The Political Economy of China's Dramatically Improved Coal Safety Record

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Abstract

China's coal safety has improved dramatically since 2003. This article will present the official data and conclude that it is almost impossible that the figures conceal a situation where there has not been remarkable improvement. Structural factors including China's level of economic development, changes in the labour market and the economic health of the industry have played an important role, but state commitment and policies have been central at least to the speed and magnitude of the improvement.

Keywords: work safety; mining accidents; Chinese state; reliability of Chinese statistics; investigative journalism; safety culture; mechanization of mining

The basic story of China's coal safety since 2003, at least as evidenced in fatalities in mining accidents, has been one of massive, continuous, uniform and sustained improvement. This has been insufficiently recognized and some still argue that China's record remains appalling, sometimes citing pre-2005 evidence to support present-tense statements. This paper will outline and evaluate China's record and then, given that in 2004 the author expected any progress to be gradual,[1] examine those factors in the broader political economy and in state policy that contributed to the improvement. Far more scholars have tried to explain why accidents did happen rather than why they did not, but some possible reasons why safety might have improved include social and economic modernization, the operation of the business cycle, legislation and state regulation, concentration of output in safer enterprises, technological progress, better training and the existence of strong unions.[2]

The Record

In the early 2000s, around 6,000 Chinese coal miners were killed each year in accidents – more than four for every million tons of coal extracted.[3] This record

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1 Wright 2004, 646.

2 See, e.g., Suttmeier 2008, 133–36; Braithwaite 1985, 2–13; Duckham and Duckham 1973, 185; Nichols 1997, 137.

3 Death rates per unit of labour are a better indicator of the miners' experience, but usable employment figures exist only for large state mines. In this paper, "death rates" refer to deaths per million tons of output. Figures for deaths per unit of labour would show a lesser improvement, because of the sharp rise in productivity; indeed, up to 2005, deaths per million work days in the large state mines were

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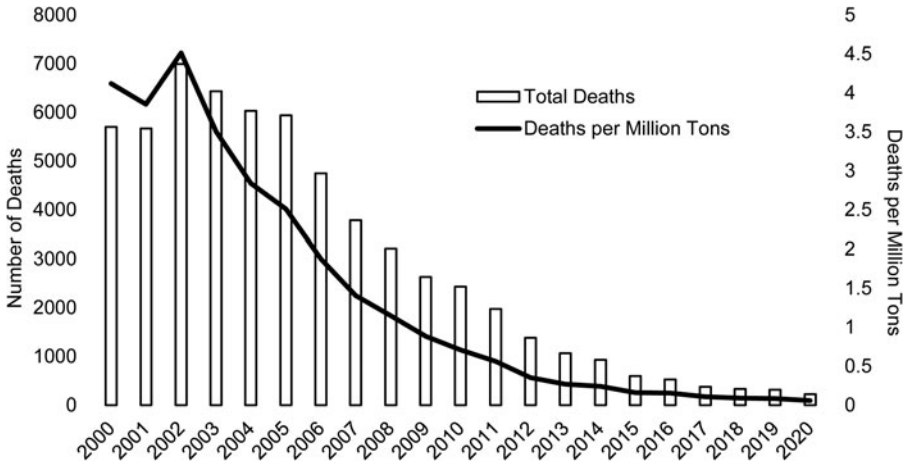
Figure 1: **Fatalities in Chinese Coal Mines, 2000–2020**



Sources:

SACMS 2010, 88–89; *Zhongguo anquan shengchan nianjian* various years; NBS various years. Detailed sources for all the data in the figures are available online at https://doi.org/10.1017/S0305741021000941.

compared very badly with those of other countries and embarrassed China's leaders and people.[4] By 2020, however, as Figure 1 shows, the number of deaths had fallen by over 95 per cent and the death rate by over 98 per cent. By any standards, this was a very substantial achievement.[5]

Some international comparisons illustrate the magnitude of the improvement. Figure 2 shows death rates in the UK and the US, 1900–1970, and in China, 2000–2020. In each case, the rate started out at over four. But in China, it fell further in 19 years than it did in the UK or the US in 70 years.

The improvement was sector wide. In geographical terms, the rate fell nationally by about 94 per cent between 2003–2005 and 2014–2016. Figure 3 shows that every province-level unit also improved dramatically. Guizhou recorded the highest reduction of 98 per cent, but even the least successful, Jiangsu, Guangxi and Heilongjiang, still managed around 60 per cent.

Nor was the improvement limited to particular types of mining enterprise. Available national figures show that death rates fell by 70 per cent between 2002 and 2009 in the large state-owned mines, 80 per cent in the generally medium-sized mines run by local states and almost 85 per cent (95 per cent by

footnote continued

increasing while deaths per million tons were falling (Guo 2008, 69). The fall in total deaths since then has been so large that the rate per unit of labour has certainly also fallen very substantially.

4 Wright 2004, 631.

5 Compare Uhalley 1998 and Suttmeier 2008 for aviation safety.

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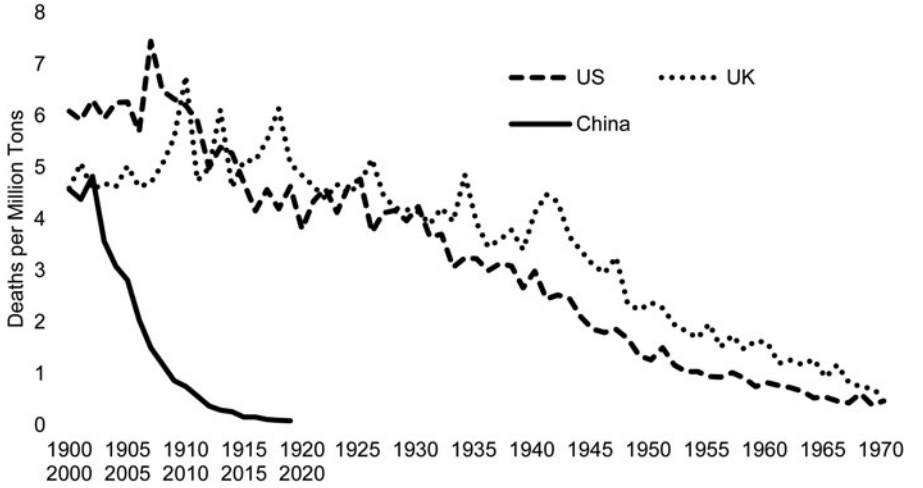
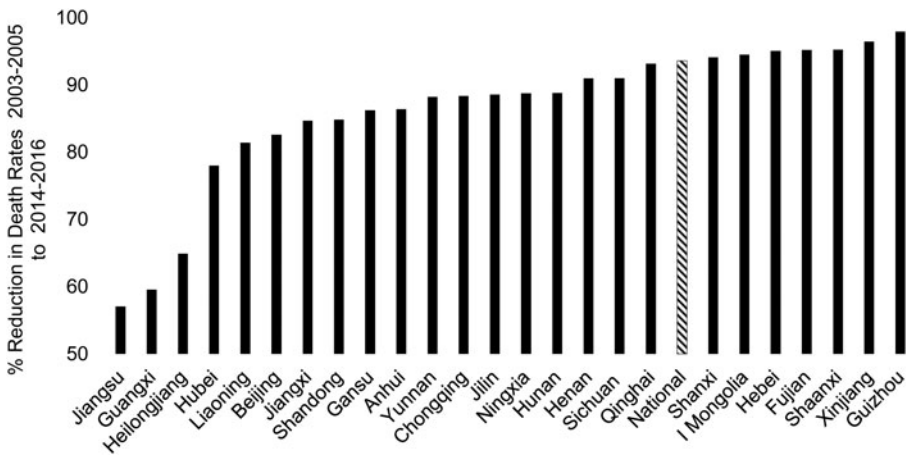
Figure 2: **Deaths per Million Tons in the US and UK, 1900–1970, and China, 2000–2020**



Sources:

Durham Mining Museum, n.d; NCB various years; NCB 1979, 3–4; US Department of Labor n.d.

Figure 3: **Reduction in Coal Mine Death Rates between 2003–2005 and 2014–2016, by Province (%)**



Sources:

Zhongguo meitan gongye nianjian 2004; 2005; *Zhongguo anquan shengchan nianjian* 2014; 2015; 2016.

Notes:

Provinces not producing coal or ceasing production are excluded. There are some small other omissions. Availability of reliable statistics determines the periods chosen.

2014) in the mostly small township and village mines (TVMs).[6] More partial provincial figures suggest that they continued to fall after 2009. The official figures

6 SACMS 2010, 88–89; Liu, Quanlong, et al. 2017, 267.

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do not, therefore, support Fan Geng and Joseph Saleh's argument that deaths declined solely because of small mine closures, whereas deaths in operating mines remained constant.[7]

Three factors qualify – although do not negate – China's achievement. First, up until the early 2000s, fatalities were excessive given existing levels of technology, and the gap between actual practice and evolving best practice was greater for China in 2000 than it was for the UK or US in 1900. So, as with economic growth, China's progress involved considerable catching up, and a lot of low-hanging fruit was waiting to be picked. Nevertheless, the fruit had to be picked, and the situation has improved continuously since 2003.

Second, fatalities, as the least ambiguous and most easily quantifiable measure of safety, are obvious objects for government action.[8] In target-driven systems, problems less easily quantified or monitored tend to attract less attention. Little is known about non-fatal injuries in Chinese coal mines, although evidence elsewhere suggests a relatively constant relationship between serious injuries and fatalities,[9] and it is likely that non-fatal injuries in China also fell. Likewise, less progress has been made with occupational diseases, notably pneumoconiosis. In fact, just as accidents were declining in number, new pneumoconiosis cases were increasing sharply (although, given the latency period, that reflected the situation 20 years earlier).[10] Half of China's pneumoconiosis cases were coal miners, and the number of diagnosed cases increased by 85 per cent between 2005 and 2013, and deaths increased by 119 per cent.[11]

Finally, for all the improvement, over 200 miners are still dying each year, and substantial work remains to be done. China still lags behind many other major coal producers, partly because it is less able to use open-cast methods. China's average death rate in 2017–2019 was 0.093 per million tons, marginally better than India at 0.096, but considerably higher than the US at 0.019.[12]

Can We Believe the Figures?

One objection must be confronted immediately: this picture relies on official figures, a factor which some might argue invalidates the conclusions drawn.[13] There are indeed reasons for caution, but it remains almost impossible that the figures conceal a situation where safety has not dramatically improved.

No one believes that the official figures include every fatality. Even apart from the limitations of statistical collection, fatalities have been deliberately concealed by both managers and local officials who face penalties if such deaths are recorded. In fact, the incentives for concealment increased in the 2000s. The

7 Geng and Saleh 2015, 44.
8 See Lewis-Beck and Alford 1980, 746, for the US.
9 Benson 1980, 40–41; Bronstein 2008, 12.
10 Kerswell and Deng 2020, 199, 204.
11 SAWS 2007; 2017; Hu, Zhang and Zhang 2019, 8.
12 US Department of Labor n.d.; Government of India, Ministry of Coal 2020.
13 The most systematic sceptical view is Geng and Saleh 2015.

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state raised the amount of compensation enterprises had to pay to bereaved families as well as the penalties for serious accidents and made accident prevention a higher priority in cadres' assessment. No doubt, these measures incentivized safety improvement but, if an accident did occur, they also gave greater reason to conceal the fact – for example, by bribing or threatening journalists to prevent them reporting the incident.[14]

A second reason for caution is that the system has become less transparent over the last decade. The publication of data has become sparser. Up until 2009, the government published detailed statistics which disaggregated accidents and fatalities for each province by different forms of ownership. They ceased to do this from 2010, reflecting in part the decline of the TVM model but also the greater efforts by the state to control information. Although the State Administration of Coal Mine Safety (SACMS) has established a (non-public) database of accidents, which Chinese scholars use, it seems incomplete, delivering substantially lower totals for fatalities than even the SACMS communiqués.

Moreover, the state has restricted investigative journalism. In the early 2000s, journalists, most notably those working for the *Southern Weekend* group, highlighted the causes and outcomes of mining disasters. From around 2011, however, predating even Xi Jinping's 习近平 installation as general secretary, the Party began to tighten its control of the press, targeting *Southern Weekend* in 2013–2015. By the late 2010s, investigative journalism had become much more difficult, with far fewer controversial stories coming to light.[15] Reporting on accidents in large state-owned mines was always problematic and the increasing concentration of production in such mines has made things more difficult for journalists.[16] State organs now face less pressure for transparency about mining accidents or other social problems.

Finally, anomalies in the official figures provide evidence of underreporting, particularly before 2007.[17] Observers have noted the large number of disasters with nine fatalities: "major" accidents with ten or more deaths were handled by the centre and those with fewer deaths at the provincial level, involving lower fines.[18] Figure 2 also shows that whereas in the UK and the US substantial annual fluctuations complicated an overall downward trend, in China deaths and death rates have declined every single year from 2003. In part, the lack of fluctuations was probably owing to the law of large numbers – the Chinese industry was much larger and total deaths around four times higher – and data from individual provinces do show much more variation.[19] Nevertheless, to sceptics these anomalies suggest that the official figures have been massaged.

14 Repnikova 2017, 149–150.
15 Svensson 2017, 441.
16 Repnikova 2017, 169–170.
17 Geng and Saleh 2015, 46.
18 Wang 2011, 34.
19 *Zhongguo anquan shengquan nianjian* various years.

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Despite these caveats, it is almost certain that coal safety has dramatically improved, even if we cannot trust all the details. Some simple arithmetic illustrates the point. Around 2002, official figures reported about 6,000 deaths a year. Assuming that a further 2,000 were concealed (probably a reasonable estimate, although within limits the exact figure does not matter), then there would have been 8,000 deaths in all, 25 per cent of which were concealed. Fast forward to 2020, when 225 deaths were reported. If actual fatalities were still 8,000 (or any remotely similar number), then around 97 per cent would have been concealed. Therefore, one must go beyond giving evidence for underreporting[20] and demonstrate that the rate of concealment has vastly increased. Even given the tighter controls over information, it is highly unlikely that, in an age of mobile phones and digital media, local or central states could have concealed all major disasters (no disaster involving more than 50 fatalities has been reported since 2009, when there were three) and nearly all mine deaths. Although we never hear about successful concealment, any such success was probably neither frequent nor easily achieved.

Finally, even if fatalities are underreported by three to five times (which I very much doubt),[21] that would still leave the number of fatalities in 2020 at only one-fifth of the official figures for the early 2000s, even without making similar adjustments to those earlier figures. So, although they point to real problems, Geng and Saleh are unsuccessful in challenging the broad narrative of safety improvement.

Modernization and Economic Growth

The safety improvement has taken place amid the rapid modernization of Chinese society. Modernization and economic growth produce the resources to address work safety, if it is a high enough priority.[22] They also change the perception of risk in that, as the marginal returns to economic growth decline, risks that were apparently tolerable in earlier stages of development cease to be so.[23] Safety, therefore, tends to improve – albeit not in a unidirectional fashion – at higher levels of development.[24] In his 2007 report, the minister of the State Administration of Work Safety (SAWS) used GDP as a rough proxy for development to put China's record in comparative context and argued that the developed countries had generally suffered high death rates earlier in their history.[25] In one view, accidents frequently occur when per capita GDP is around US$1,000–3,000, but occur less frequently when it reaches US$5,000.[26] China probably approached the US$5,000 mark in the mid-2000s at purchasing

20 Geng and Saleh 2015, 42–46.
21 Ibid., 46.
22 Uhalley 1998, 218.
23 Suttmeier 1994, 113; Inglehart 1997, 450.
24 Suttmeier 2008, 133–34.
25 Li, Yizhong 2007.
26 Guo 2008, 14.

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power parity and in the early 2010s using market exchange rates, just as death rates were falling.

As development proceeds, supplies of surplus rural labour often begin to dry up and the economic (although not, in the case of China, the political) position of labour tends to improve. Workers are less able to demand a safe work environment when they lack alternative sources of employment. In 2002, a Chinese worker lamented after an accident, "If we complain, they can always find someone else to work."[27] However, labour in China became scarcer from the mid-2000s, first in the south-east and then more broadly across the country, as reflected in accelerating wage rises.[28] In the 2010s, coal companies found it particularly difficult to recruit workers to a dirty and dangerous occupation as parents of only children became averse to the risk that employment in mines involves.[29] The tightened labour supply gave workers more options and employers fewer, improving workers' bargaining position in respect of wages and conditions.[30]

These factors affected all sectors across the economy, but coal mining performed substantially better than others. Between 2002 and 2016, the proportion of work fatalities it accounted for declined from over 30 per cent to 6 per cent, as deaths declined by 91 per cent in coal mining, and 55 per cent overall. Fatalities in the (rapidly growing) construction industry actually increased.[31] In the chemical industry, deaths fell sharply in 2007 but later fluctuated with a slightly rising trend – clearly a much inferior record to that of the coal sector, although the industry's growth meant that deaths per unit of output fell.[32] Factors specific to coal must, therefore, have also played a role.

Boom and Bust

The economic health of the industry itself has had an impact on safety, although that impact has been neither simple nor one way. In the short term, when capacity is fixed, safety tends to decline in boom times (because of the pressure to increase production) but improves somewhat during slumps.[33] But in the long term, high profits create resources that can be used to improve safety.

In the short term, the SAWS identified the key cause of China's high accident rate to be mines exceeding their production capacity because of booming business.[34] Overcapacity working was relatively "normal" throughout the early reform period,[35] and remained common during the boom of the "ten golden

27 Pan, Philip 2001.
28 Huang, Yiping, and Cai 2014, 138.
29 Zhang, Qingnian 2012; Sun 2019.
30 Du, Gao and Wang 2009, 206.
31 *Zhongguo anquan shengchan nianjian* various years. The total referred to in the text includes mining, construction, agriculture and manufacturing. Transport fatalities are excluded, because many (although by no means all) road transport fatalities cannot really be regarded as issues of work safety.
32 Huang, Shengchu 2019, 40.
33 Nichols 1997.
34 SAWS 2007; 2011.
35 Guo 2008, 103.

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years" (2002–2011), with mines working at 30–80 or even 100 per cent over capacity.[36] For every 1 per cent that capacity was exceeded in the early 2000s, the death rate increased by 1.8 per cent.[37] After the boom ended, China Labour Bulletin thus interpreted better safety figures as partly reflecting the industry's (relatively) depressed state.[38] However, the major improvement in safety during the boom makes this an unconvincing explanation of the long-term trends.

In the longer term, high prices and profits improved safety. Lack of investment had been a major factor behind high death rates in the 1990s and early 2000s, as low prices and competitive pressures induced mines to economize on apparently non-productive safety expenditures. Safety investments fell close to zero in the late 1990s, even in large state-owned mines, leading to "safety shortfalls" of 150 billion yuan or more.[39] As a result, equipment became obsolescent and dangerous: in four major north-eastern coal corporations, 40 per cent of equipment in the 2000s was obsolescent, with 30 per cent of it dating from the 1950s.[40] Chinese mines, especially but not only the smaller mines, suffered from safety hazards long overcome elsewhere: in 2007, the SAWS was still calling on mines to cease using shafts for both ventilation and transporting miners.[41]

The boom, however, enabled many coal enterprises to increase safety investments and replace outdated machinery.[42] Figure 4 shows that total investment increased very sharply from 21 billion yuan in 2002 to 537 billion yuan in 2012. Much of this investment did not go directly towards improving safety but rather to fund large increases in capacity.[43] Nevertheless, government policy mandated that any productive investment be accompanied by appropriate safety measures.[44] Therefore, even capacity-building investment improved safety, as newer mines tended to be larger and safer. The volume of investment directed specifically towards safety likewise increased massively up until the early 2010s, closely shadowing profits.[45] The decline in profits from 2012 put an end to this rapid growth: in Changzhi 长治 (Shanxi), after increasing from just over 100 million yuan in 2000 to almost 700 million yuan in 2012, such investments tailed off and made no further progress.[46] The state again became worried about the emergence of "safety shortfalls" and the weakening of the safety infrastructure.[47]

36 Niu 2018.
37 Guo 2008, 107.
38 China Labour Bulletin 2015.
39 Pan, Weier 2004, 36.
40 Xu 2010, 8.
41 Guo 2008, 186.
42 Xu 2010, 12; Guo 2008, 132–33, 145–46.
43 CNCA 2018, 14.
44 *Zhongguo anquan shengchan nianjian* 2006, 314.
45 Zhao and He 2017, 14; Ding and Liu 2015, 87, shows a much slower growth of safety inputs, and a lower level.
46 Lei 2016, 310.
47 "Jintian de anquan qianzhang jiushi mingtian de shigu yinhuan" (Today's safety shortfalls are tomorrow's accident hazards). *Zhongguo nengyuan bao*, 11 March 2019, 3.

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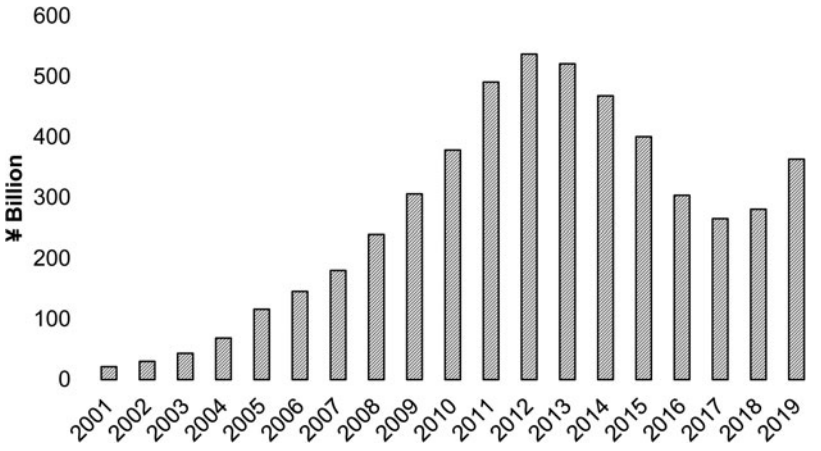
Figure 4: **Coal Industry Investment, 2001–2019 (billion yuan)**



Sources:
NBS n.d.; CNCA 2018, 9; 2019, 6.

State Commitment

China's system has long focused on centralized mechanisms to deal with risk and, despite the broader economic factors, state commitment has been crucial to the speed and magnitude of the safety improvement.[48] Richard Suttmeier argues that the state's attention is a scarce resource because it has multiple and often conflicting priorities. A focus on safety is, therefore, often short-lived, and decentralized social mechanisms are also necessary.[49] Nevertheless, for China's coal safety, there is much more evidence for state-led action than for broader social changes such as autonomous labour organizations, a free press or the rule of law.

State commitment can be attested in several ways. The Fifth Plenum of the 16th Central Committee in 2005 highlighted work safety as part of "economical, clean, safe, and sustainable development."[50] In 2006, Premier Wen Jiabao 温家宝 laid out a detailed strategy,[51] and, from 2007, specific coal safety programmes were developed within the Five-Year Plans.[52] Financially, government bond issues promoted coal safety and the 15 billion yuan raised between 2006 and 2010 leveraged 88 billion yuan of investment by enterprises and local governments.[53] More broadly, mentions of "coal safety" in the *People's Daily* increased very steeply in the early 2000s, reflecting increased attention to an existing problem rather than a suddenly worsened situation. These mentions peaked in 2005–

48 Suttmeier 1994, 108–09; 2008, 142.
49 Suttmeier 2008, 138.
50 SAWS 2007.
51 Wen 2006.
52 SAWS 2007.
53 SAWS 2011.

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2006, later falling off, no doubt partly because there were fewer disasters, and stabilizing in the 2010s at a level far higher than in the 1990s.[54]

The commitment reflected the state's priorities under Hu Jintao 胡锦涛 and Wen Jiabao, typifying the "protective authoritarianism" theorized by Jude Howell and Tim Pringle, whereby the state attempts to limit exploitation of workers, an ambition that was carried over into the harder authoritarianism of Xi Jinping.[55] Priorities shifted from a sole focus on growth to some concern with key social problems, including work – and especially coal – safety. A safe work environment was one of the aspirations of Hu Jintao's "harmonious society," as encapsulated in the oft-cited slogan *yi ren wei ben* 以人为本 (people-oriented).[56] Economic policies increasingly favoured a more intensive mode of growth, with many observers linking China's previously disastrous safety record to its extensive growth model.[57] These new priorities led the state for a while to allow reporters to cover the darker side of society,[58] and the popular unease created by frequent press reports of disasters – and the corrupt relationships underlying them – in turn put further pressure on the state.[59]

Any commitment to safety stopped well short of changing the nature of the party-state. Many observers elsewhere argue that only with autonomous worker organizations, particularly unions, can real progress be made.[60] As Michael Wallace writes of the US, "the union gives miners the collective strength to resist unsafe conditions at the point of production without fear of reprisal by the operators."[61] Likewise, Helen and Baron Duckham identify independent labour organization as a key factor behind progress in the UK.[62] In China, however, no evidence suggests that autonomous worker organizations have been allowed to grow, or that they underlie the improvement in safety. Lip service was paid to "mass supervision," in which the union (which is little more than a branch of the bureaucracy) was allocated a key role, and to the need for worker representation. The State Council stipulated the appointment of worker representatives in the TVMs, which does seem to have happened at least in some areas such as Yunnan.[63] Nationally, however, implementation was very uneven, and union activities limited;[64] problems ranged from a failure of management to take the issue seriously to low "quality" of, and low rewards for, the representatives.[65] Nor does it seem that labour NGOs played a major role, although the relatively open authoritarianism of the Hu–Wen era allowed China to absorb international

54 "*Renmin ribao* tuwen shuju ku" (Database of *Renmin ribao*), through National Library of Australia.
55 Howell and Pringle 2019, 229, 230.
56 Zhu 2017, 47–50.
57 *Zhongguo anquan shengchan nianjian* 2005, 82.
58 Repnikova 2017, 145.
59 Dangzu 2020; for air safety, see Uhalley 1998, 222–23.
60 Kerswell and Deng 2020, 214; for Singapore, see Dobbs and Loh 2020, 118.
61 Wallace 1987, 346.
62 Duckham and Duckham 1973, 185.
63 Feickert 2013, 25.
64 Ma, Hao 2019.
65 Huang, Liping 2014, 117.

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best practice by collaborating with foreign experts, with involvement by the United States, Japan and the European Union particularly, but not exclusively, in developing training programmes.[66]

Nor did the state follow the advice of liberal economists to resolve the conflict between its responsibilities for safety and for coal production by further marketizing the industry.[67] On the contrary, as outlined below, production became increasingly concentrated in the largest state-owned, or at least state-controlled, companies. Persisting conflicts of interest are indicated even in the laws, which foreground promoting economic development as well as work safety.[68]

Rather, the state's actions remained squarely within the ambit of an "illiberal regulatory state."[69] First, it strengthened the legal and regulatory framework.[70] Important milestones included the 2002 Work Safety Law, the revised coal safety regulations in 2004, and the 2015 document on coal safety permits.[71] An American lawyer concluded in 2009, "The PRC has a comprehensive, sophisticated and complex legal regime dealing with coal mine safety," a regime which contributed to the decline in fatalities.[72] Nevertheless, the key issue was not the law but rather its enforcement. Even in the 1990s, if the laws had been enforced, the prerequisites for better safety already existed, but other issues took a higher priority and attempts to address safety issues were dogged by weak accountability and conflicts of interest.[73]

In order to remedy some of the implementation problems, the state aimed to bolster the institutional basis for coal safety. It at least partially separated safety from production responsibilities by establishing a new organization in 2000, the SAWS, and, within that, the SACMS, the only sector-specific safety body. These institutions reported to the State Economic and Trade Commission separately from the Coal Industry Bureau. In practice, however, the coal and safety bureaucracies remained closely connected (the Coal Industry Publishing House publishes the *Work Safety Yearbook*) and the state itself retained ultimate responsibility for both production and safety.[74]

The state signalled increased priority for safety from 2003 by upgrading the rank of the SAWS so that it reported directly to the State Council, first at vice-ministerial level and then, from 2005 following a series of horrific mine disasters, at ministerial level.[75] In contrast, the 2018 merger of the SAWS into a new Ministry of Emergency Management was widely perceived as indicating a

66 Howell and Pringle 2019, 230; Feickert 2005.
67 Repnikova 2017, 159–160, 163.
68 Homer 2009, 429.
69 Yang 2017.
70 See Uhalley 1998, 225, for air safety.
71 Deng, Zhang and Liu 2016, 101.
72 Homer 2009, 428.
73 Feickert 2013, 28; Kerswell and Deng 2020, 213; Pringle and Frost 2003, 314–16.
74 Yan 2009, 47–48.
75 Ibid., 49; Huang, Shengchu 2019, 41.

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reduction in commitment.[76] No systematic statistics show how far the earlier upgrading was reflected in increased funding and staffing, but by 2019 there were 26 provincial-level and 76 branch bureaus, and a total of 2,762 coal mine safety inspectors in the central system, almost all of whom had been educated at college level or higher, with three-quarters having specialized qualifications[77] and a further 40,000 in local institutions.[78]

Insufficient vertical control over local safety institutions was a further cause of implementation problems, reflecting the conflicts of incentives between the *tiao* 条 (branches, directly responsible to the central, or at least higher-level, authorities) and *kuai* 块 (areas, horizontally responsible to the local government). The resistance of local governments to directives that impacted negatively on local incomes or employment caused many accidents.[79] The state, therefore, instituted a vertical and centralized system of inspection in explicit imitation of the US, although local organs retained a role in implementation, and it is unclear how far the system went to resolving the *tiao*/*kuai* issue. In other sectors, centralization operated more at the sub-provincial level than between the centre and province.[80] For coal safety, while semi-official sources emphasized that the centre controlled the funding and hiring of staff in local institutions (as happened elsewhere only with the General Administration of Customs),[81] others argued that there remained contradictions between central and local priorities.[82]

The state also boosted implementation by strengthening accountability for safety, both before and after accidents, to ensure that the enterprises and their owners and managers bore the cost of safety failures, rather than offloading them as external costs on to the affected miners.[83] In the US, safety improved when the switch from employer liability (if employers could be proven to be at fault) to workers compensation (in the case of any accident) ensured that enterprises bore the costs.[84] In China, the state began to enforce higher compensation payments to bereaved families. Before 2000, these sums were trivial, up to 30–40,000 yuan, neither providing any real support for the families nor creating incentives to improve safety. After that, provincial governments rapidly increased required payments. A major landmark came in 2004 when Shanxi, the largest coal producer, set a level of 200,000 yuan.[85] Thereafter, the general standard increasingly became 20 times the average local urban disposable income or average local net rural income (of course, these two measures could be substantially different).[86]

76 China Labour Bulletin 2018.
77 Dangzu 2020.
78 Huang, Shengchu 2019, 41; Zhu 2017, 78.
79 Wright 2007, 182.
80 Yang 2017, 122–23; Mertha 2005, 792.
81 Zhu 2017, 78.
82 Ma, Ke 2015.
83 Guo 2008, 150–51.
84 Aldrich 1997, 94–97, 241–42.
85 Guo 2008, 150–51, 230.
86 Zhang, Haina 2012, 242.

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In addition, when accidents occurred, penalties were imposed on stakeholders. When ten miners were killed at Danshuigou 担水沟 (Shanxi) in January 2017, the SACMS blamed overcapacity production and the management's delayed response to increased pressure on the roof. It imposed penalties on 33 responsible personnel: the police detained five managers for prosecution and investigated three others, and the Party or government disciplined 25 persons (for example, by demotion). The SACMS levied a fine of 5 million yuan on the company, which also faced two further 2 million yuan fines for exceeding capacity and for illegally outsourcing work to an insufficiently experienced organization. In addition, it ordered a thorough audit of the local government.[87]

Local officials, including but not only those in safety institutions, were also held accountable. From 2004, the SAWS began to issue maximum permitted numbers of accidents and deaths for each province, both overall and for key industries, which the provinces then devolved to lower-level units.[88] Importantly, the limits were prioritized in the assessment and promotion of local officials.[89]

Perhaps even more significantly, the SACMS imposed substantial penalties even without there being an accident. It enjoined inspectors to eliminate mine hazards, and between 2012 and 2019, made 155,000 mine inspections, uncovering 947,000 hazards of which 5,951 were particularly serious.[90] Companies failing to control hazards faced fines. In the first half of 2019, the 73,181 hazards uncovered by the SACMS generated 4,629 penalties, to a total of 542 million yuan, and the 241,000 uncovered by local organizations led to fines totalling 214 million yuan.[91]

More specifically, the state prioritized three key areas for change: the elimination of small-scale mines; improvement in technology, especially for ventilation; and the training of the workforce.

Concentration of Production

In general, regulation can improve safety by raising standards in all enterprises and/or by compelling, deliberately or as a by-product of enforcing higher standards, less safe mines to close.[92] Safety tends to be positively related to scale, with smaller coal mines being more dangerous.[93] In China, scale tended to vary with form of ownership and technological level. The smaller (TVM) mines were mostly technologically more primitive, the medium (local-state owned) mines semi-mechanized, and the large (central-state owned) mines highly

87 SACMS 2018.
88 *Laodong baohu* 2010, 46.
89 Jiang and Chai 2017, 131.
90 Dangzu 2020.
91 SACMS 2019b.
92 Neumann and Nelson 1982, 184.
93 Braithwaite 1985, 12.

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mechanized.[94] The safety records of the three groups differed substantially: between 1992 and 2002, their death rates were 9.57, 4.30 and 1.11, respectively.[95] The state aimed to improve safety by closing small and backward mines or forcing them to consolidate into larger units.[96]

After an earlier largely unsuccessful campaign around 1999 to close small mines,[97] in 2005 the State Council set a target to "basically solve" the problem within three years, starting by targeting unregistered mines.[98] The following year and during the 2009–2010 "coal reform," it also targeted mines deemed undesirable for other reasons.[99] These campaigns apparently have had greater success. Although such figures must be viewed with considerable caution, the number of mines nationally fell from 82,000 in 1997 to 5,300 in 2019.[100] In Shanxi, over ten months in 2009, the number of enterprises fell from 2,200 to 130, and more than half of all mines were shut; 70 per cent of those surviving had an annual capacity of over 900,000 tons.[101]

Technical upgrading and increasing the scale of surviving TVMs was as important as any contraction in their number (TVM total output continued to grow up to 2012).[102] Both processes took place in Hunan, where numbers declined steeply (from over 3,000 in 1991 to 159 in 2018) as the state continually adjusted the minimum permitted size, closing down any mine with a capacity of under 90,000 tons and putting strict conditions on any under 300,000. At the same time, local governments, keen to protect coal supplies and employment, offered incentives to owners to upgrade and expand: one county offered 2 million yuan for upgrading to fully mechanized mining, and 1.2 million yuan for a high-grade conventional coal face.[103] TVM status became less associated with excessively small scale, and average scale increased across the industry. Nationally, mines with a capacity of under 300,000 tons contributed 45 per cent of total production in 2005, 22 in 2010 and 5 in 2018, while between 2010 and 2018 mines producing more than 1.2 million tons annually increased their share from just under 60 to close to 80 per cent.[104]

Geng and Saleh argue that mine closures were wholly responsible for the decline in fatalities, but this seems to go too far.[105] As outlined above, death rates declined across all types of mining enterprise, and some rough calculations

94 Zhu 2017, 87.
95 SACMS 2010, 18–20, 88–89; supplemented by *Zhongguo meitan gongye nianjian* various years. The TVM figure here uses adjusted estimates for TVM output.
96 Dangzu 2020.
97 Wright 2007.
98 Li, Tieying 2005.
99 Zhu 2017, 91; Huang, Shengchu 2008, 71.
100 Zhang, Likuan, and Wu 2019, 5; CNCA 2019, 21.
101 Zeng, Yang and Liu 2016, 26.
102 Liu, Quanlong, et al. 2017, 267.
103 "Hunan xiangzhen meikuang de 'qianshi jinsheng'" (The past and present of Hunan TVMs). *Zhongguo meitan bao*, 2 July 2019, http://www.coalchina.org.cn/index.php?m=content&c=index&a=show&catid=15&id=51175. Accessed 19 January 2020.
104 SAWS 2011; SACMS 2019a; Qin 2019, 57, 60; Xie 2016, 77.
105 Geng and Saleh 2015, 44.

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holding death rates at 2005 levels suggest that the closure or restructuring of small mines probably saved around 2,500 lives, about half of the total decrease in fatalities.

Technology

Technological change – partly in response to state pressure, partly autonomous, but generally within the existing technological frontier – has everywhere been an important contributor to better safety.[106] In China, the technology most directly relevant and at the forefront of state concern involved ventilation to control gas and reduce the incidence of explosions, although mechanization and a shift towards open-cast mining have also played a role.

Even though roof falls often account for as many fatalities overall, most political attention, in China and elsewhere, is paid to the largest disasters, which are typically triggered by explosions, mostly of gas, sometimes of coal dust.[107] In 2007, the SAWS made gas control a top priority,[108] and the State Council confronted the issue in annual conferences from 2005 to 2011.[109] Between 2005 and 2007, 3 billion yuan was allocated annually for this purpose to large state-owned mines hampered by economic difficulties.[110] Moreover, permitted production levels were set according to a mine's ventilation capacity.[111]

These measures yielded clear results. Increased mine gas extraction – from 2.3 billion cubic metres in 2005 to 8.8 billion in 2010 and 17 billion in 2017 – reduced the number of explosions.[112] Figure 5 shows both the high toll from and the rapid improvement in gas explosions, the number of which declined substantially (in fact beginning from the late 1990s), and no major disaster costing 50 lives or more occurred between 2010 and 2020. However, whereas in the US the number of explosions clearly declined before a decrease in other smaller accidents occurred,[113] in China fatalities from roof falls fell between 2002 and 2016 by almost the same degree as deaths from explosions (94 per cent).

In general, open-cast mining (albeit environmentally problematic) tends to be much safer than underground mining. Over the past two decades, China has seen a significant increase in open-cast production, from 30–40 million tons (around 5 per cent of total output) throughout the 1990s to 90 million in 2004.[114] During the boom, new open-cast mines were established, particularly in Inner Mongolia, and output reached 528 million tons in 2017, about 14 per cent of

106 Braithwaite 1985, 6.
107 Durham Mining Museum n.d.; Duckham and Duckham 1973, 15–16.
108 SAWS 2007; Zhu 2017, 83.
109 Zhu 2017, 85.
110 Guo 2008, 149.
111 SAWS 2007.
112 Qin 2019, 60; SAWS 2011.
113 Aldrich 1997, 212; Graebner 1976, 6.
114 CNCA 2006, 183.

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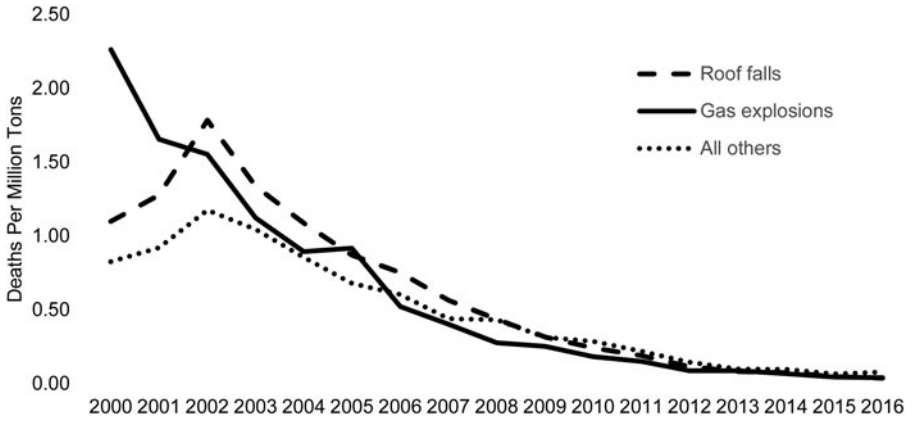
Figure 5: **Deaths Rates from Different Causes, 2000–2016**



Sources:
CNCA 2006, 676; *Zhongguo meitan gongye nianjian* 2005, 565; Liu, Yanliang 2018, 66.

the total.[115] Nevertheless, even if open-cast mines were completely safe, a 10 percentage point increase in their share would not itself contribute more than a similar fall in fatalities. In fact, open-cast mines supply a far smaller proportion of output in China than in the next three largest producers: India (70 per cent), the US (over 60 per cent) and Australia (80 per cent).[116] This constrains any attempts to improve China's safety to global levels.

Changes (in particular, mechanization) in underground mines were more important. Mechanization improves safety by reducing the labour intensity of extraction, exposing fewer workers to hazards. In the late 1990s, non-mechanized mining in China had a fatality rate six times that of fully mechanized mining and 2.5 to 4.3 times that of partially mechanized mining.[117] The industry therefore embarked on a programme of "replacing human labour with machines," so that, by 2019, 98.03 per cent of coal from large mines was cut by machine.[118] The SAWS also introduced policies specifically to reduce numbers underground: all 48 pits employing over 1,000 miners per shift in 2016 had reduced their shift sizes to under that number by 2019.[119] From 1992, state policy promoted mines with high levels of both safety and technology, whose number increased from 12 in 1993 to 763 in 2017, bringing about a general improvement in technological levels.[120] Foreign observers confirmed that the best Chinese mines matched the

115 "Zhengdi nan 'shufu' daxing lutian meikuang channeng" (Difficulty of land acquisition constrains production capacity of large-scale open-cast coal mines). *Zhongguo nengyuan bao*, 7 November 2018, 1, https://www.china5e.com/news/news-1043870-1.html. Accessed 3 February 2021.
116 "Zhongguo lutian caikuang de fazhan qushi" (Open-cast mining in China), 21 May 2019, http://www.chinacaj.net/i,33,419369,0.html. Accessed 4 November 2019; Zhao, Hongze, Zhen and Li 2016, 12.
117 Guo 2008, 174–75.
118 CNCA 2019, 21.
119 Hu, Zhang and Zhang 2019, 7.
120 Qin 2019, 57.

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standards anywhere in the world.[121] However, although mechanization undoubtedly made a contribution, in 2002 – the year before the improvement started – the proportion of mechanized extraction in the large mines was already 78 per cent.[122] So, the relatively limited increase was probably not the main factor behind better safety.

Training and the Workforce

Whatever the underlying reasons for accidents, the proximate cause is often human error, and policymakers everywhere have foregrounded upgrading the safety consciousness of workers, foremen and managers through training and the development of a "safety culture."[123] From 2003 onwards, the SACMS developed programmes to train work teams in safety, introducing a project in 2009 to upskill 10,000 foremen.[124] As a result of such policies (and also of higher levels of education as society modernized), the quality of both managers and ordinary miners improved. By 2016, 97 per cent of managers had specialist training, while the proportion of miners with qualifications at or below lower middle school level fell from 60 per cent in 2012 to just over 50 in 2017.[125]

Training was the focus of many cooperation schemes with foreign experts. One project involved 1,292 technicians, managers and safety inspectors being sent to Japan for training, while 60 Japanese experts ran more than a hundred on-site training courses in China. The students trained in Japan won promotion to many senior and important positions after their return.[126] A general strategy, as in a US programme with the Yangquan Mining Group 阳泉煤业集团 in Shanxi, was to target a pilot mine and then to cascade that experience down to other mines and areas.[127]

The idea of a "safety culture" in which all stakeholders contribute to promoting safe work practices focuses on instilling a strong safety awareness throughout the workforce. Accident prevention is a key aspect, with a zero-tolerance attitude towards violations of safety procedures.[128] Again, international best practice and collaboration played an important role, as Chinese mines adopted from their Japanese counterparts concepts such as "safety first, production second" as well as more specific techniques for confirming the safety of the production process.[129]

Conclusion

This article has argued that the dramatic improvement in China's coal safety shown in the official statistics is real, not just apparent, even if the details are

121 Feickert 2013, 26.
122 Guo 2008, 176.
123 Braithwaite 1985, 6–7; for aviation in China, see Uhalley 1998, 221.
124 Zhu 2017, 95.
125 Huang, Shengchu 2019, 41.
126 Huang, Haihui 2019, 119.
127 Eastern Research Group 2007, v.
128 Tong et al. 2020, 85.
129 Huang, Haihui 2019, 119–120.

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open to question. It has offered a relatively state-focused explanation. While structural factors played an important role and were no doubt leading to a secular decline in fatalities, it is unlikely that the decline would have been so rapid without the active agency of the state.

This particular case lends little support to political economy approaches that stress the political balance between labour and capital or that focus on independent labour organization as a key prerequisite for improving safety.[130] The party-state made coal safety a high priority, but not one nearly high enough to outweigh the overwhelming requirement to maintain its monopoly on power. There is no sign of autonomous labour organizations playing any part in the improvement in safety nor of the decentralized mechanisms that Suttmeier believes are necessary conditions for progress.[131]

What the story does show is that the Chinese state is able to effect change in a largely top-down fashion if it prioritizes that change. Just as with air safety in the 1990s, the adverse publicity within and outside China about the high coal fatality rate at the beginning of the century gave the state the impetus to devote financial and organizational resources to addressing the issue. In both cases, the aim was relatively clear – the reduction of fatalities in mine disasters or aircraft crashes – and could be addressed in a target-based system. Absent the specific conditions, however, a broader improvement in workplace health and safety would almost certainly require both greater empowerment of workers and the decentralized mechanisms suggested by Suttmeier.

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Supplementary material

Supplementary material is available online at https://doi.org/10.1017/S0305741021000941.

Conflicts of interest

None.

Biographical note

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130 See, e.g., Kerswell and Deng 2020, 217.
131 Suttmeier 2008, 143.

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摘要: 自2003 年以来，中国的煤矿安全得到了明显的好转。虽然官方的数据有时并不完全可靠，但好转是无疑的。结构性的因素比如中国经济的发展水平，劳动力市场的变化，以及煤炭工业的健康发展都起了重要性的作用。但是最为关键的还是政府的关注与政策。它们对好转的速度与幅度是起着决定性的作用。

关键词: 安全生产; 煤矿事故; 中国国家能力; 中国官方统计的可靠性; 调查新闻业; 安全文化; 采煤机械化

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