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Coal prices, ESG performance, and company performance: An empirical research study based on the Chinese A-share market

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ABSTRACT

For decades, coal has served as the dominant component of China's energy mix. Understanding the mechanisms through which coal prices variations affect China's economy and financial markets is of considerable importance. This study analyzes the influence of coal prices on company performance using a dataset comprising 33,877 annual observations from 4,491 publicly traded enterprises in China's A-share market covering the period 2014 to 2023. It further investigates how ESG (environmental, social, and governance) initiatives shape this linkage. The findings reveal that coal price fluctuations exert a significantly adverse effect on corporate performance, particularly in the overall market and energy-related sectors. In contrast, non-energy industries, which are less reliant on coal, exhibit lower sensitivity to coal price changes. Furthermore, ESG performance significantly amplifies the negative impact of coal price fluctuations on company performance. A plausible explanation is that firms with superior ESG credentials allocate greater resources to environmental and social initiatives, further increasing their cost burden. The results provide novel insights on the evolving relationship among energy price volatility, corporate performance, and ESG strategies, emphasizing the obstacles firms encounter in aligning financial objectives with sustainability targets in a coal-centric energy environment.

Contribution/ Originality: This study extends the existing literature on the dynamic interplay between energy price fluctuations, company performance, and ESG performance, providing novel insights into how firms can balance financial objectives with sustainability goals within a coal-dominated energy structure, while highlighting the key challenges companies face in achieving this equilibrium.

1. INTRODUCTION

The influence of energy price volatility on the broader economy has long been a central focus of academic research. Recently, global disruptions, including the COVID-19 crisis and the Russia-Ukraine conflict, have significantly impeded global economic growth and triggered unprecedented instability in energy markets (Lin & Lan, 2025). These disruptions have exerted a pronounced impact on energy supply chains, particularly in Europe and Asia, exacerbating global energy price volatility. China's coal market, a cornerstone of its energy infrastructure, has also been significantly affected by these shocks. Production halts and demand contractions induced by the pandemic, combined with volatility in international markets, have led to pronounced fluctuations in coal prices. A substantial body of research has explored the effects of energy price variations on macroeconomic conditions and financial systems. As a

fundamental input to economic activity and a key production factor, energy price fluctuations exert considerable influence on economic development (Lin & Shi, 2024; Lin & Song, 2024). They also affect consumption, output, and investment, trade balances, exchange rate dynamics, inflation, commodity price volatility, and stock market performance (Sun, Cai, and Huang, 2022; Yildirim and Arifli, 2021; Min, 2022; Liu, Chen, Zhong, & Ding, 2024). These mechanisms provide a strong conceptual framework for exploring the broader implications of energy price movements. In contrast to developed nations like the United States, China's economy remains heavily dependent on coal-based energy. As the leading global producer and user of coal, Wu, Liu, and Liu (2024) represented 55.3% of China's overall energy use in 2023 (China National Bureau of Statistics). Figure 1 illustrates total energy and coal consumption in China, showing a steady annual increase since 1978. Figure 2 shows that coal accounted for 55% of China's energy consumption structure in 2023. This energy dependency makes the Chinese economy more vulnerable to coal price fluctuations compared to European and American economies (Liu et al., 2024). At the macroeconomic level, coal price changes introduce heightened uncertainty and challenges, impacting inflation (Zhang, Xu, Zhu, and Huang, 2024), exchange rates (Ma and Wang, 2019), market sentiment (Liu et al., 2024), and so on. At the microeconomic level, coal price volatility impacts electricity supply (Lin and Shi, 2024), operating costs for coal-intensive industries (Kong, Yang, and Xu, 2020), and fluctuations in the coal and metals markets (Lin and Lan, 2025), among other factors.

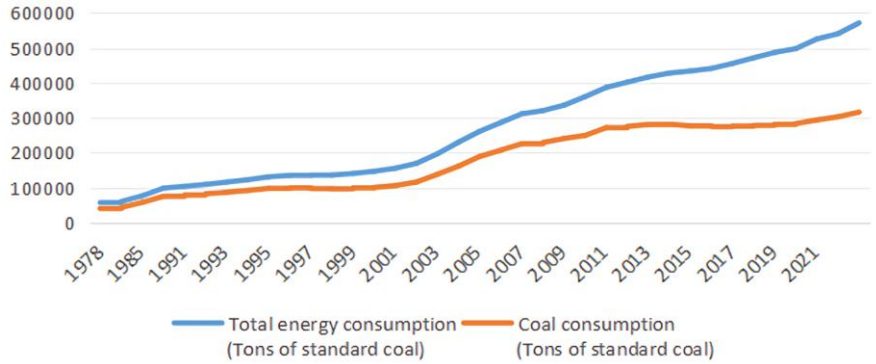

Figure 1. Total energy and coal consumption in China (Tons of standard coal).

While studies on the macroeconomic effects of energy price volatility have been increasing, the influence of coal price fluctuations on corporate performance in China has been largely overlooked. Given that industries exhibit different levels of reliance on coal, this study examines how coal price fluctuations impact company performance across energy-intensive and non-energy sectors. It also examines how ESG performance influences this association.

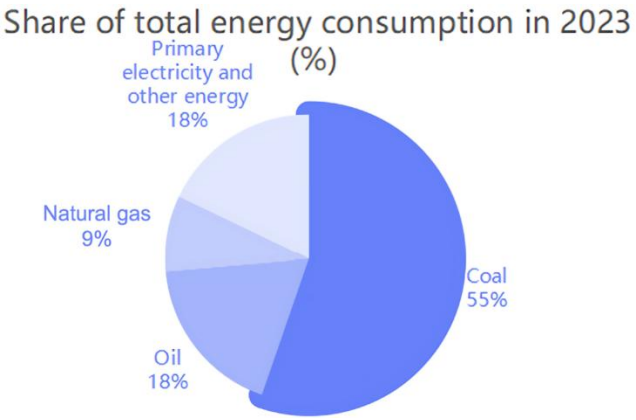

Figure 2. China's energy consumption structure in 2023 (%).

ESG performance is a key factor in assessing the effects of coal price volatility. The extraction and use of coal are associated with major environmental challenges, including air, soil, and water pollution, which pose significant risks to public health (Su, Li, Umar, & Lobonţ, 2022). To tackle these challenges, China has pledged to reach carbon neutrality by 2060, marking a shift toward a more sustainable energy system. Companies that prioritize environmental sustainability and social responsibility are increasingly gaining competitive advantages, particularly as corporate awareness of environmental issues continues to grow (Ren, Li, He, & Lucey, 2023). Moreover, strong company governance provides a solid foundation for long-term growth (He, Du, & Yu, 2022). ESG performance, as a key indicator of company sustainability, has become increasingly influential in company management and investment decision-making. High ESG performance not only enhances company reputation but also strengthens resilience in volatile markets through improved risk management and resource optimization (Chen, Yuan, Cebula, Shuangjin, & Foley, 2021; Zhou & Zhou, 2021). Research conducted amid the COVID-19 crisis further demonstrates that firms with strong ESG performance exhibited notable resilience, effectively mitigating systemic risks. However, the interplay among coal price fluctuations, firm performance, and ESG performance remains an underexplored area that warrants empirical investigation.

This research explores the intricate link between coal price volatility and corporate financial outcomes in China, addressing three key research questions. First, how do coal price fluctuations affect corporate performance in China? Second, how does exposure to coal price volatility differ across energy-intensive and non-energy sectors? Third, what role does ESG performance play in influencing the interplay between coal price changes and corporate financial outcomes? To answer these questions, this study employs a comprehensive dataset of 4,491 publicly listed companies in China, comprising 33,877 firm-year records covering the period from 2014 to 2023. This extensive dataset facilitates a detailed examination of the differential effects of coal price volatility across industries and the moderating influence of ESG performance. The findings indicate that coal price fluctuations significantly and negatively impact corporate performance in China, highlighting firms' susceptibility to energy price swings in a coal-dependent economy. Second, the magnitude of this adverse effect varies by sector, being more pronounced in the overall market and energy-intensive industries, while remaining statistically insignificant for non-energy sectors. This contrast emphasizes the role of energy dependence in shaping corporate resilience. Third, ESG performance emerges as a key moderating factor in this relationship. Contrary to conventional expectations that ESG performance would shield firms from market volatility, the study finds that higher ESG performance exacerbates the detrimental effects of coal price volatility on business performance.

This research makes significant contributions to both theoretical research and practical application in corporate performance, energy economics, and sustainability. First, it broadens the research perspective on factors influencing corporate performance by introducing coal price fluctuations as a critical determinant. While existing studies primarily focus on organizational structure, technological innovation, and macroeconomic conditions, this study highlights the often-overlooked but significant impact of coal price volatility, particularly in economies heavily dependent on coal. It provides practical insights into performance management, especially for industries highly sensitive to energy costs. Second, this research enhances the understanding of how coal price fluctuations affect energy-intensive and non-energy sectors differently. The results indicate that coal price volatility impacts firms unevenly, with energy-intensive businesses facing heightened risks, while non-energy firms demonstrate greater resilience. This distinction provides a foundation for sector-specific strategies for mitigating financial risks. Third, by examining the moderating role of ESG performance, the study fills an important research gap. The study reveals that ESG performance may intensify the adverse effects of coal price volatility, contradicting the common assumption that ESG strategies consistently reduce risk. By shedding light on this dynamic, the study provides theoretical support for refining ESG practices within the framework of energy market fluctuations.

In this paper, Section 2 provides a review of existing studies on energy price dynamics, ESG factors, and corporate financial outcomes, along with the development of hypotheses. Section 3 outlines the data sources, variable

selection, filtering principles, model construction, and descriptive statistics. Section 4 contains the empirical analysis, including econometric model construction, multivariate regression, and robustness checks. Section 5 is the discussion part, and Section 6 concludes the study.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Prior Studies on the Impact of Energy Price fluctuation

A significant body of literature demonstrates that energy price fluctuations exert a significant influence on corporate financial outcomes, with effects varying considerably across industries. Specifically, rising energy prices tend to positively affect the performance of resource-intensive sectors such as oil, gas, coal, and mining (Broadstock & Filis, 2014; Dayanandan & Donker, 2011). Bagirov and Mateus (2019) found that increases in crude oil prices significantly enhanced the profitability of oil and gas companies in Western Europe, highlighting the direct financial benefits for firms in these sectors during periods of high energy prices. Similarly, Azis et al. (2020) reported that rising coal prices boosted profits and market valuations of mining companies. Additionally, a significant body of research has explored the effects of energy price fluctuations on stock market performance. Oberndorfer (2009) found that rising energy prices led to increased stock prices for energy companies, reflecting investor expectations of benefits accruing to the sector. Fossil fuel price hikes also had a favorable impact on the stock valuations of renewable energy companies, albeit to a lesser degree than anticipated (Sun, Ding, Fang, Zhang, & Li, 2019). These results support the broader perspective that energy producers benefit from revenue surges during energy price hikes, as their products gain increased market value.

Conversely, the negative implications of energy price fluctuations for other industries have also been well documented. Nandha and Faff (2008) observed that while rising energy prices benefit the oil, gas, and mining sectors, they adversely affect industries such as automotive and transportation, which rely heavily on energy as a key input. These findings illustrate the asymmetrical effects of energy price volatility. Energy price fluctuations introduce significant uncertainties that impact corporate decision-making and broader economic dynamics. Such volatility often impedes investment decisions by creating financial instability, which in turn hinders capital accumulation and long-term planning. Rising coal prices increase production costs in energy-intensive industries, squeezing profit margins and curtailing overall output (Kong et al., 2020). These cost pressures often ripple through the broader economy, as these industries serve as critical links in the supply chain. Chen (2014) identified coal price inflation as a primary transmission channel for macroeconomic shocks, directly influencing key economic indicators such as inflation, production levels, and employment rates.

Broadstock and Filis (2014) discovered that fluctuations in energy prices have an adverse impact on energy consumption and disrupt industrial performance across various sectors. Similarly, oil price volatility disproportionately impacts the operational efficiency of Chinese firms, with energy-intensive industries facing pronounced challenges (Song & Yang, 2022). Phan, Tran, Nguyen, and Le (2020) demonstrated that crude oil price volatility undermines company performance across multiple markets and industries. These adverse effects were attributed to heightened energy costs and increased employment uncertainties, which strained operational stability. However, the authors emphasized that proactive and effective management strategies could mitigate these negative impacts, underscoring the need for risk management frameworks tailored to energy market conditions.

In addition to affecting company operations, energy price fluctuations significantly influence financial markets. An expanding field of research has investigated the relationship between energy price movements and stock market trends, revealing intricate relationships. Chun, Cho, and Kim (2022), using wavelet adjustments and regression analysis, identified an inverse relationship between fluctuations in coal prices and the valuation of carbon-intensive equities, suggesting that coal price fluctuations indirectly impact investor sentiment in carbon-intensive sectors. Similarly, Cao, Guo, and Zhang (2020) explored how variations in oil prices influenced investment trends in China's renewable energy sector. Their findings revealed that oil price volatility negatively affects the performance of

renewable energy firms, likely due to shifting investor preferences and perceived instability in energy market policies. Pham (2019) further advanced the discussion on energy price impacts by analyzing the effect of oil price instability on the performance of renewable energy stocks. His findings highlighted significant heterogeneity, with the effects varying not only across markets but also among different sub-sectors within the renewable energy industry. This nuanced perspective underscores the complexity of energy price dynamics and their sector-specific implications.

Overall, energy price volatility exerts a broad influence on financial markets. For instance, Cunado and de Gracia (2014) demonstrated that fluctuations in energy market volatility negatively affect stock market performance, a conclusion further supported by Hasan, Hassan, and Alhomaidi (2023), who highlighted the disruptive impact of instability in energy prices on investor sentiment and overall market equilibrium.

However, some studies have found insignificant effects of energy price volatility on company performance. For example, Endri, Rinaldi, Arifian, Saing, and Aminudin (2021) revealed that coal price fluctuations did not significantly impact the return on assets (ROA) of coal companies, as firms often mitigate such risks through diversification strategies. Similarly, Sihotang and Munir (2021) emphasized the adaptability of coal firms to energy price volatility, suggesting that certain companies have developed resilience mechanisms to counteract such fluctuations.

In summary, while energy price fluctuations have become a key focal point in academic inquiry, studies specifically focusing on coal price fluctuations and their influence on company performance remain limited, especially in the Chinese context. This paper seeks to address this gap by assessing the impacts of coal price fluctuations on company profitability, with a particular focus on both energy-intensive and other companies.

2.2. Prior Studies on ESG Performance and Company Performance

With the increasing prominence of sustainability in business strategy, the growing emphasis on and commitment of companies to ESG practices have led to a surge in related research. Substantial empirical evidence suggests a strong correlation between ESG effectiveness and corporate financial outcomes (Garcia & Orsato, 2020). ESG practices enhance investment efficiency and foster investor trust, Wang, Yu, and Li (2022) effectively reducing agency and transaction costs (Lee & Kim, 2020; Samet & Jarboui, 2017). Additionally, strong ESG performance constrains managerial short-sightedness and optimizes resource allocation, thereby improving investment efficiency (Ghoul, Guedhami, & Kim, 2017). Moreover, strong ESG adherence is associated with lower capital costs for firms. Research indicates that ESG practices, by earning stakeholders' trust, transmit optimistic indicators to the market and lessen information disparities (Cui, Jo, & Na, 2018). Corporate social responsibility (CSR) activities can serve as a signaling mechanism for a company's future financial prospects, enhancing its reputation and social capital (Su, Peng, Tan, & Cheung, 2016). Furthermore, firms that align with government and regulatory expectations may, in some cases, receive additional government support, thereby improving investment efficiency (Zeng, 2019).

However, not all scholars agree on the unequivocal financial advantages of ESG investments. Some argue that ESG initiatives could negatively impact firm performance. Di Tommaso and Thornton (2020) and Duque-Grisales and Aguilera-Caracuel (2021) suggest that ESG investments may not directly benefit a company's core business and could create resource constraints. This, in turn, may limit firms' ability to pursue other high-return investment opportunities, potentially resulting in an inverse relationship between ESG effectiveness and company profitability. Additionally, excessive ESG expenditures, sometimes driven by managerial self-interest, may result in inefficient resource allocation and increased financial volatility (Chandan & Das, 2017). Krüger (2015) further argues that management could exploit ESG activities for personal gain, potentially weakening investment efficiency and impairing financial profitability.

Certain researchers contend that the connection between ESG initiatives and company profitability lacks statistical significance. Hong and Kacperczyk (2009) and Atan, Alam, Said, and Zamri (2018), using data from multinational firms, found no significant association between the three main dimensions of ESG and firm profitability or market capitalization. Additionally, studies conducted throughout the COVID-19 period indicated that companies

with stronger ESG ratings did not display increased abnormal returns (Takahashi & Yamada, 2021). Similarly, Song, Zhao, and Zeng (2017) reported an absence of a significant association between ESG ratings and financial enhancement among publicly traded Chinese firms.

Moreover, Zhou and Zhou (2021) found that businesses with robust ESG engagement exhibit enhanced adaptability to adverse market conditions, suggesting that ESG may have a risk-mitigating effect. Their study also noted that ESG practices enhance firm resilience during turbulent periods, particularly for companies excelling in environmental and social dimensions (Díaz, Ibrushi, & Zhao, 2021). During crises, firms with higher ESG scores can significantly reduce their systemic risk Broadstock, Chan, Cheng, and Wang (2021) by strengthening their reputation and benefiting from insurance-like effects (Fiorillo, Meles, Pellegrino, & Verdoliva, 2024).

In summary, as existing studies have not fully explored how ESG influences the connection between changes in coal prices and corporate financial stability in China, this study addresses this gap and provides new empirical evidence to understand ESG's role in the context of energy price volatility.

2.3. Hypothesis Development

Building on the literature review, this research proposes two hypotheses regarding the relationship between coal price volatility, company ESG rating scores, and financial profitability in China.

Coal is a crucial input in China's industrial sectors, including electricity, manufacturing, and heavy industries, all of which heavily rely on coal resources. According to cost theory, escalating input costs drive up production expenses, thereby compressing profit margins and diminishing overall business viability (Chen, 2014; Kong et al., 2020). Industries with high coal dependence are particularly affected, as higher production costs compress profit margins and negatively impact financial performance (Maghyereh & Abdoh, 2020).

Moreover, coal price volatility heightens financial uncertainty and restricts investment, adversely affecting company performance across various sectors (Phan et al., 2020). Research on China's economy highlights that rising coal prices not only elevate production costs but also contribute to inflationary pressures, further straining company operations (Guo, Zheng, & Chen, 2016). Therefore, we propose Hypothesis 1.

Hypothesis 1: Coal price fluctuations negatively influence the financial performance of Chinese listed companies.

Although companies with high ESG performance often exhibit long-term resilience and social recognition, the immediate financial impact of ESG practices during periods of cost pressure can be adverse. Firms with high ESG ratings may incur higher operational costs to comply with environmental standards or adopt sustainable practices. These additional costs could amplify the negative effects of coal price increases. For instance, Krüger (2015) found that ESG-focused firms often experience greater cost burdens during periods of market volatility.

Empirical evidence suggests that while ESG initiatives enhance company reputation, they may reduce financial flexibility in the short term. Di Tommaso and Thornton (2020) argued that ESG investments might not directly enhance core business activities and could divert resources from more profitable projects. This is particularly evident in energy-intensive industries, where transitioning to sustainable energy sources involves additional costs, further compressing profit margins (Duque-Grisales & Aguilera-Caracuel, 2021). Building on these findings, we put forward Hypothesis 2.

Hypothesis 2: In China, high ESG performance exacerbates the adverse effects of coal price volatility on corporate financial outcomes.

3. METHODOLOGY

3.1. Data Sources and Sample Selection

This article selects publicly listed firms in China's A-share market from 2014 to 2023 as the study sample, covering key stages of China's economic transition and energy sector reforms. During this period, coal prices have fluctuated frequently and significantly, providing rich empirical data for the research. Additionally, the 10-year time

span is adequate to encompass long-term patterns and cyclical variations, strengthening the study's robustness and broader applicability. ESG considerations gained increasing prominence throughout this period, offering a crucial framework for assessing ESG's moderating influence on the coal price–corporate performance nexus. ESG rating scores were obtained from the Wind database, and macroeconomic variables such as the Consumer Price Index (CPI) and Producer Price Index (PPI) were collected from CEIDATA. The CPI and PPI were converted to the 2010 base year in the database. The Bohai Rim Thermal Coal Index, used to measure coal prices, was also sourced from the Wind database.

Firm-specific data underwent several exclusions during the sample selection process. First, firms in the financial sector were excluded due to their distinct financial statement structures. Second, samples of ST and ST companies were excluded because these firms had been reporting losses for more than two consecutive years, which indicated abnormal operational conditions. These companies had declining financial statement quality, and their stock prices and market capitalizations were heavily influenced as a result. This exclusion helps minimize the impact of outliers on the empirical results. Third, firms with a listing duration of less than three years were excluded. Fourth, samples with missing values were removed. The final dataset comprises 4,491 firms, yielding 33,877 firm-year observations. This study utilizes an unbalanced panel dataset, integrating cross-sectional and time-series dimensions. To mitigate the influence of extreme values, all variables were winsorized at the 1% and 99% thresholds.

3.2. Variable Definitions

In exploring the impact on firm performance, this paper uses the accounting-based metric ROA as the dependent variable to measure financial profitability (Carnini Pulino, Ciaburri, Magnanelli, & Nasta, 2022). ROA reflects a company's ability to generate net profits by utilizing all its assets (both long-term and short-term assets). As a robust performance metric, ROA effectively reflects the influence of coal price volatility on corporate profitability and is extensively utilized in prior studies.

The key independent variable, coal price, is represented by the natural logarithm of the annual average of the Bohai Rim Power Coal Index. This index is one of the most widely used sources of coal price data in China and has been extensively adopted in prior studies (Lin & Lan, 2025).

Firm performance is shaped by a combination of internal and external determinants. At the macro level, this paper includes the period of the Russian-Ukrainian conflict as a control variable (if the period falls within the Russian-Ukrainian conflict, the value is 1; if not, the value is 0), along with the Producer Price Index (PPI) and the Consumer Price Index (CPI). Including the Russia-Ukraine conflict as a control variable helps account for energy market disruptions, ensuring the accurate estimation of coal prices' effects on company performance. This approach helps isolate the multiple indirect effects of the war on enterprise performance and avoids confusing causality. CPI and PPI are used as indicators of inflation, influencing investment decisions and consumption patterns. Including these indices as control variables allows the study to adjust for price fluctuations, thereby refining the model's explanatory strength and accuracy.

Additionally, company performance is influenced by its own operations based on prior literature on company performance (Fiorillo et al., 2024; Zhou & Zhou, 2021). This paper includes control variables that may impact company performance. At the micro level, these variables include company size, shareholding concentration, financial leverage, and firm growth, which help enhance the explanatory power of the study and the reliability of the empirical results.

The moderating variable is the average logarithm of Huazheng ESG rating scores. Huazheng ESG ratings align with mainstream international approaches and practical insights, integrating essential international ESG frameworks while accounting for China's domestic conditions and capital market dynamics. This relevance enhances their applicability for studies targeting the Chinese market. Variable details are outlined in Table 1.

3.3. The Empirical Model

This article uses two-way fixed effects panel regression models to examine whether coal price fluctuations affect the financial performance of Chinese companies. By controlling for heterogeneity at the firm level, the model accounts for individual characteristics that may influence the results. At the same time, it controls for macroeconomic factors at the year level, eliminating systemic shocks across years. This approach effectively reduces the bias from omitted variables, making the research conclusions more reliable and robust. The estimation model is as follows:

$$ROA_{i,t} = \beta_0 + \beta_1 CP_t + \sum Control_{i,t} + Firm\ FE + Year\ FE + \varepsilon_{i,t} \quad (1)$$

Where i represents firm i, t represents year t, ROA $_{i,t}$ represents company financial performance firm i in year t, and CP_t represents the natural logarithms of the Bohai Rim Thermal Coal Index in year t. The $Control_{i,t}$ include macroeconomic variables (CPI, PPI) and firm-specific factors (size, leverage, growth, and ownership concentration).

Table 1. Variable definition.

Variables	Definition
ROA	Return on assets (ROA)= Net profit/Average balance of total assets
CP	Average logarithm of year Bohai Rim thermal coal index.
CPI	Consumer price index, (2009＝100)
PPI	Industrial producer price index, (2009＝100)
CONFLICT	Dummy variable that equals 1 if the Russia-Ukraine conflict broke out and 0 otherwise.
SIZE	Natural logarithm of total assets.
LEV	Leverage of financing = Total liabilities/Total assets.
GROWTH	Growth rate on operating revenue= (Revenue for the current quarter - Revenue for the previous quarter)/ (Revenue for the previous quarter).
CONC	The sum of the shareholding ratios of the top 10 circulating shareholders of the company.

Table 2. Descriptive Statistics.

Variables	Obs.	Mean	Sd	Min.	Max.
ROA	33877	0.0376	0.0690	-0.247	0.226
LNCP	33877	6.385	0.169	6.058	6.602
CPI	33877	128.7	6.721	117.0	136.5
PPI	33877	109.8	6.564	98.91	120.0
CONFLICT	33877	0.258	0.437	0	1
LEV	33877	0.417	0.203	0.0582	0.908
CONC	33877	38.02	22.17	0.224	101.2
GROWTH	33877	0.329	0.841	-0.713	5.653
LNSIZE	33877	22.29	1.299	19.99	26.36
LNESG	33877	4.292	0.0681	4.064	4.434

3.4. Descriptive Statistics

The dataset comprises 33,877 firm-year observations, providing a sample with extensive industry representation. Descriptive statistics for the key variables are presented in Table 2. The average return on assets (ROA) is 3.76%, with a standard deviation of 6.9%, indicating significant variation in profitability across firms and reflecting substantial differences in firms' returns on equity. The logarithmic value of the coal price index (LNCP) averages 6.385, with a standard deviation of 0.169. For control variables, the CPI and PPI exhibited a range of volatility over the sample period. Firm-level characteristic variables, such as firm size (mean logarithmic value = 22.29) and leverage (mean = 41.7%), exhibit notable variability, suggesting diverse financial structures across the sample. The average ESG score (mean logarithmic value = 4.292) suggests varying levels of commitment to sustainability practices among Chinese firms.

To explore heterogeneity, following Song and Yang (2022), the sample was categorized into energy-related and non-energy-related industries. Table 3 shows the descriptive statistics of the two subsamples. The difference in mean ROA between energy-related and non-energy firms is small (0.0387 vs. 0.0365). However, energy firms exhibit a

higher standard deviation (0.0662 vs. 0.0719), suggesting that their profitability is more volatile. Leverage ratios are similar, with a mean of about 0.420, but they are slightly lower for non-energy firms. This may reflect the capital-intensive characteristics of the energy sector. The mean and extreme values of firm size are almost identical for both types of firms, indicating a more balanced distribution of firm size in the sample. This helps to eliminate the interference of size effects in the statistical analysis. As for growth, non-energy firms exhibit higher mean and volatility (0.411 vs. 0.255; standard deviation 0.971 vs. 0.696), reflecting the fact that non-energy firms are likely to dominate in rapidly expanding industries. Non-energy companies have more concentrated stakes (mean = 39.06 vs. 37.08), which may be related to differences in industry regulations and company governance structures. The ESG scores of the two types of companies are very close, with means of 4.289 and 4.294, respectively.

Table 4 presents the Pearson correlation coefficients of the variables. The Pearson correlation coefficient between ROA and LNCP is -0.058, which is highly significant ($p < 0.01$). This indicates that coal price volatility has a negative impact on company profitability, aligning with the hypothesis that energy price volatility increases company costs. This finding supports the subsequent empirical analysis.

Table 3. Descriptive statistics of the energy-related subsample and the non-energy-related subsample.

Variables	Energy-related companies	Non-energy-related companies	Energy-related companies	Non-energy-related companies	Energy-related companies	Non-energy-related companies	Energy-related companies	Non-energy-related companies	Energy-related companies	Non-energy-related companies	Energy-related companies	Non-energy-related companies
	Obs.		Number of firms		MEAN		SD		MIN		MAX	
ROA	17,858	16,019	2,495	2,192	0.0387	0.0365	0.0662	0.0719	-0.247	-0.247	0.226	0.226
LEV	17,858	16,019	2,495	2,192	0.42	0.413	0.193	0.214	0.0582	0.0582	0.908	0.908
LNSIZE	17,858	16,019	2,495	2,192	22.28	22.3	1.298	1.3	19.99	19.99	26.36	26.36
GROWTH	17,858	16,019	2,495	2,192	0.255	0.411	0.696	0.971	-0.713	-0.713	5.653	5.653
CONC	17,858	16,019	2,495	2,192	37.08	39.06	22.2	22.1	0.224	0.268	101.2	96.19
LNESG	17,858	16,019	2,495	2,192	4.289	4.294	0.0673	0.0688	4.064	4.064	4.434	4.434

Table 4. Pearson correlation coefficients of variables.

Variables	ROA	LNCP	CONFLICT	CPI	PPI	LEV	LNSIZE	GROWTH	CONC
ROA	1								
LNCP	-0.058***	1							
CONFLICT	-0.093***	0.733***	1						
CPI	-0.065***	0.863***	0.670***	1					
PPI	-0.067***	0.963***	0.752***	0.863***	1				
LEV	-0.372***	-0.001	0.007	-0.007	0.005	1			
LNSIZE	0.016***	0.059***	0.051***	0.073***	0.057***	0.486***	1		
GROWTH	-0.012**	-0.079***	-0.068***	-0.072***	-0.080***	0.059***	-0.006	1	
CONC	-0.056***	0.057***	0.062***	0.079***	0.064***	0.217***	0.377***	-0.029***	1

Note: Standard errors in parentheses.
** $p < 0.05$, *** $p < 0.01$.

Table 5. Regression results.

Variables	Aggregate market	Energy-related companies	Non-energy-related companies
LNCP	-0.0791***	-0.1315***	-0.0222
	-0.0133	-0.016	-0.0218
CPI	-0.0017***	-0.0010***	-0.0023***
	-0.0001	-0.0002	-0.0002
PPI	0.0023***	0.0037***	0.0007
	-0.0003	-0.0003	-0.0004
CONFLICT	-0.0117***	-0.0139***	-0.0092***
	-0.001	-0.0014	-0.0016
LEV	-0.1962***	-0.2036***	-0.1883***
	-0.0055	-0.0078	-0.0079
LNSIZE	0.0263***	0.0256***	0.0253***
	-0.0014	-0.002	-0.002
GROWTH	0.0060***	0.0055***	0.0059***
	-0.0006	-0.0009	-0.0007
CONC	-0.0002***	-0.0002***	-0.0002***
	0	0	0
_cons	0.014	0.1333**	-0.0837
	-0.0544	-0.0648	-0.0904
N	33877	17858	16019
adj. R2	0.1876	0.179	0.1991
Year/Firm F.E.	Yes/Yes	Yes/Yes	Yes/Yes

Note: Standard errors in parentheses.
** p < 0.05, *** p < 0.01.

4. EMPIRICAL ANALYSIS

4.1. The Impact of Coal Price Fluctuations on company Performance

Table 5 indicates that, in the aggregate market, the coal price coefficient is -0.0791, statistically significant at the 1% level. This finding suggests that coal price volatility adversely affects the operational performance of Chinese firms, reinforcing Hypothesis 1. Economically, a one standard deviation increase in the coal price index (LNCP) leads to a 0.0791 decline in ROA. These findings confirm that coal price volatility exerts a statistically and economically significant negative impact on the profitability of firms in the Chinese A-share market.

4.2. Influence of Coal Prices on the Performance of Energy-Related and Non-Energy-Related Industries

To capture sectoral heterogeneity, we divided the sample into energy-intensive and non-energy-intensive industries and re-estimated the regression models. The results are summarized in Table 5.

Table 5 further analyzes the differential impact of coal price volatility on these two sectors. The coefficient of coal prices in the energy sector is -0.1315, statistically significant at the 1% level. This indicates that coal price fluctuations have a more pronounced negative effect on ROA in energy-related industries, with the coefficient being nearly twice as large as that of the overall market. This finding supports Hypothesis 1. Specifically, a one standard deviation rise in LNCP corresponds to a 13.15% decline in ROA. This substantial impact underscores the heavy dependence of energy-related industries on coal as a core production input. Higher coal prices directly elevate operating costs, erode profit margins, and reduce investor returns.

4.3. The Moderating Role of ESG Performance

Finally, we examine whether ESG performance moderates the link between coal price fluctuations and financial profitability by introducing interaction terms between coal price measures and ESG scores. The estimation model is specified as follows.

$$ROA_{i,t} = \beta_0 + \beta_1 CP_t + \beta_2 ESG_{i,t} + \beta_3 CPt * ESG_{i,t} + \sum Control_{i,t} + Firm\ FE + Year\ FE + \varepsilon_{i,t} \quad (2)$$

Where $ESG_{i,t}$ refers to the moderating variable ESG rating of firm i at time t, CP_t*$ESG_{i,t}$ refers to the interaction term between coal price and ESG performance for firm i at time t. Table 6 reports the estimated impact of coal price volatility on firms' operating performance, accounting for ESG performance as a moderating factor. The interaction term (LNCP × ESG) is negative (-0.2676 for the overall market and -0.2267 for energy-related industries) and statistically significant at the 1% level across all models. This suggests that high ESG rating scores amplify the adverse effects of coal price volatility on financial profitability. The moderating effect of ESG rating scores in the non-energy sector is not examined here, given that coal price fluctuations do not exert a statistically significant influence on non-energy firms. This result supports Hypothesis 2, underscoring that high ESG performance intensifies the statistically significant negative impact of coal price volatility on firms' business performance. This phenomenon is evident in both the overall market and the energy-related sectors.

Table 6. The moderating role of ESG performance.

Variables	Aggregate market	Energy-related sector
LNCP	1.0742***	0.8477***
	-0.1767	-0.246
LNESG	1.7264***	1.4460***
	-0.2578	-0.3596
LNCPLNESG	-0.2676***	-0.2267***
	-0.0406	-0.0566
CPI	-0.0017***	-0.0011***
	-0.0001	-0.0002
PPI	0.0022***	0.0035***
	-0.0003	-0.0004
CONFLICT	-0.0115***	-0.0135***
	-0.001	-0.0014
LEV	-0.1959***	-0.2045***
	-0.0055	-0.0079
LNSIZE	0.0269***	0.0266***
	-0.0014	-0.002
GROWTH	0.0060***	0.0055***
	-0.0006	-0.0009
CONC	-0.0002***	-0.0002***
	0	0
_cons	-7.4220***	-6.1076***
	-1.1174	-1.5564
N	33877	17858
adj. R2	0.1906	0.1807
Year/Firm F.E.	Yes/Yes	Yes/Yes

Note: Standard errors in parentheses.
*** $p < 0.01$.

4.4. Robustness Check

To assess the robustness of our findings, we conduct sensitivity analyses by replacing return on assets (ROA) with return on equity (ROE) as the dependent variable and substituting the Bohai Rim Power Coal Index (CP) with an alternative coal price measure (CP2). ROE measures shareholder equity returns and is commonly used in academic research as an alternative indicator of corporate profitability to support the robustness of the conclusions. The Bohai Rim Power Price, a crucial indicator of the electricity market, directly reflects supply and demand dynamics within the energy sector. Thus, it provides a reliable alternative to the Bohai Rim Power Coal Index for evaluating the robustness of coal price effects on corporate performance. By replacing ROA and the Bohai Rim Power Coal Index, we can effectively assess the consistency and reliability of the research findings. Models 3, 4, and 5 were used to evaluate the consistency of the primary findings under these alternative specifications. Additionally, Models 6, 7, and 8 were employed to examine the robustness of the moderating effects.

$$ROA_{i,t} = \beta_0 + \beta_1 CP2_t + \sum Control_{i,t} + Firm\ FE + Year\ FE + \varepsilon_{i,t} \quad (3)$$

$$ROE_{i,t} = \beta_0 + \beta_1 CP_t + \sum Control_{i,t} + Firm\ FE + Year\ FE + \varepsilon_{i,t} \quad (4)$$

$$ROE_{i,t} = \beta_0 + \beta_1 CP2_t + \sum Control_{i,t} + Firm\ FE + Year\ FE + \varepsilon_{i,t} \quad (5)$$

$$ROA_{i,t} = \beta_0 + \beta_1 CP_t + \beta_2 ESG_{i,t} + \beta_3 CP2_t * ESG_{i,t} + \sum Control_{i,t} + FirmFE + YearFE + \varepsilon_{i,t} \quad (6)$$

$$ROE_{i,t} = \beta_0 + \beta_1 CP_t + \beta_2 ESG_{i,t} + \beta_3 CP_t * ESG_{i,t} + \sum Control_{i,t} + FirmFE + YearFE + \varepsilon_{i,t} \quad (7)$$

$$ROE_{i,t} = \beta_0 + \beta_1 CP_t + \beta_2 ESG_{i,t} + \beta_3 CP2_t * ESG_{i,t} + \sum Control_{i,t} + FirmFE + YearFE + \varepsilon_{i,t} \quad (8)$$

The results of the robustness test further confirm the negative impact of coal price changes on firm performance. Table 7 reports the robustness test results assessing the impact of coal price fluctuations on firm performance. In Model (3), the alternative coal price (LNCP2) is used, and its coefficient is -0.0427, statistically significant at the 1% level. In Model (4), the alternative ROE is used, and its coefficient is -0.1392, also significant at the 1% level. In Model (5), when both the alternative ROE and the alternative coal price (LNCP2) are used, the coefficient is -0.075, significant at the 1% level. These results indicate that regardless of which measure of firm performance or coal price is used, the findings remain consistent with Hypothesis 1. The results robustly demonstrate that an increase in coal prices negatively affects firm performance (measured by ROA or ROE). This effect may be attributed to coal price volatility imposing financial pressure on firms, driven by rising production costs and shrinking profit margins, particularly in energy-intensive industries.

Table 7. Robustness test of coal price changes on firm performance.

Variables	Model (3)	Model (4)	Model (5)
LNCP		-0.1392***	
		-0.0313	
LNCP2	-0.0427***		-0.0750***
	-0.0072		-0.0169
CPI	-0.0018***	-0.0040***	-0.0042***
	-0.0001	-0.0003	-0.0003
PPI	0.0027***	0.0040***	0.0048***
	-0.0003	-0.0007	-0.0008
CONFLICT	-0.0270***	-0.0171***	-0.0440***
	-0.0026	-0.0024	-0.0061
LEV	-0.1962***	-0.4415***	-0.4415***
	-0.0055	-0.0153	-0.0153
LNSIZE	0.0263***	0.0659***	0.0659***
	-0.0014	-0.0035	-0.0035
GROWTH	0.0060***	0.0156***	0.0156***
	-0.0006	-0.0014	-0.0014
CONC	-0.0002***	-0.0002***	-0.0002***
	0	-0.0001	-0.0001
_cons	-0.2493***	-0.2512**	-0.7143***
	-0.0256	-0.1264	-0.0607
N	33877	33877	33877
adj. R2	0.1876	0.167	0.167
Year/Firm F.E.	Yes/Yes	Yes/Yes	Yes/Yes

Note: Standard errors in parentheses.
** p < 0.05, *** p < 0.01.

Table 8 reports the robustness test results examining the moderating role of ESG performance. In Model (6), using the interaction term of the alternative coal price (LNCP2), the coefficients are -0.1828 and -0.1540 (industry-wide vs. energy industry). In Model (7), using the interaction term of the alternative ROE, the coefficients are -0.3477 and -0.3070 (industry-wide vs. energy industry). In Model (8), using the interaction term of the alternative ROE and the alternative coal price (LNCP2), the coefficients are -0.2327 and -0.2202 (industry-wide vs. energy industry), all significant at the 1% level. The consistently negative interaction term coefficients provide strong support for Hypothesis 2. While high ESG performance is generally perceived as enhancing firm resilience, it may exacerbate the

negative impact of coal price volatility. This could be due to the higher costs associated with ESG investments, which place additional financial pressure on firms, making it more challenging to cope with energy price fluctuations.

Table 8. Robustness test for the role of ESG performance's moderating effect.

Variables	Aggregate market	Energy-related sector	Aggregate market	Energy-related sector	Aggregate market	Energy-related sector
	Model(6)		Model(7)		Model(8)	
LNCP			1.3552***	1.0708*		
			-0.4463	-0.6217		
LNCP2	0.7423***	0.5911***			0.9219***	0.8090*
	-0.1374	-0.1886			-0.3497	-0.4844
LNESG	1.1920***	0.9876***	2.2754***	1.9502**	1.5503***	1.4035**
	-0.2022	-0.2782	-0.6485	-0.9079	-0.513	-0.714
LNCP1LNESG			-0.3477***	-0.3070**		
			-0.1023	-0.143		
LNCP2LNESG	-0.1828***	-0.1540***			-0.2327***	-0.2202**
	-0.0318	-0.0437			-0.0808	-0.1123
CPI	-0.0018***	-0.0013***	-0.0040***	-0.0030***	-0.0042***	-0.0033***
	-0.0001	-0.0001	-0.0003	-0.0004	-0.0003	-0.0004
PPI	0.0027***	0.0044***	0.0039***	0.0069***	0.0049***	0.0085***
	-0.0004	-0.0004	-0.0007	-0.0008	-0.0008	-0.001
CONFLICT	-0.0269***	-0.0385***	-0.0170***	-0.0223***	-0.0449***	-0.0710***
	-0.0026	-0.0032	-0.0024	-0.0031	-0.0061	-0.0074
LEV	-0.1955***	-0.2042***	-0.4388***	-0.4593***	-0.4383***	-0.4590***
	-0.0055	-0.0079	-0.0153	-0.0217	-0.0153	-0.0217
LNSIZE	0.0268***	0.0264***	0.0663***	0.0696***	0.0660***	0.0694***
	-0.0014	-0.002	-0.0035	-0.005	-0.0035	-0.0049
GROWTH	0.0060***	0.0055***	0.0156***	0.0139***	0.0156***	0.0139***
	-0.0006	-0.0009	-0.0014	-0.0021	-0.0014	-0.0021
CONC	-0.0002***	-0.0002***	-0.0002***	-0.0003***	-0.0002***	-0.0003***
	0	0	-0.0001	-0.0001	-0.0001	-0.0001
_cons	-5.3718***	-4.5516***	-10.0284***	-8.4552**	-7.3685***	-6.9236**
	-0.8716	-1.1979	-2.8145	-3.9279	-2.2115	-3.0695
N	33877	17858	33877	17858	33877	17858
adj. R2	0.1901	0.1803	0.1686	0.1572	0.1684	0.1571
Year/Firm F.E.	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes

Note: Standard errors in parentheses.
* p < 0.1, ** p < 0.05, *** p < 0.01.

4.5. Summary

This research provides empirical evidence of the adverse effects caused by coal price volatility on corporate financial outcomes and further examines the moderating effects of industry heterogeneity and ESG performance. In both the energy-related sector and the overall A-share market in China, coal price fluctuations significantly reduce firms' operating performance, supporting Hypothesis 1. In contrast, while the coefficient of coal prices in non-energy industries is negative, it is not statistically significant. Moreover, ESG rating scores moderate the link between coal price fluctuations and corporate profitability. High ESG rating scores significantly amplify the adverse effects of coal price fluctuations on financial profitability, supporting Hypothesis 2. These findings provide valuable insights for industry policy and corporate strategy. They indicate that while policymakers and businesses aim to control coal price fluctuations, they should also carefully balance the long-term benefits and short-term costs associated with industry characteristics and ESG strategies.

5. DISCUSSION

In Table 5, the results indicate that the coefficient of coal prices is negative, suggesting that coal price volatility has a significant negative impact on the profitability of Chinese companies. This result aligns with prior studies, such as Kong et al. (2020) and Maghyereh and Abdoh (2020). As a major component of energy costs, coal prices directly influence the production costs of energy-intensive industries. Fluctuations in coal prices increase firms' production costs, thereby negatively affecting their profitability and overall performance. Additionally, higher coal prices are often accompanied by inflationary pressures, which elevate overall production costs and weaken firms' competitiveness and profitability. This effect is particularly relevant for large energy-consuming economies like China, where the economic structure is highly sensitive to coal price fluctuations. These findings align with Guo et al. (2016), who reported that coal price inflation transmits costs throughout the economic system, particularly affecting coal-intensive industries. This ripple effect not only reduces profitability but also introduces financial uncertainty, leading to financing constraints (Arellano, Bai, and Kehoe, 2019) and cautious investment behavior (Phan et al., 2020), thereby impacting firm performance.

The sectoral heterogeneity analysis in Table 5 highlights that the coefficient of coal prices in the energy sector exhibits statistically significant and negative results. This underscores the heavy reliance of energy-related industries on coal as a core production input. Higher coal prices directly increase operating costs, erode profit margins, and reduce investor returns. In contrast, in the non-energy sector, the coefficient remains negative but is not statistically significant, suggesting that the direct influence of coal price volatility is limited. This resilience may be attributed to diversified energy sources and low dependence on coal as a primary input. Cong, Wei, Jiao, and Fan (2008) revealed that fluctuations in oil prices had no statistically significant effect on actual stock returns in most non-energy industry indices in China's stock market. Similarly, our findings indicate that coal price fluctuations do not significantly impact the performance of non-energy-related firms. This may be due to the lower reliance of non-energy firms on coal as a key production factor, making their performance more stable amid coal price fluctuations. Consequently, the transmission mechanism of coal price volatility is less pronounced in non-energy industries, resulting in statistically insignificant effects.

The findings presented in Table 6 indicate that the interaction term is negative, suggesting that elevated ESG performance intensifies the negative impact of coal price volatility on financial performance. This finding aligns with prior studies, such as Krüger (2015); Di Tommaso and Thornton (2020) and Duque-Grisales and Aguilera-Caracuel (2021), which argue that while high ESG investments enhance a firm's social responsibility, they often sacrifice short-term financial resilience, making firms more vulnerable to external shocks. For example, high ESG firms may face stricter environmental obligations or need to increase social investments, further squeezing profit margins as rising coal prices drive up costs. Moreover, these firms may lack the flexibility to quickly adjust resource allocation, making them more susceptible to the negative effects of energy price volatility. Therefore, while high ESG performance may contribute to long-term brand and social image building, its short-term negative financial impact has been particularly pronounced over the past decade, especially amid volatile coal prices.

6. CONCLUSION AND POLICY IMPLICATIONS

This study investigates the impact of coal price fluctuations on corporate financial outcomes in China while assessing the moderating role of ESG performance. Utilizing a dataset comprising 4,491 publicly listed firms and 33,877 firm-year observations spanning 2014 to 2023, this research identifies the following key insights:

First, the negative impact of coal price fluctuations is evident. Coal price volatility significantly reduces a company's financial performance. This supports the hypothesis that rising coal prices increase production costs, compress profit margins, and adversely affect company profitability.

Second, sectoral heterogeneity. The detrimental impact of coal price swings is statistically significant in energy-dependent industries but insignificant in non-energy sectors. Energy-intensive firms, which heavily rely on coal as a

primary input, are more sensitive to price volatility. In contrast, non-energy firms demonstrate greater resilience due to limited direct exposure to coal price shocks.

Third, the moderating role of ESG performance is significant. ESG performance amplifies the negative impact of coal price fluctuations on financial performance. High ESG firms, while benefiting from an enhanced social reputation and resilience, face additional financial pressures, particularly during periods of rising coal prices. The increased costs associated with ESG compliance and sustainable practices may limit their ability to absorb price shocks, leading to greater financial vulnerability.

7. CONTRIBUTIONS OF THIS RESEARCH

First, providing empirical evidence of the detrimental effects of coal price fluctuations on corporate performance, especially within the context of China's coal-reliant economy. Second, highlighting the sectoral heterogeneity of this impact, with energy-related industries experiencing the most severe effects of price shocks. Third, exploring the moderating role of ESG performance, offering new insights into the financial implications of sustainability practices during periods of economic volatility.

These results offer meaningful guidance for government, company managers, and investors to navigate the challenges posed by coal price volatility and advancing sustainability goals.

From the perspective of policymakers, these findings first highlight the need for targeted support for ESG-compliant companies in energy-intensive industries. Subsidies for green energy and regulatory flexibility during periods of price volatility can alleviate these short-term financial pressures. Second, developing policies to reduce coal price volatility, such as strategic reserves and price caps, could alleviate financial pressures in energy-intensive industries and help maintain economic stability.

For company managers, first, companies, especially those in energy-intensive industries, should reduce their reliance on coal by transitioning to cleaner and more stable energy sources. Second, managers must find a balance between attaining strong ESG rating scores and maintaining financial flexibility, especially in times of market stress. Third, developing hedging mechanisms and improving operational efficiency can increase resilience to coal price fluctuations.

For investors, first, they should assess ESG risks and consider the trade-off between the long-term benefits of ESG performance and its short-term financial costs, particularly in industries sensitive to energy price fluctuations. Secondly, investors can proactively promote sustainable practices by integrating ESG factors into their investment choices and collaborating with company management on sustainability initiatives.

Future research could explore specific strategies employed by firms to mitigate the adverse effects of coal price volatility, such as technological innovation and digital transformation.

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