater mechanization, eliminates the risk of methane explosion and is therefore much safer than underground mining. In this regard, China has the lowest percentage of strip mining among major coal producers (a common form of surface mining) at below ten percent, while the U.S. is above sixty percent and India eighty percent (see Figure 3).

**Figure 3 Proportion of strip mining in total national output**

<sup>14</sup> Generally speaking, the deeper the coal deposit, the riskier mining becomes. Chinese data comes from (Pan 2005). India data comes (Programme 1997)

<sup>15</sup> Chinese data comes from (Pan 2005). India data comes (Programme 1997)



Source: (Pan 2005)

The combined effects of tightening supply-demand dynamics and poor reserve properties undoubtedly present great challenge to mining safety management. Under such a condition, it is within reason to argue that only large and well capitalized mines can scale up production and build up necessary safety infrastructure. However, China’s coal industry has been purposefully structured to pursue a decentralized model. Next, we will turn to the history and the reasons behind such an industrial policy.

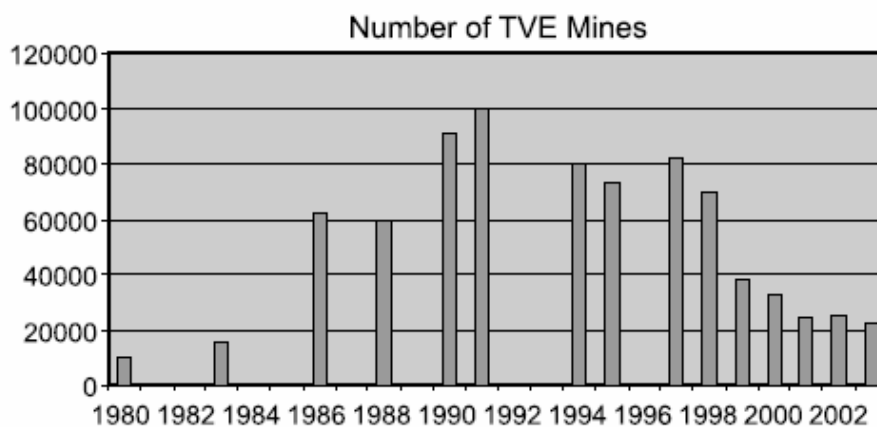
## Decentralization of the Coal Industry

Coal mining used to be dominated by state-owned enterprises. At the beginning of the planned economy (circa 1953), Mao’s government adopted an industrialization strategy modeled after that of the Soviet Union. Investment poured into heavy industries where energy consumption was the highest. Before a petroleum industry came online in the 1970, coal was almost the only source of energy that fueled the economy, reaching 90% of total consumption at times (Pan 2000). Consequently, the state played an outsized role in the growth of the coal industry. Between 1953 and 1968, state funding accounted for 90% of industry investment. And output from state-owned mines accounted for 95% of total production as late as the 1970s (Pan 2000; Wang 2006).

Entering 1980s, soon after Deng Xiaoping launched the economic reforms, the coal industry underwent a significant structural change. Departing from the long-held state-dominant model,

the central government actively encouraged the participation of non-state actors in coal mining. Following a dip in coal output during 1979-81, the State Council issued a series of directives that set policy guidance for expanding coal production by non-state enterprises. Simply known as the policy of “bringing out the water faster”,<sup>16</sup> it called on entrepreneurs from “all walks of life” to invest in coal mining (Su 2004). The government also offered generous state support through credits, subsidies, and through investing in rural infrastructure (Pan 2000). The sizes of mines and the scale of the operations were not policymakers’ top concern. In fact, in a policy directive issued in 1985, the central government further clarified its position by declaring: “state, collective and private enterprises are equally welcome. Mines of all sizes, large, medium or small, can operate side by side”<sup>17</sup> (Pan 2000; Su 2004).

**Figure 4 Number of TVE Mines**



Source: (Wang 2006)

In contrast to the boom of TVE mines, the state-owned mines suffered from various ills. The increase of coal production from the TVE mines created a surplus on the market and depressed price of coal. At the same time, the state mines were facing a crisis of its own: after years of intense (and some say wasteful) extraction, many the mines were drying up.<sup>18</sup> State enterprises

<sup>16</sup> 有水快流.

<sup>17</sup> The Chinese version of this policy is: “国家、集体、个人一齐上，大、中、小煤矿一起搞”.

<sup>18</sup> China’s coal recovery rate (a measure of extraction efficiency) is among the lowest in major coal producers in the world. Whereas the rate in the U.S. is on average above 60%, even the large state mines in China can achieve only 40%. This gap has caused great concern among industry observers and decision makers in China. However, we decide not to broach on this topic since it is not directly related to coal mine safety.

needed capital to explore new deposits, to update technologies and to improve safety infrastructure. At the same time, the SOE mines were asked to be financially independent without additional investment from the state. This meant the state-owned mines had to assume the cost of social welfare (employee housing, pension and even childcare) that once was shouldered by the state (刘飞 2004). All things considered, despite significant amount of central-directed investment around 1985, the combined effects of market condition and state policy led to a precipitous drop of output and profitability among the state mines throughout the 1990s (Su 2004; 223).

As a result, there was a qualitative shift in the makeup of the coal industry. Whereas non-state owned coal mines produced less than 4% of total output before 1980s, the share had grown to 50% by 1996. At the beginning of the 1980s, there were approximately 10,000 TVE operated coal mines. By the end of the decade, the number had increased by ten fold to 100,000 (see Figure 4).<sup>19</sup> Even after years of cutbacks, today, China has more coal mines than the rest of the world combined. As the number of TVE mines increased, however, the average size, measured by output declined.<sup>20</sup>

The structural change in coal industry during the 1980s and 1990s clearly followed the decentralization template that had been used in other industries. In many cases, decentralization proved to be a tremendous success, particularly in light industries such as food, textiles, and garments.<sup>21</sup> However, its result in the coal mining industry is mixed. Initially, the addition of non-state mines did achieve the state's economic objective. As more local governments and collectives entering the industry, output increased steadily after a period of stagnation in early 1980s and never looked back. However, the safety implication of this structural change was disheartening. Given the material, technology and human resources TVE mines could afford,

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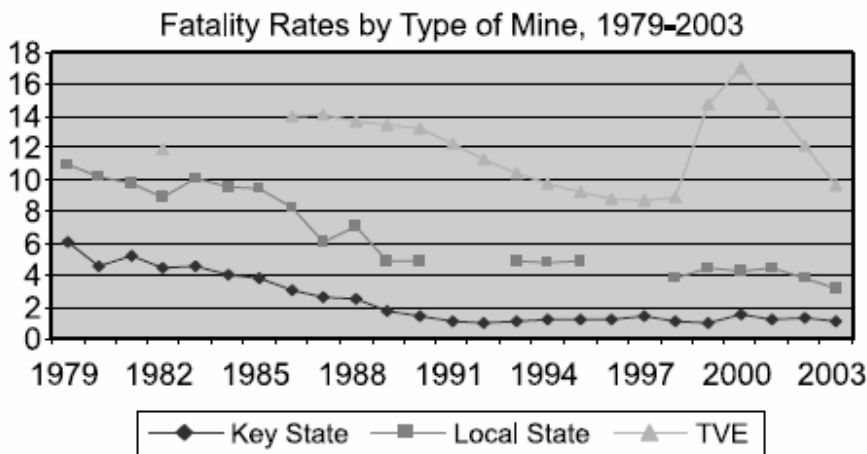
<sup>19</sup> To put things in perspective, production from small coal mines in India accounts for only about 3% of its total output. In the U.S. there are only 700 small mines, about the same number as large mines. However, the definition of a "small mine" differ from country to country. For example, in China, the size of mine is measured by its output. But in the U.S. and India, it is measured by number of employee hired. Data derived, compiled from (Chakravorty 2002; Lahiri-Dutt 2003; EIA 2007)

<sup>20</sup> According to Wang's calculation, coal production grew at an average rate of 8.8% between 1950 and 2003 (2006). But the number of mine grows by 26% annual throughout 1980s.

<sup>21</sup> Naughton has compiled a table of profit rates from 38 industries in 1980 and 1989. With a few exceptions, the profit rate dropped dramatically in a decade. Naughton uses this table to show the effect of increased competition across the board, presumably from TVE and private sector.

fatality rate was significantly higher in local mines than in state mines. As seen in the Figure 5, throughout the 1990s, the differential in fatality rates between non-state and state mines remained over 5 to 1 and briefly approached 10 to 1 in the early 2000s. In 2001, the year for which data is most reliable and complete, 90% of fatality (6045 out of 6729) came from non-state controlled mines (including locally run but nominally state owned ones). To look at it differently, had the entire output were produced by large, state-owned mines, there would have been 4671 *fewer* death.<sup>22</sup>

**Figure 5**



Source: (Wang 2006)

Clearly the central government is aware of the safety issue, for it has been trying constantly to rein in the accidents and death in the coal mines. In the next section, we will review the efforts made by the central government and assess their effectiveness.

### Central Government’s Efforts to Improve Safety

The rise of TVE and other non-state coal mines brought with it several challenges to the central government at microeconomic level. First, the sudden increase of production created a supply glut on the market, depressed newly liberalized coal price and added fresh strains to the struggling large SOE sector. Secondly, many of the local small mines were either not properly

<sup>22</sup> Using 2001 overall death rate of 5.2 per million ton, 1.59 for state mines only, and total coal output in 1,294 million ton. Sources from (Wright 2004).

registered or being operated illegally, further disrupting market and weakening state's control of the industry. Lastly, the primitive extraction methods in small mines created severe waste and safety problems (Su 2004).

In 1994, the State Council issued "TVE Coal Mine Regulations"<sup>23</sup>, setting up a high level regulatory framework. Four years later, another edict, "Notice on Some Issues Regarding Closing down of Illegal or Improperly Configured Coal Mines",<sup>24</sup> formally started the long march toward eliminating excess mines. However, ten years later, the march has yet to reach its destination: by 2010, there will still be at least 10,000 small mines (张明 2008).

The central government's drive to curb the growth of small mines is widely seen as an important component of the overall efforts to improve mining safety. In order to achieve its objective, the central government has deployed a variety of measures. Those measures generally fall into one of the following groups: legal, administrative, and (party) organizational.

In the legal arena, Chinese legislature passed or updated a series of laws that dealt with coal mine safety. SACMS' website lists a total of 19 national level laws regulating coal mine operations and safety violations. Chief among them are the Mine Safety Law (1992), The Labor Law (1995) and the Coal Law (1996). At sub-national level there are even more locally erected laws and regulations. Besides that, there are numerous directives, circulars and notices issued by all levels of government every year.

In terms of safety administration, the industry used to be managed by a hodgepodge of agencies: the state mines by Ministry of Coal and the TVE mines by Ministry of Agriculture. Within the state mines, safety inspection and enforcement were largely self-imposed and lacked common standards and independence. With the creation of SACMS in 2001, coal mine safety management became centralized and independent of production. Today, SACMS is a ministry level agency and has branch offices all the way to the county level.

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<sup>23</sup>乡镇煤矿管理条例

<sup>24</sup>关于关闭非法和布局不合理煤矿有关问题的通知

Organizational efforts include safety campaigns and personnel decisions. Safety campaigns such as “no-accident month” are largely uncoordinated, enterprise-level event. During our research, we have often come across state mining companies announcing the commencement of a campaign. But we have not found any instance of an industry-level or even provincial level campaign.

The organizational option, in the form of cadre evaluation, is a more potent disciplinary tool. Instituted at the same time as the economic reforms, cadre evaluation is considered by some as a limited form of official accountability in place of direct election. Cadres are periodically evaluated against a set of performance criteria and the results often play a big role in their career prospect (Whiting 2004). Depending on a cadre’s position and location, some criteria are more important than others: a few are called “singularly disqualifying offense” (SDO)<sup>25</sup> because when any one of those criteria is *not* met, it is enough to deny the subject’s promotion (Saich and Yang 2003). In some areas, coal mine safety has been added to the list of SDO.

Despite the all regulations and disciplinary tools, after ten years, the central government is still struggling to bring down the fatality rate (relative to the rest of the world). Even on the mine-closing front, the result is mixed to say the best. Every year, SACMS officials tout the total number of mines closed as a sign of pending final triumph. But their accounts sometimes contradict with each other, leading observers to question whether new mines are created as fast as they are being closed.<sup>26</sup>

There are many ways to explain why individual efforts might have failed. For example, given the increased number of regulations, critics point to a growing enforcement deficit: local inspection offices are understaffed (刘学勇 2007), inspectors are under-trained and underpaid (郑飞 2004). Besides, the number of mines makes enforcement a logistic challenge. Recently, SACMS has to

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<sup>25</sup>一票否决.

<sup>26</sup> For example, the latest goal from SACMS is to reduce the number of small mines from 16,000 to fewer than 10,000 in 2010. This calculation implies an average of less than 3000 mines a year. However, according to SACMS own numbers, it has been closing at least 4500 mines every year since 2005. At this pace, it will take only a year and half to achieve the reduction goal. If the numbers are to be believed, the only other explanation is that new mines are added as existing ones are being shutdown. Financial analysts found similar inconsistency from published coal output number and actual consumption. See (原国锋 and 吕苑鹃 赵银平 2007; Liu 2008; 张明 2008; 阮晓琴 2008)

deputize 100,000 frontline miners (without any training) as “special safety inspector” to help monitor their workplace (Chen 2007).

Even when SACMS discovers an unsafe mine, it does not have the authority to shut it down on the spot, as its counterpart in the U.S. does. Instead, it has to rely on the local government to carry out their decision. It is so because, like many regulatory agencies in China, SACMS agency at sub-national level is placed under dual leadership: it reports to both upper level agency and to the local government. Such a structure gives the local government the final say.<sup>27</sup> Not surprisingly, even after SACMS was promoted to ministry level in 2005, there was little substantial increase in its actual regulatory power. The head of SACMS, Li Yizhong,<sup>28</sup> calls himself a “firefighter” for he is largely relegated to cleaning up a disaster *after* it happened.<sup>29</sup>

With regard to the cadre evaluation system, its application in managing coal mine safety may be rather limited.<sup>30</sup> Mechanically, the system works best when the evaluation criteria are simple, mutually compatible and actionable (i.e. results can be measured within a few cycles of evaluations). Coal mine safety, on the other hand, is a complicated issue that takes time to materialize. In the short run, at least, it is not compatible with the goal of increased output. Because the cadre evaluation system is designed to promote growth first,<sup>31</sup> it is a poor fit for safety objectives. In fact, it may even worsen the prospect of safety improvement (Whiting 2004; 周黎安 2007).

How do we evaluate the central government’s efforts to improve coal mine safety? On the one hand, the central government is struggling to restore orders in the economy. Its efforts are designed to benefit the society as a whole, not any particular socio-political group. In this regard,

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<sup>27</sup> This combination of vertical and horizontal command structure is also known as Tiao-Kuai. It is a bureaucratic arrangement to balance the powers of the central and local government and is largely thought to have favored local interests more (Lieberthal 1997; Mertha 2005).

<sup>28</sup> 李毅中

<sup>29</sup> More than once he was moved to tears in public by the tragedy on hand, and more than once he pounded on table, screaming and pointing fingers at local officials. Yet he must be painfully aware that even if his agents decided that a mine was in violation of safety code, they still had to get the very same local officials’ permission to close it.

<sup>30</sup> So far, we have only found in two provinces (Helongjiang and Shandong) where major mining accident is listed as a singularly disqualifying offense. Between the two, only Shandong has more than two years’ history (three). Therefore, we do not have sufficient evidence to model cadre evaluation system’s impact on coal mine safety.

<sup>31</sup> At the peak of the battle against the anti-reform forces within the Party, Deng Xiaoping famously said, “Economic development is the only thing that counts!” (“发展才是硬道理 ” )

the Chinese state does not belong to the predatory group. On the other hand, it is highly questionable that the Chinese state has become an effective regulator just because it has issued so many regulations. After all, the impact of those regulations has failed to substantially lower the death rate in Chinese coal mines.

Yet it is not sufficient to offer ad hoc critiques for a problem this serious and lasted for this long. There needs to be a narrative that can make sense of all the deaths in the coal mines and of all the failed efforts. In the next section, we will discuss several versions of such a narrative offered by the Chinese central government, our critique of them, and finally, our alternative answer.

## **An Alternative View of the Cause**

Coal mine disaster, once a taboo subject in China, has been out in the open since the mid 1990s.

<sup>32</sup> SACMS frequently releases statistics and investigation reports on coal mine accidents and maintains an online database open to the public. The media is largely free to report on accidents in real time or to conduct in-depth journalistic investigations. As a result, the public is well aware of the severity of the safety problem in the coal industry. After a succession of high profile accidents in 2005, a new term, “blood coal”,<sup>33</sup> was coined by the media to capture the public outrage. As the problem persists and bad news keeps streaming in, popular anger turns into an anxious search for an answer: what went wrong? Why cannot we solve the problem?

Many narratives surfaced. A popular, if not dominant, one places the blame on corrupt local officials. The central government encourages this interpretation and seeks to reinforce this notion whenever possible. For example, Li Yizhong, the safety tsar, repeatedly said that the root cause of coal mine disasters lies in the collusion between corrupt local officials and conscienceless entrepreneurs. Media picked up the theme and framed the campaign to eradicate coal mine

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<sup>32</sup> According to a book published in China, the worst coal mine disaster in Chinese history occurred in 1960, when a dust explosion in Da Tong, Shanxi killed 684 miners. The details of the incident were kept in dossiers marked “top-secret” for three decades.

<sup>33</sup> 血煤

disaster as part of the larger struggle against corruption. The notion “where there is corruption, there is coal mine disaster” is repeated across several media outlets.<sup>34</sup>

However, after combing through coal mine disaster reports from SACMS own archive (SACMS 2008), we found the evidence unconvincing: between 2003 and 2006, there have been 46 published reports of major accidents,<sup>35</sup> resulting in at least 295 arrests. But only five of the 295 arrests involved any kind of corruption.<sup>36</sup> Given the intense media coverage and public attention, it is inconceivable that the central government would not pursue charges if corruption were indeed involved in those high profile accidents.

When we researched coal mine related corruption prosecutions by region, we also found a gap between the perception of corruption as a main cause of coal mine disasters and the dearth of prosecutions. For example, Guizhou has had the worst coal mine safety records in China for years,<sup>37</sup> but there was only one high profile prosecution related to coal mining in recent years.<sup>38</sup> This was particularly striking given that Guizhou has a solid track record of prosecuting corruption cases: in 2003 alone, over a thousand cases were opened and twelve hundred people were investigated. Among them, fifty three local officials, including a deputy governor, were convicted of criminal offense involving corruption.<sup>39</sup> In this context, if corruption were a main cause of coal mine disasters, which numbered two dozen in that year, one would expect at least some corruption prosecutions. But there was none.

Another popular explanation of why efforts to improve coal mine safety have failed is that local governments acquiesce to safety abuse because they needed the taxes generated by the private

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<sup>34</sup> For example, several large newspapers ran several articles on this theme in the summer 2005. Some of the headlines include: “Punch Hard against the Corruption behind Coal Mine Disasters” (检察日报, 2005/09/02), “Look Out for the Cashless Official-Businessman Collusion” (人民日报, 2005/08/23)

<sup>35</sup> “Major accidents” are defined as death toll greater than 10 in each instance. Some of those reports cover multiple incidents at once.

<sup>36</sup> It is difficult to unambiguously define what construct as corruption in an industry as heavily dependent on government as coal mining (e.g. getting license, receiving inspections, etc.) Here the term is used loosely—as in Chinese media—to denote any transactions outside of official sanction, including when local officials have financial stakes in the mines—a practice that is not illegal but is forbidden according to Communist Party discipline. Data source from (SACMS 2008), using accidents from 2002-2006.

<sup>37</sup> For details, see Table 3 Death toll by region in major coal mine accidents from 2001-2004

<sup>38</sup> For a detailed account of the case, see (刘文国 and 武勇 2005)

<sup>39</sup> Data compiled from multiple sources. For details, see (周以明 2003; 李楠 2003)

and collective mines. From our research, however, it appears this argument lacks empirical support and may not explain the high fatality rate.

This argument certainly has its appeal though. Since 1994 tax reform, a large portion of what used to be local tax revenues is turned over to the central government. But local governments are left with the same, if not more, social obligations (e.g. maintaining road, schools, paying for welfare payments and healthcare, etc.) as before. The intent was that the gap would be filled by inter-governmental transfers and/or rebates. In reality, however, this is not always the case. As a result, many local governments suffer from chronic budget shortfalls.<sup>40</sup> At the same time, while a local government only retains a small portion of taxes from local SOE mines,<sup>41</sup> it can levy fees and charges on locally owned mines.<sup>42</sup> Therefore, it is conceivable that a desperate local government would keep a TVE mine open at all cost, thus increase the likelihood of accidents.

Yet, when we put this hypothesis to test, we find the results unconvincing. In China, most of the coal production areas tend to be remote, mountainous and poor. Therefore, it is reasonable to assume that the more important a role coal plays in local economy, the fewer alternative sources of revenue there is available and, consequently, the stronger the temptation for the local government to interfere with mining operations, resulting in higher fatality rate.<sup>43</sup> If this were true, we ought to be able to find strong correlation between the weight of coal industry in local economy and the fatality in local coal mines. Our test uses the weight of revenue from non-state coal mines in total local industrial output as a proxy for the level of local dependency on coal. After testing with provincial level data in the years 2003 and 2004, we find the correlations in both years rather weak (<0.4).<sup>44</sup>

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<sup>40</sup> For an in-depth discussion of the 1994 tax reform and a follow-up change in 1996, see (Whiting 2000; Chap 7). Some researchers also suggest that the 2003 policy of streamlining rural agriculture tax further depletes local fiscal resources. See (Tsai 2007)

<sup>41</sup> As in any other heavily regulated economy, tax rules in China can be complicated and confusion. The original 1994 tax code dictates that the majority of taxes paid by all enterprises are shared between the central and local governments 75% to 25%. However, we learned from multiple sources that the actual rate varies quite significantly in practice. Here we can only state that local governments can retain between 10-25% of taxes from local businesses.

<sup>42</sup> In some cases, the fees and charges approach the level of tax rate. See (张晓东, 王蒲成 et al. 2004)

<sup>43</sup> Some county in Shanxi province reports that tax and fees from local coal mines counts for 60% of annual budget. See (宋宏民 and 何岗 2005; 町店镇 2008)

<sup>44</sup> For a more in-depth discussion of the calculation, please see Appendix Supplemental Material 1 Finding correlations between coal mine fatality rate and other variables.

Here we are faced with a paradox and a dilemma. The paradox is that although statistically local mines have higher fatality rate, we cannot find direct evidence to unambiguously linking local management, *per se*, to high fatality rate. The dilemma is that, despite constant efforts to regulate the coal mine industry, the combined deterrence of public campaigns, media condemnation, party discipline and legal punishment seemed powerless to stop the loss of life in coal mines. What is missing here?

Our hypothesis is that the decentralization policy is ill suited for China's coal industry. Because of the challenging geological condition and the strategic role coal plays in the economy, safety is best served by large, well capitalized and centrally managed mining operations.<sup>45</sup> To the extent that recalcitrant local corruption or mismanagement is a factor, it is the result of a decentralized strategy that fragmented the coal industry. Therefore, it is misleading to frame the coal mine safety issue as part of the political struggle between central and local governments. Instead, we argue, the safety problem in Chinese coal mines is the result of a flawed industrial policy.

Previous studies of coal industry elsewhere suggest that, when it comes to coal mine safety, the size of mines matters: controlling other factors (e.g. mining conditions, regulatory environment, etc.), the size of mine, measured in number of workers employed and total output, is negatively related to the number of fatal accidents (Andrews and Christenson 1974). Our research comes to similar conclusion with China's coal industry. In general, larger coal mines consistently have much lower fatality rate than smaller mines.

When analyzing regional data, we find the correlation between fatality rate and the average size of mines (measured by average output of the mines) in a region is consistently greater than that between fatality and the weight of local coal industry (see Table 2). In other words, the average size of local coal mines is a better indicator for safety performance than how important coal is to local economy is—an indicator we used earlier to measure the likelihood of local opportunistic

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<sup>45</sup> It is important to differentiate between “centrally managed” and “centrally owned”. We are not advocating re-nationalizing the coal industry. In fact, we are not even considering “ownership” as an independent variable, but a proxy for the size of mines. Mine ownership does not appear to be a differentiating factor in safety performance among other major coal producers in the world. For example, coal mining is fully privatized in Australia and South Africa. Russia has a mixture of state and private companies. India's coal mines are entirely state-run. All those countries have comparable safety records.

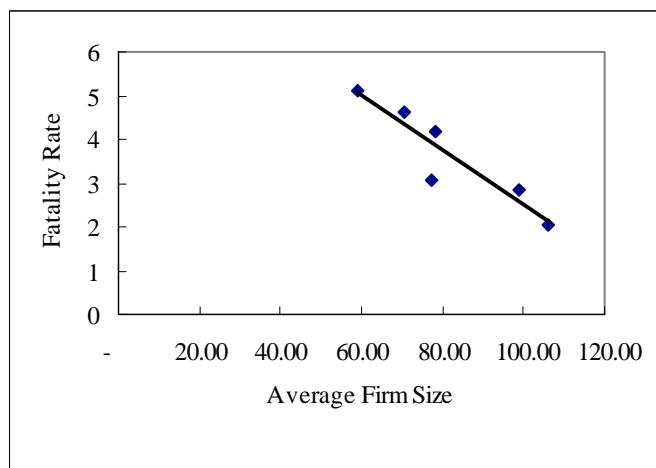
tendency. Finally, when we aggregate regional data into national average and compare them across time, we find the correlation between size average and fatality rate is very high (-0.93).

**Table 2 Correlations between fatality rate and industry weight, productivity and size: regional data from 2001-2004**

Correlation	Year	Local Dependency on Coal	Average Employee Output	Average Firm Output
Fatality Rate	2004	-0.2864	0.2951	-0.4854
	2003	-0.2711	-0.1371	-0.4880
	2002	-0.2343	-0.2348	-0.3435
	2001	-0.3077	0.0459	-0.4110

*Throughout the period, it appears that the size proxy (average firm output) has the highest correlation with fatality rate. Although the size-fatality correlation is still rather weak (only two out of four years are there moderate correlations), what is important to our discussion here is that it is consistently higher than that of the local-coal-dependency-fatality correlation. For an in-depth discussion of our analysis, including data source, assumptions and interpretations, please refer to Supplemental Material 1 Finding correlations between coal mine fatality rate and other variables.*

**Figure 6 Fitting for the relation between fatality rate and average firm size, aggregated regional data from 2001-2006**



*Source: see Table 4 National fatality rate and average firm size from 2001-2006 in Appendix. Graph generated by StatPad.*

What we have identified is a pattern that, as far as safety is concerned, large firm size is better suited for China's coal industry. Conversely, the decentralization policy creates a fragmented production base that is inherently detrimental to mining safety. What is more, decentralization

also creates strong incentives for local officials to keep production fragmented. As described earlier, because small mines are owned, operated or controlled by local governments, they become their critical source of revenue. Even without corruption involved, the budgetary shortfall leaves local decision makers no choice but to cling on their cash cow.<sup>46</sup> Recently, news reports revealed that when central government started to experiment with industry restructuring and consolidation, it encountered strong resistance from local level. Only after the central government agreed to significant fiscal concession in return did they receive local cooperation (李明三 2008; 高杨 2008).

In addition, a fragmented production base creates enormous difficulties for even the most well-intentioned regulations to function. To begin with, a fragmented industry creates information asymmetry for central regulators because they have neither the access to production information nor decision-making powers. The sheer number and diversity of local operations also make enforcement a costly affair. Put in a principal-agent framework, as the principal's monitoring capability decreases the temptation for agent's opportunistic behavior (i.e. cut corners on safety) increases—even if the seemingly severe punishment remains (Whiting 2004).

Besides the institutional reasons, the macro-economic condition further reinforces the fragmented production mode. As stated earlier, Chinese economy relies heavily on coal as major source of energy. As the economy grows at double-digit rates, it places enormous stress on supply. With the decentralization policy in place, production tends to gravitate toward involution more than evolution. In this context, involution refers to the practice of extracting more coal by adding more laborers or opening more mines, instead of through gains made from improved efficiency and productivity.

Because the decentralization policy created an environment where industry consolidation becomes untenable, it is very difficult to achieve the level of scale that is required to make coal mining safe but still profitable. As the demand pressure persists, the only option left is to replicate over and over the inefficient and unsafe operations. This vicious cycle has become

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<sup>46</sup> As noted earlier, some counties rely heavily on local coal mines to fill their budget gap. In some cases, 60% or more of local government's budget comes from coal production. See also (范思立 2006)

evident in recent years. Early this year (2008), a snow storm of historical proportion blanked a large area in Southern China. The extremely cold weather created an acute coal supply shortage. So much so that the Chinese president Hu Jintao found it necessary to spend the Chinese New Year in coal mines to personally ensure that production is at full speed (孙承斌 2008). At the same time, in a less publicized move, the central government was set to reopen nearly 10,000 coal mines previously closed or suspended for safety reasons (魏铭言 2008).

In the concluding section, we will summarize again our argument here and to discuss where future research is needed to further understand the impact the decentralization policy has on the coal industry.

## **Conclusion**

There is really no simple answer as to “why the fatality rate in Chinese coal mines remains so high for so long?” Many reasons may apply. For example, coal reserves in China are generally deeper, thinner and harder to extract than other major coal producers in the world. In the meanwhile, China is heavily dependent on coal, and the continuing economic surge will only increase such a dependency and worsen the supply-demand balance. In addition, the coal industry began its modernization stage rather late and has been plagued with technological and financial challenges. Lastly, China has a large but desperately poor labor force that is under no meaningful legal protection.

Almost every single one of the aforementioned conditions can be used to explain why Chinese coal miners face the worst safety prospects in the world. We are fully aware the significance in those factors. Nevertheless, we ask the question: given those exogenous conditions, what role does policy design play in creating a safety problem as alarming as one exists in China today?

In this paper, we reviewed some popular explanations. In the end, we are not convinced by many of them, particularly those that lay the blames squarely on local officials. Our conclusion is based on two observations: first, we cannot find unequivocal evidence to back up such a narrative, let alone to match its popularity. Secondly, the portrayal of a trusting center being

taken advantage of by conniving and recalcitrant local despots does not fit the power configuration we observe in China.<sup>47</sup>

Further analysis reveals that fatality rate in coal mines is related more closely to the average size of mines than to the likelihood of unsavory local interference. This lead us to question whether the decentralization policy initiated in the early 1980s may have created a fragmented production landscape that is now forestalling industry consolidation—a necessary condition to improve productivity and safe lives at the same time.

There is little question that in the beginning of the reform, the Chinese economy benefited greatly from a decentralized development strategy. Growing local participation in national economy eased the state out of the role of a central planner and helped to create a truly national market. However, as the economy gradually recovers from historical distortion brought by Mao's policies, it is time to re-examine whether it is still appropriate to adhere to the decentralization ideology.

Federalist political economists advocate economic decentralization not because they consider it a means to unwind tight state control, but because they are doctrinally mistrustful of the state. To those theorists, a fragmented econo-political landscape is the best check on the predatory instinct of the state. Hence, Weingast starts his thesis by calling it a “fundamental political dilemma” that a state capable of protecting is equally capable of “[confiscating] the wealth of its citizens” (1995; 1).

We consider this portrayal of the state as some kind of racketeer is unwarranted. Without engaging in a hermeneutical speculation of the nature of the state, it is suffice to say that China's struggle to curb coal mine fatality shows that a state can be tentative and re-active in the face of rapid socio-economic changes. In China's effort to tackle mining safety, the endless stream of rules, regulations, campaigns and party disciplines tells not a strong-or-weak state. But one that is constantly adjusting to the reality in order to remain relevant and credible.

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<sup>47</sup> In China today, the local officials are being blamed for almost all social ills. Surprisingly, there is little coming from academia that challenges this notion. We believe it is inherently contradictory that in a strictly top-down administration model there can exist a benign center that consistently chooses predatory peripheral leaders.

When viewed from this perspective, the decentralization development model should be transient rather than constitutional. This is perhaps best seen in the development of China's coal industry. On the one hand, coal industry is not quite a "natural monopoly" (such as gas or oil exploration) in that the barrier to entry may be lowered at the expense of high human casualty, thus making a decentralized development model workable under certain conditions. On the other hand, history as well as contemporary common practice leave no doubt that coal mining is a capital intensive industry that is most efficient and safe in an economy of scale. This is true in China too: without the state's heavy investment in the 1950s, there would not have been a coal industry today. Among major coal producing countries, the most productive and the safest ones are without exception dominated by large corporations, regardless of ownership types.

Therefore, we believe a viable solution to China's coal mine safety problem is to create a condition under which natural consolidation can occur. State's leadership and commitment is needed to secure the financial, technological and managerial resources in order for this new industry configuration to materialize. However, before any meaningful change can happen, it is imperative for the Chinese leadership to unlearn the decentralization model that used to serve them so well.

## Appendix

Figure 7 Calculating margin return on investment: coal vs. petroleum and gas

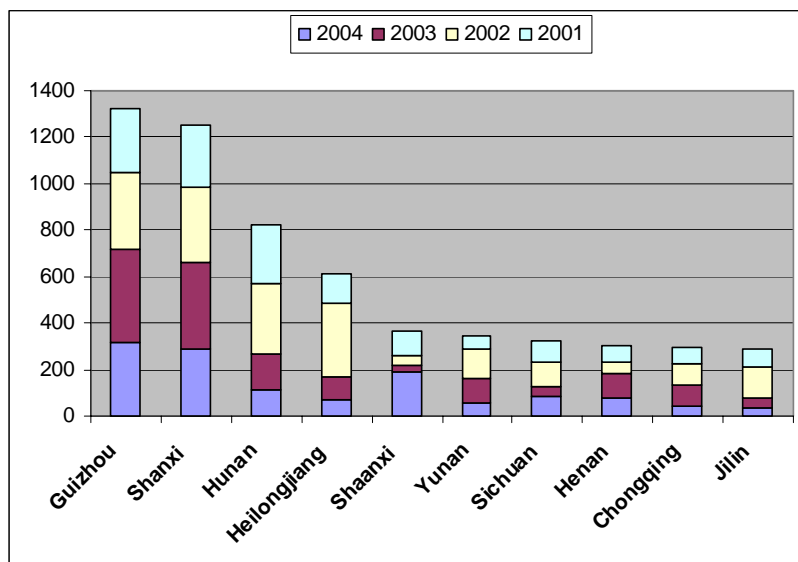
	Fixed Investment (average net, 1000 yuan)		Petro (1000 Barrels per Day)	Coal Output (Million Short Tons)	Gas Output (Billion Cubic Feet)
	Petro-Gas	Coal			
2006	495,928,271.00	417,442,224.00	3,844.90	2,620.50	1,960.00
2005	423,531,911.00	329,949,299.00	3,780.80	2,430.30	1,762.90
2004	414,945,360.00	301,382,890.00	3,657.50	2,156.40	1,439.40
2003	336,156,232.00	259,943,557.00	3,559.00	1,837.60	1,211.30

Energy measured in British thermal unit (BTU), using conversion rates:  
 1 Pound of Coal = 10,000 Btu  
 1 Cubic Foot of Natural Gas = 1,021 Btu  
 1 Barrel = 42 U.S. gallons = 5,800,000 Btu

Finding **marginal energy output per unit investment** for:  
 Coal: **129.7 BTU/yuan**  
 Petro+Gas: **26.37 BTU/yuan**

Sources: Investment data from CDO; Annual production from EIA online database  
 ([http://tonto.eia.doe.gov/country/country\\_time\\_series.cfm?fips=CH](http://tonto.eia.doe.gov/country/country_time_series.cfm?fips=CH), accessed on May 15, 2008)

Table 3 Death toll by region in major coal mine accidents from 2001-2004



Source: SACMS online accident database  
 (<http://media.chinasafety.gov.cn:8090/iSystem/shigumain.jsp>, accessed on May 2008).

**Table 4 National fatality rate and average firm size from 2001-2006**

	Fatality Rate	Firm Size
2001	5.13	58.83
2002	4.64	70.44
2003	4.17	78.35
2004	3.08	77.47
2005	2.85	98.89
2006	2.041	106.04

Source: (朱向东, *Statistics et al.* 2004; CDO 2008) Correlation resulted: -0.9289

**Supplemental Material 1 Finding correlations between coal mine fatality rate and other variables**

In order to support the exploratory hypothesis advanced in this paper, we find it necessary to find the relative relevance to coal mine fatality rate among various factors. The three factors we have chosen are: the degree in which a local economy depends on coal, the productivity of employees and the average size of coal operations.

The first variable, we call it coal's weight in local economy, is a proxy measure for the likelihood of opportunistic interference in coal production by local officials. The second variable, the productivity, is a proxy for level of mining difficulty. A higher level of productivity may signal an easier mining condition is or a higher level of mechanization. Lastly, the average size is measured by average coal output (in tonnage) per enterprise within a region on the assumption that, the larger average output, the higher level of production concentration.

Given the limited data source we have access to, we have to settle on provincial level data, instead of county level as we have hoped. To measure the weight of coal in local economy, we have excluded output from state-owned mines because those mines are not controlled by, not do they pay most of their tax to, local authorities. However, since we do not have ownership type-delineated fatality data, when we calculate productivity or size of mining firms, we do not differentiate mine ownership. Again, as we stressed earlier, we do not consider ownership type is a differentiating factor in safety record. We use ownership only to denote the size of a mine since almost all state mines are much larger than local ones.

We have also decided to use correlation as an indicator for factor relevance. Because coal mining is a very complicated operation that involves many variables, for the purpose of this paper, we are satisfied to look for correlations rather than pursuing some more ambitious goals, such as building a predictive model using regression.

Below is the data we have compiled from various sources (朱向东, *Statistics et al.* 2004; CDO 2008). This is the basis of our calculation.

2004 Regional coal mining data: safety, output, firm numbers, employment, etc.

District	Fatality	Gross Industrial Output Value (100 million yuan)	Gross Coal Output Value (all types of enterprises, at current price in 1,000 yuan)	Number of Coal Enterprises	Number of Employees in Coal Industry	Gross Sate Mine Output Value (1,000 yuan)	Total Output (10,000 tons)
Anhui		2,610.03	22,296,562.00	80	12,614,944.00	19,067,796.00	7,900.00
Beijing	10	3,810.36	12,078,198.00	34	2,667,311.00	7,755,861.00	900
Chongqing	40	1,588.00	4,355,753.00	143	2,116,668.00	932,845.00	1,800.00
Fujian	8	4,953.74	2,953,487.00	84	1,939,748.00	1,049,783.00	1,100.00
Gansu	20	1,147.52	3,817,086.00	66	2,109,894.00	815,336.00	3,100.00
Guangdong	30	21,513.46	866,201.00	33	393,397.00	-	200
Guangxi		1,436.43	1,017,641.00	20	508,177.00	918,919.00	500
Guizhou	320	977.64	6,607,458.00	231	3,147,777.00	4,663,960.00	9,800.00
Hebei	33	5,708.76	21,934,453.00	178	9,980,369.00	8,225,515.00	7,200.00
Heilongjiang	73	2,909.98	13,408,477.00	102	5,651,908.00	10,578,307.00	7,200.00
Henan	74	5,365.65	46,600,127.00	732	25,507,195.00	7,545,429.00	14,400.00
Hubei	20	4,030.11	798,712.00	56	313,846.00	138,838.00	400
Hunan	114	2,611.45	9,939,703.00	478	4,366,290.00	3,061,465.00	3,000.00
Inner Mongolia	21	1,355.70	19,661,378.00	208	10,254,127.00	10,927,982.00	17,200.00
Jiangsu	4	18,036.74	9,955,985.00	14	5,973,584.00	9,745,913.00	2,700.00
Jiangxi	61	1,472.33	4,797,952.00	119	1,969,016.00	3,537,500.00	1,200.00
Jilin	34	2,662.27	3,526,559.00	99	1,284,809.00	1,833,338.00	2,400.00
Liaoning	68	6,112.96	13,512,147.00	83	5,654,890.00	7,683,897.00	6,200.00
Ningxia		352.81	5,125,842.00	54	2,525,552.00	3,988,549.00	2,400.00
Qinghai	5	247.9	468,968.00	27	190,991.00	31,747.00	400
Shaanxi	189	1,879.26	13,755,589.00	165	5,827,007.00	10,936,983.00	8,400.00
Shandong	15	15,379.54	78,896,716.00	241	42,086,062.00	61,332,284.00	14,600.00
Shanxi	291	2,439.30	92,290,142.00	1427	44,581,967.00	48,084,729.00	37,200.00

Sichuan	81	3,387.43	10,028,679.00	418	4,761,848.00	2,812,934.00	4,400.00
Xinjiang	24	1,113.14	2,287,479.00	69	1,367,792.00	1,575,902.00	2,200.00
Yunnan	58	1,557.17	2,893,076.00	78	1,500,063.00	1,530,342.00	1,700.00

2003 Regional coal mining data: safety, output, firm numbers, employment, etc.

District	Fatality	Gross Industrial Output Value (100 million yuan)	Gross Coal Output Value (all types of enterprises, at current price in 1,000 yuan)	Number of Coal Enterprises	Number of Employees in Coal Industry	Gross State Mine Output Value (1,000 yuan)	Total Output (10,000 tons)
Anhui	141	2,610.03	13,136,711	61	238,837	10,816,707	6,726.41
Beijing	4	3,810.36	5,410,508	19	24,366		822.57
Chongqing	96	1,588.00	2,548,660	89	64,931	1,340,518	1,484.20
Fujian	16	4,953.74	1,672,335	56	23,565	707,192	778.22
Gansu	36	1,147.52	2,888,975	89	68,823	2,524,471	2,603.27
Guangdong	25	21,513.46	319,956	18	9,934	11,168	202.34
Guangxi	3	1,436.43	667,794	17	17,747	616,185	417.14
Guizhou	396	977.64	3,508,477	132	86,062	2,766,269	7,802.51
Hebei	117	5,708.76	13,756,676	107	241,743	8,967,087	6,600.15
Heilongjiang	93	2,909.98	9,984,416	80	244,520	6,707,176	
Henan	110	5,365.65	29,531,654	380	467,172	17,560,695	11,871.01
Hubei	17	4,030.11	691,289	35	20,831	312,041	366.40
Hunan	154	2,611.45	6,577,666	295	137,798	3,315,106	2,366.69
Inner Mongolia	55	1,355.70	11,473,143	102	121,154	6,117,635	11,959.35
Jiangsu	159	18,036.74	7,079,539	9	115,122	7,079,539	2,760.40
Jiangxi		1,472.33	3,167,347	64	65,134	2,689,462	951.66
Jilin	40	2,662.27	2,804,209	50	83,964	1,691,168	
Liaoning	51	6,112.96	9,729,278	55	172,558	3,895,789	

Ningxia	6	352.81	3,620,898	26	58,759	3,219,251	2,047.90
Qinghai		247.9	363,455	14	6,919	179,693	310.57
Shaanxi	27	1,879.26	6,666,964	75	94,001	5,760,854	7,392.76
Shandong	96	15,379.54	45,270,993	266	499,337	21,264,507	14,667.27
Shanxi	369	2,439.30	54,730,766	747	659,365	37,984,146	29,508.66
Sichuan	45	3,387.43	5,581,658	219	156,578	2,401,031	3,133.88
Xinjiang	27	1,113.14	1,955,457	62	43,089	1,457,176	1,845.71
Yunnan	105	1,557.17	1,907,656	66	34,227	1,144,497	1,399.39

2002 Regional coal mining data: safety, output, firm numbers, employment, etc.

District	Fatality	Gross Industrial Output Value (100 million yuan)	Gross Coal Output Value (all types of enterprises, at current price in 1,000 yuan)	Number of Coal Enterprises	Number of Employees in Coal Industry	Gross Sate Mine Output Value (1,000 yuan)	Total Output (10,000 tons)
Anhui		2,123.61	11,925,544.00	56	237,421.00	9,691,699.00	6137.84
Beijing	8	3,173.48	5,019,074.00	21	28,360.00	0	880.95
Chongqing	86	1,228.37	1,960,491.00	70	69,277.00	1,552,000.00	1211.73
Fujian	3	3,676.37	1,348,520.00	50	22,382.00	1,022,662.00	644.51
Gansu	6	1,035.52	2,247,143.00	103	65,381.00	1,864,990.00	2089.21
Guangdong	27	16,378.60	249,541.00	20	7,814.00	9,832.00	168.71
Guangxi	60	1,180.55	620,043.00	22	21,268.00	592,065.00	463.51
Guizhou	331	797.90	2,625,395.00	77	79,147.00	2,373,500.00	5001.12
Hebei	87	4,294.68	11,621,486.00	106	261,992.00	10,383,163.00	6083.7
Heilongjiang	319	2,487.63	8,781,781.00	79	256,005.00	6,115,078.00	5882.58
Henan	49	4,303.66	23,283,867.00	356	459,668.00	15,845,084.00	9921.21
Hubei	50	3,589.26	651,848.00	39	23,377.00	351,013.00	372.55
Hunan	304	2,099.40	4,620,463.00	233	129,759.00	2,724,512.00	1845.42
Inner Mongolia	44	994.75	8,335,277.00	87	131,380.00	4,426,549.00	2593.59

Jiangsu		13,865.86	6,131,834.00	13	126,702.00	6,109,734.00	1375.04
Jiangxi	43	1,188.80	2,897,108.00	59	64,467.00	2,597,888.00	1685.25
Jilin	139	2,171.17	2,218,205.00	52	90,307.00	1,530,103.00	5180.77
Liaoning	78	4,888.02	8,407,744.00	53	174,908.00	3,536,984.00	8880.3
Ningxia		268.62	2,218,477.00	20	49,790.00	2,096,620.00	1707.31
Qinghai	14	207.59	259,344.00	11	6,656.00	143,133.00	249.77
Shaanxi	43	1,505.45	5,059,011.00	74	99,540.00	4,602,185.00	5859.31
Shandong	20	11,497.53	37,797,278.00	234	487,682.00	18,675,346.00	13065.97
Shanxi	325	1,717.88	39,379,551.00	669	647,738.00	27,764,629.00	24361.3
Sichuan	109	2,737.35	4,931,813.00	175	149,579.00	2,557,930.00	2753.89
Xinjiang	33	917.03	1,751,455.00	65	41,153.00	1,397,711.00	1582.28
Yunnan	122	1,320.62	1,511,885.00	61	36,165.00	1,117,198.00	1219.34

2001 Regional coal mining data: safety, output, firm numbers, employment, etc.

District	Fatality	Gross Industrial Output Value (100 million yuan)	Gross Coal Output Value (all types of enterprises, at current price in 1,000 yuan)	Number of Coal Enterprises	Number of Employees in Coal Industry	Gross Sate Mine Output Value (1,000 yuan)	Total Output (10,000 tons)
Anhui	8	2,123.61	9152705	52	235345	7,705,912.00	5524.98
Beijing	7	3,173.48	2703195	18	27166	-	690.22
Chongqing	73	1,228.37	1722434	66	68880	1,483,046.00	1918.46
Fujian		3,676.37	959140	48	21354	710,971.00	1063
Gansu	28	1,035.52	2074558	102	68186	1,666,780.00	1819.05
Guangdong		16,378.60	217859	16	6938	93,912.00	462.72
Guangxi	3	1,180.55	699374	27	22542	694,094.00	613.52
Guizhou	279	797.90	2279157	74	80253	2,141,924.00	4898.66
Hebei	49	4,294.68	9462968	99	243623	8,045,570.00	5865.7

Heilongjiang	126	2,487.63	7682290	74	270620	5,352,467.00	5686.73
Henan	73	4,303.66	18333237	348	463635	12,465,928.00	9170.98
Hubei	63	3,589.26	532883	38	20714	384,932.00	1016.54
Hunan	248	2,099.40	3570195	182	135229	2,297,482.00	3673.35
Inner Mongolia	34	994.75	6435691	86	135235	3,381,612.00	2505.14
Jiangsu	9	13,865.86	4840795	14	113973	4,760,036.00	1515.09
Jiangxi	76	1,188.80	2140468	76	75967	1,859,606.00	1761.95
Jilin	32	2,171.17	2198916	53	97743	1,448,860.00	4468.15
Liaoning	49	4,888.02	7415183	53	183214	2,909,822.00	8162.89
Ningxia		268.62	1872835	31	51195	221,152.00	1635.72
Qinghai		207.59	135543	14	5362	132,623.00	192
Shaanxi	109	1,505.45	3729997	72	94799	3,452,805.00	5282.2
Shandong	100	11,497.53	26201128	207	455571	12,883,346.00	10824.96
Shanxi	264	1,717.88	30158855	585	626947	22,848,687.00	27614.67
Sichuan	89	2,737.35	3708495	126	144066	2,168,597.00	4371.75
Xinjiang	51	917.03	1516207	70	40469	1,230,634.00	2819.61
Yunnan	62	1,320.62	1344544	63	38428	1,013,150.00	2394.12

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