

ORIGINAL RESEARCH ARTICLE

Understanding institutional and policy challenges in China's coal transition: Insights from the case of Chongqing

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ABSTRACT

China's efforts and decisions to phase out coal will shape global endeavors in addressing climate change in the upcoming decades. This study investigates the action logic and interactions among different stakeholders, including the central government, local government, coal enterprises, and mine workers, in the case of Chongqing to gain valuable insights into existing institutional and policy challenges. Our results demonstrate that: First, the provincial government is the key to managing and implementing the local coal transitions, its motivation for coal transition, however, may not always align with the nation's overall priorities. This highlights the need for a top-down coal transition policy to address the mismatched incentives among various participants. Second, Chongqing's successful experience in maintaining economic development and whole employment demonstrates the possibility of adopting a rapid coal closure in places with similar resource endowments and industrial structures. Chongqing's collaborative approach to transferring social responsibilities to local governments also serves as a valuable model that may apply to others' contexts. Lastly, it is crucial to make context-based policy adjustments and establish an integrated and independent governance system when pursuing a rapid, efficient, and safe coal phase-out.

Keywords: coal transition; stakeholders; institutional challenges; policy-making

1. Introduction

As the world's largest consumer, producer, and importer of coal, China's economy heavily relies on coal, which has contributed to more than half of global coal consumption since 2011¹. Coal is the largest single source of CO₂ emissions, accounting for 42% of the 36.8 Gt CO₂ of global energy-related CO₂ emissions in 2022². China's strong dependence on coal presents a significant challenge to global decarbonization efforts, highlighting the importance of China's coal transition in the global endeavors to address climate change³. In

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order to achieve the carbon neutrality goal by 2060, China must reduce coal demand to almost negligible levels (i.e., 0) by 2050⁴, which, in turn, necessitates a proactive and well-planned approach to the coal closure^{5,6}.

Although China has made significant strides in addressing climate change by pledging to stop the construction of new coal-fired power plants abroad since 2021⁷ and reduce domestic coal consumption in the period of 2026 to 2030⁸, China's continued dependence on coal is further prolonged due to energy security concerns and uncertainties⁹. Nowadays, China faces increasing pressure due to the global trend of coal phase-out, with 31 countries incorporating specific dates for coal phase-out into their national plans by July 2022. Notably, Belgium, Austria, Sweden, and Portugal had successfully achieved their goals by August of 2022¹⁰.

While China's regional and local governments have targets for coal phase-out, coal phasedown has been very slow. Until recently, only the municipality of Chongqing has proactively completed its coal mine closure whilst retaining the coal-fired plants. Chongqing is the only municipal city directly under the management of the central government in the western region of China. It is one of the biggest cities in the world, with a population of 32.133 million in 2022 and an area of 82,400 square kilometers, roughly the areal size of Austria or the French region of Nouvelle Aquitaine¹¹. In 2021, Chongqing successfully shut down 14 state-owned coal mine enterprises, involving an eliminated coal production capacity estimated at 11.5 million tons/year and affecting over 20,000 coal workers. The scale and scope of Chongqing's coal closure are unprecedented. However, little research exists to prudently consider and deliberate Chongqing's experience by systematically analyzing its institutional, political, and socio-economic contexts. Chongqing's coal closure is a complicated and dynamic process involving multiple stakeholders, including the central government, local government, coal enterprises, and mine workers. Each participant would make different strategies by weighing its own costs and benefits. This paper tries to examine Chongqing's experience, either success or failure, to develop a deeper understanding of the effectiveness of the coal mine closure based on the analysis of action logic and interactions among different participants and provide insights for policymakers and practitioners to improve the local and national government's ability to manage this transition in a rapid, safe, and efficient manner with minimized negative effects.

2. Background

2.1. Coal production and consumption in Chongqing: Current trends and future directions

The energy sector in Chongqing was primarily dominated by coal, accounting for 44%–49% of energy consumption from 2015 to 2020¹². As of 2017, 90% of the city's coal production came from the local state-owned coal mines¹³. Chongqing is one of the main areas facing a structural coal shortage, relying heavily on external supplies. During the entire duration of the 13th Five-Year Plan, Chongqing's local coal production in Chongqing met only 63.17% of its coal consumption in 2016, a figure that decreased to 23.90% by 2020. The primary objectives of coal production in Chongqing were: i) stabilizing coal market prices; ii) meeting the power generation demand of local power plants during periods of coal supply interruption; iii) guaranteeing the energy consumption for residents and small industries in remote areas, such as flue-cured tobacco and ceramics. Although Chongqing was previously one of China's 24 coal-producing provinces, its contribution to the country's total coal production only ranged from 0.23% to 0.7%. Chongqing is a coal-importing province, and its dominant industries are non-energy-intensive industries, such as microcomputers, mobile phones, automobiles, and motorcycles.

The closure of coal mines in Chongqing can be divided into three phases. From 1998 to 2000, China initiated a plan to close illegal and irrational coal mines to deal with the over-capacity in the coal industry and promote state-owned enterprises (SOEs) reform. During this phase, small-scale mines, namely township and

village coal mines (TVCM) were targeted, and a total of 3300 TVCMs were closed during the period in Chongqing¹⁴. Since 2016, the Chinese government has adopted a range of de-capacity policies following a period of rapid expansion in the industry between 2002 and 2012, known as the “Golden Decade”. And state-owned coal mines became the primary target during this phase. From 2020 to 2021, Chongqing decided to completely eliminate coal production capacity, and large state-owned coal mines became the focal point. As shown in **Table 1**, Chongqing’s coal output experienced a gradual decline during the period of the 13th Five-Year Plan (2016–2020) and then a dramatic decline, reaching 0 tons in 2021. The data in **Table 1** highlights an intriguing trend where coal production has reached a point of complete decline since 2016, while coal consumption has remained consistent. To bridge the widening gap between coal supply and demand, the local government resorted to importing coal from other provinces to meet immediate energy security needs. Since then, Chongqing has transferred from a modest net importer of coal to a big net importer. This paper limits the analysis to large state-owned coal mines and their employees.

Table 1. Chongqing’s coal production, consumption, and industrial SO₂ discharged (2016–2021).

Primary index	2016	2017	2018	2019	2020	2021
Coal production (million tonnes)	24.20	11.72	11.87	11.51	9.39	0
Coal consumption (million tonnes)	38.30	38.99	40.51	40.62	39.31	39.83
Industrial SO ₂ discharged (tonnes)	111,400	104,900	85,800	68,900	47,000	41,700

Source: Chongqing Statistical Yearbook 2022¹⁵.

The coal consumption in Chongqing is divided between thermal coal, utilized for power generation, and non-thermal coal, utilized in various industries such as metallurgy, construction materials, chemicals, ceramics, flue-cured tobacco, roasted wine production, and supporting the livelihood of people in remote areas. Both types collectively constitute about half of the total coal consumption. Local authorities have recognized this approach is not sustainable unless there is a concerted effort to reduce coal consumption. Chongqing’s 14th Five-Year Plan for Energy Development (2021–2025) clearly articulates its dedication to diminishing the share of coal consumption in the energy framework. This will be achieved by bolstering clean energy supply and advocating for coal replacement in coal-consumption industries, primarily through projects like coal-to-electricity and coal-to-gas initiatives. As articulated in Chongqing’s 14th Five-Year Plan Electric Power Development Plan (2021–2025), coal-fired power is slated to play a fundamental role in ensuring energy security and serving as a system-regulating source in the future. It is worth noting that during the 13th Five-Year Plan period, Chongqing experienced an increase in total energy consumption in line with economic development. However, what’s particularly significant is that, despite this, the proportion of coal consumption decreased from 49.1% in 2015 to 44.3% in 2020, which is 12.5% lower than the national average. This reflects the impressive progress Chongqing has made in its coal transition. Although Chongqing still faces the challenge of fully phasing out coal and embracing renewable energy alternatives, it is reasonable to expect a continued decline in coal consumption as a proportion of the region’s total energy consumption.

2.2. Mining accidents accelerated Chongqing’s coal closure

Chongqing’s transformation away from coal was primarily driven by incident prevention, while also giving consideration to the energy transition. Chongqing’s coal mines are characterized by thin coal seams, poor gas permeability, and complex geological structures, which often lead to coal fires, methane-coal dust explosions, water intrusion, roof caving, and rock bursts. Chongqing is the region with the most serious coal and gas outbursts¹⁶, with the majority of coal mines (95%) being high-gas or gas outburst mines¹⁷. Coal mining

in Chongqing has been recognized as a high-risk industry with significant mining difficulties, high costs, and frequent accidents. Moreover, the coal quality in Chongqing is generally poor with high sulfur content (> 4%) and medium ash content (15%–25%)¹⁸.

Following two large-scale fire accidents that occurred at Songzao coal mine (16 deaths from carbon monoxide poisoning induced by conveyer belt fires, September 27) and Diaoshuidong coal mine (23 killed by excessive levels of carbon monoxide gas during the equipment demolition process, 5 December) in 2020, Chongqing's determination to reduce coal production capacity and remove hidden dangers of coal-mine accidents had been very strong. In January 2021, Chongqing agreed to shut down 14 State-Owned Coal Mines (SOCMs) under the ownership of Chongqing Yuxin Energy Co., Ltd., a subsidiary of Chongqing Energy Investment Group (CQEIG), before June 2021, with a total eliminated coal production capacity estimated to 11.5 million tons/year. Mining accidents are the direct cause of the total shutdown of Chongqing coal mines in the past decade.

Chongqing shut down coal mines with an annual output of less than 300,000 tons from 2016 to 2020. This led to a substantial decrease in the total number of coal mines, dropping from 407 in 2016 to just 42 by the end of 2020. While this reduction in the number of coal mines indeed represents a decline in potential hazard sources, it does not automatically equate to enhanced safety in the remaining mines. As shown in **Table 2**, Chongqing saw a gradual decline in the number of coal mine accidents from 2010 to 2017, and then a sudden increase in 2020. Both the Songzao coal mine accident and the Diaoshuidong coal mine accident illustrate this situation. These two mines fall into the category of coal and gas outburst mines. The Songzao coal mine accident can be traced back to a failure to promptly address safety hazards related to the underground transport belt. This negligence ultimately led to a production safety liability incident. In contrast, the Diaoshuidong coal mine accident was the result of unapproved equipment demolition during the mine's closed phase. These two accidents highlight the critical significance of effective coal mine safety management and rigorous government safety oversight, both during active mining operations and the closure phase. Furthermore, they serve as a reminder of the necessity to establish an exit mechanism that can offer technical support during the mine closure phases. This proactive step is vital for minimizing accidents and ensuring a safe transition away from coal mining activities.

Table 2. Chongqing coal mine accidents (2010–2020).

Year	General accident		Large accident		Major accident		Serious accident		Total	
	Accident quantity	Death toll								
2010	135	149	8	34	0	0	0	0	143	183
2011	102	106	6	20	1	14	0	0	109	140
2012	87	92	4	13	0	0	0	0	91	105
2013	57	64	7	28	0	0	0	0	64	92
2014	47	55	2	8	1	22	0	0	50	85
2015	21	23	2	8	0	0	0	0	23	31
2016	10	12	1	3	0	0	1	33	12	48
2017	3	3	0	0	0	0	0	0	3	3
2018	7	7	1	7	0	0	0	0	8	14
2019	5	5	0	0	0	0	0	0	5	5
2020	2	2	1	3	2	39	0	0	5	44
Total	476	518	32	124	4	75	1	33	513	750

Source: Chen et al.(2021)¹⁹.

2.3. Planning system, administrative framework, and closure procedures

The development of China's coal industry is largely influenced by the "Five-Year Plan". This top-down

planning system has been effective in aligning development direction, policy design, and target setting across multiple levels of governance, including central, provincial, prefecture, county, and township²⁰. The “China’s Five-Year Plan for Energy Development” and “The 13th Five-Year Plan for Coal Industry Development” set an overall framework and development goal for China’s coal industry. In the decentralized executive power structure, both the central and provincial levels of government hold capacities for oversight, licensing, and policy-making of the coal sector²¹. Meanwhile, the central government relies on provincial governments to facilitate policy implementation. As a result, the provincial government is the key to managing and implementing local coal transition.

Chongqing State-owned Assets Supervision and Administration Commission (SASAC), as a government agency, holds full ownership of CQEIG and secures controlling rights as the ultimate owner as shown in **Figure 1**. As stated on the official website of Chongqing SASAC, its main responsibilities contain asset management supervision, personnel appointments, and party-building within SOEs. In each SOE, there exists a local party committee (LPC) that possesses the authority to veto “three-important and one-large” matters before they are presented to the board of directors for consideration²². The process, known as the ex-ante procedure, empowers the LPC to exert influence and control over the decision-making process, ensuring adherence to the principles and policies of the Communist Party of China (CPC) and the state within SOEs²³. It is important to note that executives in Chinese SOEs hold a dual role, serving as both managers and quasi-officials with political ranks²⁴. CPC membership is also a prerequisite for holding high positions in government as well as large SOEs²¹. Since the local SASAC holds the authority to appoint, dismiss, assess, reward, and penalize SOE executives based on performance evaluation, these executives must align with both political requirements and commercial guidelines in their decision-making and management practices. The administrative framework and closure procedures in Chongqing are illustrated as follows:

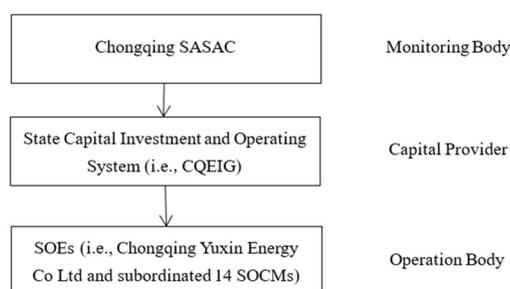


Figure 1. Administrative framework of SOEs in Chongqing.

Source: Jin et al. (2022)²².

2.3.1. Closure plan

The Chongqing SASAC assumed the responsibilities associated with the closure of SOCMs. This involved the development of an overall closure plan and complementary plans for asset disposition, personnel relocation, transition of social functions, compensation for closure, and handling of bank debts. The final endorsement of these plans rested with the provincial government. CQEIG held a distinct responsibility for executing the closure and subsequent proceedings of its subordinate SOCMs. These actions were carried out in full alignment with the directives set forth by the Chongqing SASAC.

2.3.2. Technical review and acceptance

Chongqing Yuxin Energy Co., Ltd. entrusted qualified firms with the task of compiling and preparing essential documents, such as the “Safety Technical Plan”, “Coal Closure Report” and “Coal Closure Geological Report”. The district and county governments assumed the responsibility to undertake preliminary technical

reviews and acceptance. Subsequently, the Chongqing Municipal Energy Bureau was responsible for double review and acceptance at the municipal level.

2.3.3. Safety responsibility and oversight

Local township (or street) governments were accountable for overseeing closed coal mines that had successfully undergone the double review and acceptance process. This entailed establishing a framework for safety inspections, a system to report and address safety hazards, as well as a mechanism for reporting and rewarding positive practices. Mines that had not yet received double review and acceptance remain the focal points. In such cases, coal mine enterprises were responsible subjects. The authorities responsible for coal mine safety supervision, including local emergency management bureaus, were tasked with upholding their roles in supervision and enforcement.

2.3.4. Post-management of personnel and assets

As outlined in the closure plan, a series of transfers took place from CQEIG to local district or county governments before September 2021. These transfers involved a range of elements, including coal-related land and housing assets, financial provisions for retired individuals, and the dependents of those affected by work-related injuries or fatalities. Additionally, the responsibilities associated with managing personnel in these areas were also transferred as part of the process. Furthermore, the shift also included the responsibilities of providing compensation related to agriculture, overseeing the safety of closed mine shafts and their exits, and managing the obligations of relevant agencies. The scale of this transfer was substantial, involving 13,000 mu of land (equivalent to around 8667 hectares), over 600,000 square meters of housing space, and more than 40,000 households eligible for agricultural compensation, along with a population exceeding 70,000 individuals.

Personnel resettlement was the top priority.

- For employees who were within 5 years of the statutory retirement age, they could choose early retirement. They could still receive their normal salaries from the company without working until they reach the official retirement age (60 for males, 55 for females).
- For those employees who wished to keep working, they could be reemployed by other subsidiaries or affiliated companies of the SOE.
- Employees who were qualified to start up their own businesses would receive support such as guaranteed loans for entrepreneurship and financial discounts.
- In principle, model workers and advanced workers were given priority over job placement; those who met assistance conditions were included in the scope of social assistance in a timely manner to ensure basic living.

Land assets were handed over from CQEIG to local governments for free. And local governments wielded decision-making authority in augmenting the value of state-owned assets. In practice, local governments often cooperated with SOEs (e.g., property management companies) to manage housing assets (e.g., office buildings, factories, canteens, and plazas) via methods like investment attraction, joint operation, sale, conveyancing, and public leasing. Local governments could also rejuvenate or repurpose land assets by adjusting land-use planning, executing listed transfers, implementing land swaps, and undertaking comprehensive reconstruction projects.

2.3.5. Underground non-coal resources management

Chongqing possesses a wealth of underground non-coal resources, encompassing coalbed methane, geothermal energy, mine water, and subterranean spaces. Despite their abundance, the utilization of these

resources for purposes such as energy storage, CO₂ geological storage, geothermal applications, and cultural spaces remains largely undeveloped and underemphasized. Presently, Chongqing has preliminarily evaluated the resource endowment of coalbed methane shallower than 1000 m in key exploration areas such as Qijiang, Hechuan, Nanchuan, and Yuxi, and implemented seven surface-drilled coalbed methane wells. The regions of Qijiang Songzao, Nantong, and Hechuan Libixia have also been designated as favorable areas for coalbed methane exploration through delineation processes²⁵.

2.3.6. Clean energy development and power security

In April 2021, the Chongqing municipal government announced a series of complementary measures. These include: i) modifying land-use plans, providing partial refunds of land transfer fees, and offering tax benefits to support the construction of a coal storage base by CQEIG to strengthen energy security capabilities; ii) introducing hydropower projects to enhance the allocation of resources within power grid; iii) expanding the township gas market and establishing an LNG center in the upper reaches of the Yangtze River that integrates filling storage and inland river reception; iv) implementing the “Xinjiang Power into Chongqing” project, and undertaking the construction of seven energy transformation projects.

2.3.7. Financial subsidy

According to the notice issued by the Chongqing Municipal Finance Bureau in July 2021²⁶, CQEIG obtained a financial subsidy of CNY 7.2 million from “Municipal-level Awards and Subsidies for Overcapacity Reduction” that was allocated to 12 closed coal mines, with each mine receiving CNY 6 million. Additionally, CQEIG received CNY 567.37 million from the “Central Industrial Enterprise Structural Adjustment Special Awards and Subsidies”. Chongqing’s coal closure involved both large state-owned coal mines and privately owned mines that were distributed in 17 districts and counties. The district and county governments obtained CNY 40 million in total from the “Central Industrial Enterprise Structural Adjustment Special Award and Subsidies” to facilitate personnel resettlement in all closed coal mines. The Municipal Finance Bureau assumed the responsibility of overseeing and inspecting the utilization of these funds or subsidies within coal-producing districts, counties, and associated enterprises.

2.4. Economic, social, and environmental impacts

2.4.1. Energy shortages

Chongqing faces a shortage of renewable energy sources such as solar, wind, and biomass, and the city’s electricity generation heavily relies on thermal power, with only a minimal contribution from hydropower in arid seasons with persistently high temperatures. The coal shortage induced by coal mine closure not only led to tight coal supply and increased coal prices in the surrounding provinces but also made Chongqing a “highland” of coal prices in 2021²⁷. Chongqing’s coal closure further intensified its difficulty in procuring coal from external regions to fill the coal and power gap in the summer 2021²⁸. To secure a coal supply of 19 million tons of coal for its coal-fired power plants and critical manufacturing enterprises, Chongqing signed a coal cooperation agreement with Shaanxi Coal Group in 2023²⁹.

2.4.2. Economic impacts and its consequences for vulnerable people

Coal mine closures often lead to stranded mining assets, reduced profits, and financial instability. After the coal mines were forced to shut, the largest local state-owned energy company CQEIG, that was once ranked among Top 500 Chinese Enterprises in 2021, was requested to increase guarantee measures and change the leased property on the grounds that the leased assets would experience a significant impairment after coal closure³⁰. The surge in coal prices in 2021 also resulted in loss-making operations for coal power plants under CQEIG, further exacerbating its operational challenges. As CQEIG’s main profit contribution comes from the

coal production and power (gross profit percentage: 29.55% in 2020) and gas sectors (gross profit percentage: 32.07% in 2020)³¹, the coal closure and coal power plants running at a loss made the situation even worse for CQEIG. Due to long-term operating inefficiency, heavy debt burden, and financing difficulties³², CQEIG defaulted on USD 141 million debt in 2021³³, and officially entered the judicial restructuring process in 2022³⁴. China Resources Co., Ltd. will act as a strategic investor in the judicial restructuring of CQEIG, and jointly promote judicial restructuring procedures and related project development³⁵. CQEIG's coal closure affected over 20 thousand less educated and older people, with only 3000 relocation jobs being offered in the first batch, many of which were temporary or dispatched positions with monthly pay below CNY 3000. Therefore, most grassroots workers preferred to seek jobs in the labor market following the receipt of financial compensation, except for a small proportion accepted voluntary early retirement³⁶. At present, only a small proportion of workers remain working at the closed coal mine, handling the shut-down operations.

2.4.3. Environmental impacts

As little media coverage was found to focus on the environmental effects of closed coal mines, we tried to discover the truth by reviewing previous policy documents. We found that comprehensive utilization of coal gangue and coalbed gas, ecological restoration of abandoned and closed mine lands, and closed coal mine water treatment, were frequently mentioned by a series of “Five-Year Plans”, including Chongqing's 14th Five-Year Plan for Economic and Social Development and Long-Range Objectives, Chongqing's 14th Five-Year Plan for Energy Development (2021–2025), Chongqing's Mineral Resources Overall Plan (2021–2025), and Chongqing's 14th Five-Year Plan for Ecological and Environmental Protection (2021–2025). According to an announcement from the Chongqing Municipal Development and Reform Commission, coal mining subsidence was already a prominent concern even before the coal closure in 2021. In 2019, there were 105 coal mining subsidence areas spread over 19 districts and counties in the city, affecting 108,000 households and 356,000 people and covering a total area of 1985 square kilometers³⁷. Additionally, Chongqing's 14th Five-Year Plan for Ecological and Environmental Protection (2021–2025) indicates there are 28.82 square kilometers of historically abandoned and closed mines that have required ecological restoration and rehabilitation since 2022³⁸. Despite the harmful environmental consequences of coal mine closure, it is clear that sulfur dioxide (SO₂) emissions and acid rain could be reduced, coupled with high-quality coal import, desulphurization, and natural gas as a coal substitute. According to the Chongqing Statistical Yearbook 2022, there has been a steady decline in the amount of SO₂ gas released by industries over the past six years, consistent with the coal production trend (as shown in **Table 1**).

3. Discussion

3.1. Contradictory and changing attitudes from the central government

Despite China's rapid progress in expanding its clean energy sector, it still relies on coal for power generation. Chinese authorities realize that renewable energy resources in China are currently inadequate and characterized by intermittent availability, making it difficult to reduce coal reliance in the foreseeable future³⁹. Local governments, which are often motivated to develop clean energy and facilitate coal transition to meet the climate change targets allocated by the central government, are not incentivized to pursue a rapid transition by closing down all coal mines. A report released by the China Coal Industrial Association in 2021 openly expressed reservations about Chongqing's immediate closure of coal mines, citing concerns over coal supply security and cautioning against a “one-size-fits-all” approach to energy transitions⁴⁰.

It is worth noticing that China's “Two Sessions”, namely plenary meetings of the National People's Congress and the Chinese People's Political Consultative Conference in March 2023, reinforced the importance of coal for the country's energy security, by stating that coal would be the mainstay of the nation's

energy mix rather than being relegated to a supplementary energy source as indicated in previous policies⁴¹. This shift in attitude came after the widespread power shortage in 2021, after which China's leadership has moved heavily toward supporting coal to ensure an adequate and affordable energy supply⁴³. According to the Centre for Research on Energy and Clean Air, China has six times as much coal power capacity starting construction in 2022 as the rest of the world combined 错误!未找到引用源。. This near-term policy stance, coupled with ongoing investment in coal infrastructure, will further complicate China's coal transition and pose significant challenges to the dual-carbon target⁴¹.

China operates under a multi-level system of government, where the central government's primary objective is to maintain a healthy and sustainable economy by optimizing the structure of industries and enhancing economic quality through policy formulation. Energy security, as the major factor influencing economic development, naturally becomes the main concern for the central government. When facing the dual target set by itself, the central government may temporarily disregard the dual-carbon target and prioritize short-term energy security after carefully assessing the pay and gains. China is such a big country that every province has different pre-existing political and economic conditions and hence different development goals and interest demands, which are, unsurprisingly, not always consistent with the nation's overall priorities.

3.2. Political incentive: A trade-off between economic growth and safety governance at the provincial level

In 2021, the deputy mayor of Chongqing Municipal People's Government emphasized the importance of coal production safety by stating that "coal is no longer a scarce product, and there is no need to waste lives when just a few more tons of coal are dug. Everyone must understand this and put safety first"⁴⁴. His statement clearly reflects the attitudes of Chongqing's high-ranking officials towards coal production. According to the "Provisions of the State Council on Investigation for Administrative Responsibility for Extraordinarily Serious Safety Accidents"⁴⁵, officials in coal-producing areas generally face high political risks. When an extremely fatal accident occurs, principal government leaders may face administrative sanctions, such as demotion or dismissal, based on the severity of safety accidents. They may also face criminal investigations and legal consequences if they are found to neglect responsibilities. Even in cases where accidents occur without fatalities, responsible officials would still be punished due to "very bad social impact", especially during local and national "Two Sessions"错误!未找到引用源。⁴⁶. In Chongqing, the two coal accidents in 2020 led to administrative penalties for 60 officials, with 10% of them facing criminal charges or suspected duty-related crimes.

If we look further into promotion criteria for Chinese provincial officials, we find it is very important for provincial high officials to seek a balance between economic growth and safety governance. While local officials' chances of promotion are tied to the economic growth (i.e., GDP) in their jurisdictions⁴⁷, their political careers can be sealed by extremely fatal accidents. Given that Chongqing is neither a major coal-producing area nor a coal-dependent industrial hub, Chongqing can mitigate the potential negative impact of coal closure on energy supply and economic development by coal importing from other top coal-producing provinces such as Shanxi, Inner Mongolia, Shaanxi, and Xinjiang. Therefore, it is logical for Chongqing's high officials to seek a more efficient economic development model by closing down enterprises with low economic efficiency and high accident rates.

Due to the tax-sharing reform in 1994, the responsibility for generating revenues, allocating budgets, and mobilizing resources shifted from the central government to the provincial government to achieve the goals set by themselves and the upper level (e.g., dual carbon target)⁴⁸. Projects like coal-fired power plants that solve energy shortages and satisfy the power demand can potentially generate higher incomes. Provincial governments such as Chongqing, therefore, may be reluctant to close coal-fired power plants to achieve a

complete coal phaseout. Chongqing's steady economic growth during the period of 2020–2022 spanning the coal closure campaign, demonstrates its efforts to maintain local economic development and aligns with its previous expectations. According to data from the Chongqing National Economic and Social Development Statistical Bulletin in relative years⁴⁹⁵¹, Chongqing's GDP increased from CNY 2.50 trillion in 2020 to CNY 2.79 trillion in 2021 and CNY 2.91 trillion in 2022, with year-on-year annual growth rates of 3.9%, 8.4%, and 2.6% respectively. Although employment in the mining industry in Chongqing fell from 76,500 persons in 2020 to 41,600 persons in 2021, the overall employment figures remained stable, ranging from 16,760,100 to 16,682,700 persons, as reported in the Chongqing Statistical Yearbook in 2022¹⁵. This suggests that the labor force in the mining industry was able to transition to other sectors. Furthermore, Chongqing's GDP per capita in 2022 was calculated at CNY 90,663⁵¹, which was 5.8% higher than the national average. More importantly, the general public budget revenue of Chongqing rose from CNY 2094.85 trillion in 2020 to CNY 2285.45 trillion in 2021¹⁵. These figures indicate that the majority of people's incomes and employment were not influenced by coal closure, and the vested interests such as GDP and financial revenue, remained intact. Therefore, Chongqing's decision to close coal mines while maintaining coal-fired plants can be seen as a choice that serves the fundamental interests of the overwhelming majority of the people in Chongqing.

3.3. The dilemma of state-owned energy enterprises

SOEs play a critical role in China's economy and hold significant importance for the Chinese state in general²². According to the "Guiding Opinions on Functional Definition and Classification of State-Owned Enterprises" issued in 2015⁵², state-owned energy enterprises such as CQEIG can be categorized as public welfare SOEs that provide public goods and services to society. Unlike commercial SOEs in competitive industries, their primary focus is not solely profitability, but maximizing social welfare contributions and also ensuring the profit is within an acceptable level. Although SOEs benefit from their state ownership and close ties to the government, such as favorable financing rates, lower return expectations, implicit or explicit state guarantees, and direct government subsidies⁵³, their decision-making process and financing activities are heavily influenced by government control and involvement.

As key participants in the market economy, state-owned energy enterprises' first consideration is to minimize the high costs of personnel relocation and mining asset disposal during the process of coal closure to profitably survive in the market. This creates opportunities for negotiation between state-owned energy enterprises and local governments in areas such as government subsidy and implementation details of the coal mine closure plans. A valuable lesson we can learn from Chongqing is we can leave some room for discussion between SOEs and territory governments to determine how much social responsibility that SOEs are willing and capable of taking. This approach allows for flexibility and encourages a collaborative approach that considers the interests of both SOEs and local governments.

Public welfare SOEs are fully owned by the government and operate under a governance approach dominated by political considerations⁵⁴. When controlling shareholders, whether it is the government or politicians, prioritize social or political benefits over corporate profitability⁵⁵, and lack effective managerial mechanisms or executives' incentives⁵⁶, SOEs frequently face significant agency costs. To address these challenges, future research can focus on how to enhance SOEs' management efficiency and reduce their policy burden based on their ownership structure and executives' incentive structure, and then identify the best practice for SOEs' governance in the context of the political ecosystem of China.

3.4. Vulnerable people and affected local communities

In China, a large portion of coal workers are above the age of 40⁵⁷. Unlike coal workers in Western countries, many of them have limited education and lack transferable skills due to the absence of the

government or employer-sponsored re-training program. The coal sector in China offers higher average wages compared to industries such as manufacturing, construction, and agriculture²¹. As a result, coal workers who were previously employed in local communities often have to relocate to new work locations in order to maintain a similar salary level. This separation from their families or the burden of a long commuting distance may be challenging for their daily lives. In China, only the government holds the decision-making power for the transition process⁵⁸. Labor unions may face challenges in actively participating in various activities (e.g., consultations, discussions, and voting) and effectively advocating for improved compensation measures.

During the process of coal closure, local communities have encountered numerous economic and social challenges, including the loss of employment opportunities and local revenue from taxes and fees. In the case of Chongqing, the responsibility for tackling those challenges falls upon the district and county governments, with little support from the provincial government. The major focus of coal closure efforts in Chongqing is centered around Qijiang and Wansheng, with the former as a coal-dependent city and the latter as a coal-resource-exhausted city. As reported by Sina Finance, Qijiang's coal production capacity constituted around 60% of Chongqing at its highest point and the value generated from coal accounted for half of Qijiang's overall industrial value⁵⁹. Both cities successfully developed alternative economic activities to create new employment opportunities for former coal workers and diversify the source of financial revenue. As shown in **Table 3**, in spite of a minimal rise in the number of registered unemployed persons, there was minimal impact on economic development and government revenue. In Qijiang, various measures were implemented to facilitate the transition towards a high-tech city. These measures include the integration of intelligent technologies into traditional industries, the expansion of the industrial chain within advantaged industries, and the establishment of an innovative economic corridor⁵⁹. Similarly, in Wansheng, efforts were focused on promoting the specialty crops industry, nurturing strategic emerging industries, and fostering tourism⁶⁰.

Local communities in post-mining areas have traditionally faced challenges related to geological instability and safety issues. Nowadays, there is a growing demand for sufficient technical assistance and monitoring measures to ensure an efficient and safe coal closure. For instance, in August 2021, the Emergency Management Bureau of Qijiang District was reported to conduct supervision activities to address local residents' concerns regarding methane leakage from the closed underground coal mine—Fengchuan Coal Mine⁶¹. In March 2021, Chongqing quickly issued the “Notice from the Chongqing Municipal Work Safety Commission Office on further strengthening coal mine closure safety work”⁶², following the tragic incident when the collapse of an old fence at Yuyang Coal Mine caused two deaths and three injuries in February 2021⁶³. Chongqing's prompt response and decisive actions indicate its strong commitment to placing the well-being of local communities as a top priority.

Table 3. Gross domestic product (GDP), general public budget revenue, and registered unemployed persons in Qijiang and Wansheng.

Primary index		Qijiang district (excluding Wansheng)	Wansheng economic development district
GDP (CNY trillion)	2020	500.30	213.97
	2021	506.91	235.42
	2022	531.31	239.48
General public budget revenue at district or county level (CNY trillion)	2020	20.5	10.7
	2021	21.1	10.9
	2022	21.24	7.68
Registered unemployment at district or county level	2020	3403	3743
	2021	5353	3334
	2022	5135	4222

Source: 2020–2022 Qijiang^[64–66] and Wansheng^[67–69] National Economic and Social Development Statistical Bulletin.

4. Conclusions and policy implication

4.1. Policy challenges

Unlike the specialized policy framework observed in Western countries, Chongqing has continued to rely on de-capacity policies to manage personnel relocation and financial subsidies during the process of coal closure. Given its rapid transformation, Chongqing doesn't receive extra financial support from the central government and relies on itself to tackle the massive socio-economic impacts. With limited support from the central government, the provincial government faced challenges in terms of technical assistance, financial support, and participatory decision-making processes required for a rapid, efficient, and safe coal closure. China features a top-down and command-control regime⁷⁰, and this system proves to be effective in policy formulation and implementation¹⁴, which enables a rapid transition⁷¹. Chongqing's rapid coal closure, therefore, presents unique opportunities for experimentation, enabling a more profound exploration of how provincial governments identify potential socio-economic risks and proactively mitigate potential impacts to enhance the coal closure process. In light of this, we hereby propose policy measures and comprehensive strategies to accelerate Chongqing and China's transition away from coal.

4.2. Enlightenment of Chongqing's case

A rapid coal closure presents economic, social, and environmental challenges for various stakeholders, which include local governments (e.g., impacts on employment levels, local tax revenues, and energy security), existing coal-asset owners (e.g., stranded mining assets and reduced profits of hundreds of enterprises among the entire coal value chain, especially coal-fired plants and coal-consuming enterprises), local communities (e.g., geological instability, land subsidence, potential risk of methane leakage), and coal workers (e.g., job loss, low incomes, and separation from family). While coal transition is primarily driven both by market economics and governmental regulations, such a short time frame is unlikely to give affected stakeholders sufficient time to plan and transition to new directions. Therefore, it is necessary to adopt a participatory and gradual coal closure process, where a dedicated task force is able to be established to advocate the interests and concerns of affected stakeholders, and experimental projects and policies could be tested in advance. Moreover, a financial and tax system is essential to assist existing coal-asset owners in addressing potential financial instability and transitioning toward renewable energy or new development directions before coal closure. Furthermore, there is an urgent need to establish an exit mechanism that not only provides adequate technical assistance on coal mine shafts permanent closure, the disposal and dismantling of underground equipment, following monitoring measures, but also offers policy support and guidance for repurposing of closed mines for energy storage, geothermal applications, and cultural spaces. Finally, it would be highly beneficial to establish collaborative partnerships among provinces to exchange strategies and experiences and extend coal transition initiatives beyond the provincial level.

4.3. Future reform direction

China's coal transition is still in its early stages compared to other developed countries. As a result, there is a growing need for a top-down coal transition policy to address the mismatched incentives among various participants, including the central government, local government, coal enterprises, and mine workers. Given the vast size and regional diversity of China, each province faces a different situation during coal closure. The impacts of coal phase-out can vary greatly, from coal-rich provinces (e.g., Shanxi, Inner Mongolia, Shaanxi, and Xinjiang) that have built revenue systems on coal resources³, to coal-reliant provinces (e.g., Hebei, Jiangsu, and Shandong) that have developed energy-intensive consuming industries (e.g., steel, cement, chemicals, and textiles)²¹, and coal-importing provinces (e.g., Chongqing) that face a shortage of renewable energy. Therefore, it is necessary to make context-based policy adjustments in these regions to mitigate transitional risks and

potential socio-economic impacts. When formulating a reliable coal phase-out plan at the national level, it is crucial to incorporate the prioritization of coal phase-out among provinces based on the analysis of their resource's endowment and industrial structures⁷².

The management of coal mine closure necessitates the cooperation of multiple governance actors and departments; however, the functions are fragmented across numerous government agencies. For example, the Administrative Department of Ecology and Environment and its local bureaus are responsible for mine water pollution monitoring; the Administrative Department of Natural Resources and its local bureaus are in charge of ecological restoration and rehabilitation of closed coal mines; the Administrative Department of Emergency Management and its local bureaus are responsible for safety supervision; the Administrative Department of Human Resources and Social Security and its local bureaus are responsible for personnel relocation. The lack of centralized authority overseeing the entire process may lead to inefficiencies and inconsistencies in policy formulation, implementation, and coordination. To address these challenges, future institutional reforms could establish an independent vertical governance system through the newly established Project Management Office at the national, provincial, and district levels to mobilize financial resources and exclude the influence of local governments. Under the leadership of the Project Management Office, task forces could be organized at these three levels to integrate the perspectives of various stakeholders, such as coal enterprises, coal workers, and local residents. The adoption of an integrated and independent governance system, along with a well-defined coal phase-out plan, is highly beneficial for navigating China's coal transition in a rapid, efficient, and safe manner.

Author contributions

Conceptualization, DY; methodology, DY; validation, ZF and CZ; formal analysis, DY; investigation, DY, ZF and CZ; data curation, ZF and CZ; writing—original draft preparation, DY; writing—review and editing, DY, HK, ZF, CZ and ML; supervision, HK. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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