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Policy effect of the "blue sky plan" on air pollution, ESG investment, and financial performance of china's steel industry

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This study aims to examine the policy effects of the "Three-Year Action Plan to Win the Blue Sky War" on the steel industry and air pollution in China. Specifically, we analyze the impact of the "Blue Sky Plan" on Chinese steel companies' ESG investments, corporate financial performance, and the emissions of sulfur dioxide and nitrogen oxides in the exhaust gas. Our evidence suggests that ESG investment in steel companies can lead to a significant decrease in financial performance. The "Blue Sky Plan" compensated for about one-third of corporate ESG investment losses and played a significant role in promoting the ESG investment of steel companies. In addition, we found that after the implementation of the "Blue Sky Plan," the emissions of sulfur dioxide and nitrogen oxides in the exhaust gases were significantly reduced.

KEYWORDS

steel industry, policy effects, Blue Sky Plan, ESG investment, air pollution

1 Introduction

Environmental pollution is widely recognized as an important issue for sustainable economic growth. In recent years, with rapid economic development, China has been consuming a large amount of fossil energy. Air pollution in China has reached a serious level, causing environmental and health problems (Chen et al., 2017), and has largely aroused residents' dissatisfaction. Since then, the Chinese government has attached great importance to the ecological environment and has made many efforts to achieve specific emission reduction targets in the "13th Five-Year Plan" (2016–2020) to tackle environmental deterioration. These reduction targets mainly focus on the emission of nitrogen oxides and sulfur dioxide. In 2018, the Chinese government issued a "Three-Year Action Plan to Win the Blue Sky war" (hereinafter the "Blue Sky Plan"). In 2015, China's total SO_2 and NOx emissions were 18.591 million tons and 18.518 million tons, respectively. The major goal of the "Blue Sky Plan" is to reduce the total emissions of sulfur dioxide and nitrogen oxides by more than 15% by 2020.

Environmental pollution can be classified into water and air pollution. In terms of water pollution, Chen et al. (2018) studied the water pollution regulation in China and found evidence that the regulation reduced pollution-intensive activities in highly regulated areas. Liu et al. (2017) estimated the impact of stricter wastewater discharge standards on all the textile printing and dyeing enterprises in Lake Tai. They find that enterprises facing new, more stringent standards decrease labor demand by approximately 7%. Most countries have begun to monitor air quality in recent years. Peng et al. (2019) examined the consistency of city- and individual-level air pollution perceptions and investigated how environmental transparency affects the actual perceived air pollution relationship. Ai et al. (2021) studied the relationship between the desulfurization price subsidy policy and SO_2 emission reduction from coal-fired power plants in China. They found an obvious causal relationship between the policy and SO_2 emission reduction, and the dynamic effect of the policy showed an upward trend throughout the sample period. In terms of studying policy effects, Lin et al. (2021) examined the impact of the Electricity Price Subsidy policy on NOX emission from China's coal-fired power generation industry. They found that the EPS policy significantly reduced NOX emissions by 1.1% and increased NOX removal by 2.8%.

This study focuses on the policy effects of the "Blue Sky Plan" on the steel industry as well as the emissions of sulfur dioxide and nitrogen oxides. Although the problem of environmental pollution has been raised for decades, the Chinese government has been balancing economic growth and environment problems until the serious air pollution occurred. Air pollution became the most serious environmental problem in China since 2013, which not only significantly harmed the public health, but also decreased satisfactory to the government. The implementation of "Blue Sky Plan" is the first time the Chinese government decided to protect the environment at the cost of sacrificing economic growth. In 2017, the major pollutant emissions from the steel industry exceeded those of the power industry and became the largest source of pollutant emissions in the industrial sector. The steel industry in China has become a major source of air pollutants such as particulate matter, SO_2, and NOx emissions. For the purpose of investigating the policy effect of the "Blue Sky Plan" on air pollution, we focus on the steel industry instead of the whole polluting industries, to avoid using irrelevant information (e.g. water pollution).

Gu et al. (2018) analyzed the sulfur dioxide emission reduction effect, energy-saving synergy effect, and carbon dioxide emission reduction of power generation, steel, and cement industries during the "11th Five-Year Plan" and "12th Five-Year Plan" periods. They showed that during the "11th Five-Year" period, the emission reduction of coal-fired power plants' desulfurization projects is critical to emission reduction. Both engineering and structural reductions can achieve low pollution emissions, but the contributions are not the same, owing to differences in related industries. Bo et al. (2021) used measurements from China's continuous emissions monitoring system to develop estimates of emissions from the steel industry. They assessed particulate matter, sulfur dioxide, and nitrogen oxide emissions associated with China's increasingly stringent policies from 2014 to 2018.

Recently, ESG investment has attracted substantial research attention (see Zhao et al., 2018; Gillan et al., 2021). Yuan et al. (2022) investigated the impact of ESG disclosure on the financial irregularities of Chinese listed firms. They find that ESG disclosures decrease corporate financial irregularity risks and help mitigate information asymmetry. Zhang et al. (2021) examined the heterogeneity of ESG investments in China before and after the release of the guidelines for establishing a green financial system in 2016. They show that high-ESG portfolios earn significantly higher abnormal returns than low-ESG portfolios after 2016.

Existing research rarely investigates policy effects on ESG investments in the steel industry. To the best of our knowledge, this is the first study to investigate the policy effects of the "Blue Sky Plan" on the steel industry in China. We close this gap and contribute to the literature in the following ways. First, we collected the latest available environmental, industrial, and financial data and analyzed the policy effect of the "Blue Sky Plan" on ESG investment and financial performance in China's steel industry. Second, we collected provincial economic and environmental data to investigate the policy effects on air pollution.

Our results suggest that ESG investment significantly reduces the financial performance of steel companies, contrary to the findings of Zhang et al. (2021). The "Blue Sky Plan" compensates for one-third of losses from corporate ESG investments and significantly stimulates ESG investment in the steel industry. In addition, we find that the "Blue Sky Plan" reduces SO_2 and NOx emissions significantly and alleviates China's air pollution problem to a large extent.

The remainder of this paper is organized as follows. Section 2 briefly describes the study's data. Section 3 introduces the model. The empirical results are presented in Section 4. Section 5 concludes the paper.

2 Data

The sample period for our data is from 2015 to 2020. We collected the latest and most complete relevant environmental and financial data for Chinese listed steel companies. Specifically, the ESG data come from China's SynTao Green Finance, including ESG investment and environmental scores. The financial data of the steel companies were sourced from the RESSET database, including a range of financial variables such as stock return, market cap, cash holdings, short-term debt, long-term debt, profitability, and book-to-market ratio. Provincial economic and environmental data for 28 provinces were collected from the

TABLE 1 Definition of variables.

Steel Company variables	Definition	Sources
ESG	ESG aggregate score	SynTao
Environment	Environmental score	
Return	Annual holding period return of stock	RESSET
Market cap	Natural Logarithm of firms' total market value at the end of the year	
Cash holdings	Money funds and short-term investment divided by assets	
Short-Term Debt	Total current liabilities divided by assets	
Long-Term Debt	Total long-term liabilities divided by assets	
Profitability	Operating income divided by assets	
Book to market	Book Value at the end of the period divided by assets	
Provincial variables	Definition	
SO_2	Sulfur dioxide emission of waste gas (10 thousand tons)	the National Bureau of Statistics of China
NOx	Nitrogen oxide emission of waste gas (10 thousand tons)	
Thermal Power generation	Thermal Power Generation by Region (10 billion kWh)	
Power consumption	Electricity Consumption by Region (100 million kWh)	
GDP Per Capita	Total output (gross domestic product, the total output of social goods and services) divided by total population (Yuan per capita)	
Industrial added value	The gross output value of industrial enterprises minus the purchase of raw materials	
Treatment of waste gas	Amount of investment completed in industrial waste gas pollution control projects	
Treatment of wastewater	Amount of investment completed in industrial wastewater pollution control projects	
Population	Total population at year end	
Secondary industry share	The share of the output value of the secondary industry in GDP	
tertiary industry share	The share of the output value of the tertiary industry in GDP	
R&D	Science and technology expenditure divided by GDP	
Cars	Civilian vehicles divided by the length of roads	
Afforestation area	In all the land that can be planted, trees and shrubs are planted by various methods, and the survival rate reaches 85% or more (hectare)	

National Bureau of Statistics of China, including SO_2 emissions, NOx emissions, thermal power generation, power consumption, GDP per capita, industrial added value, treatment of waste gas, treatment of wastewater, population, secondary industry share, tertiary industry share, R&D, cars, and the affected area. Table 1 briefly describes the definitions of the variables. Table 2 provides descriptive statistics of the data.

3 Models

First, we construct a heterogeneous timing difference-in-differences (HT-DID) model to examine the policy effect of the "Blue Sky Plan" on the relationship between ESG investment and the financial performance of steel companies. The model is represented as follows:

$$ret_{i,t} = a_0 + a_1 BSP2018 + a_2 ESG_{i,t} + \mathbf{X\beta} + \eta_i + \tau_t + \varepsilon_{i,t} \quad (1)$$

where $ret_{i,t}$ denotes the annual holding period stock returns of the steel companies. ESG is the aggregate ESG investment score. $BSP2018 = Treat_{i,t} \times Post_t$ represents the heterogeneous timing treatment effect of the "Blue Sky Plan." $Post_t$ equals 0 before 2018 and equals 1 otherwise. $Treat_{i,t}$ equals 1 if the company i started ESG investment before the year t, and 0 otherwise. $\mathbf{X}$ represents the vector of control variables. According to Lins et al. (2017) and Drempetic et al. (2020), major financial variables, including market cap, cash holdings, short-term debt, long-term debt, profitability, and book-to-market ratio, are selected. η_i and τ_t represent the firm and time-fixed effects, respectively.

Similarly, we construct the following HT-DID model to investigate the policy effect of the "Blue Sky Plan" on steel companies' ESG investment decisions.

$$ESG_{i,t} = a_0 + a_1 BSP2018 + \mathbf{X\beta} + \eta_i + \tau_t + \varepsilon_{i,t} \quad (2)$$

Finally, we studied the effect of the policy on air pollution. Specifically, we collected provincial economic and environmental data and investigated whether SO_2 and NOx emissions were reduced significantly after the "Blue Sky Plan." The model is introduced as follows.

TABLE 2 Descriptive statistics.

Variables	Mean	Std.Dev	Min	Max	Obs
ESG	0.258	0.255	0.000	0.656	174
Environment	0.247	0.259	0.000	0.759	174
Return	0.099	0.629	−0.554	5.875	174
Market cap	23.437	0.836	21.597	25.975	174
Cash holdings	0.128	0.079	0.003	0.4721	174
Short-Term Debt	0.512	0.178	0.096	1.006	174
Long-Term Debt	0.096	0.078	$0.035*10^{-3}$	0.354	174
Profitability	0.907	0.379	0.121	1.898	174
Book to market	1.401	1.041	$0.117*10^{-3}$	4.750	174
SO_2	2.850	1.173	−1.715	5.028	168
NOx	3.746	0.638	2.160	5.244	168
Thermal power generation	7.167	0.769	5.472	8.621	168
Power consumption	7.567	0.591	6.480	8.845	168
GDP Per Capita	10.956	0.409	10.164	12.013	168
Industrial added value	9.114	0.796	7.018	10.697	168
Treatment of waste gas	11.441	1.038	7.513	13.782	168
Treatment of waste water	9.610	1.305	3.951	12.013	168
Population	8.328	0.626	6.528	9.443	168
Secondary industry share	3.678	0.213	2.760	3.921	168
Tertiary industry share	3.916	0.151	3.659	4.430	168
R&D	−5.446	0.528	−6.498	−4.265	168
Cars	−5.348	0.751	−6.457	−3.374	168
Afforestation area	12.006	1.212	7.838	13.487	168

$$SO2_{i,t} \text{ or } NOx_{i,t} = a_0 + a_1 BSP2018 + a_2 ESG_{i,t} + a_3 BSP2018 \times ESG_{i,t} + \mathbf{X\beta} + \eta_i + \tau_t + \varepsilon_{i,t} \quad (3)$$

where $SO2_{i,t}$ or $NOx_{i,t}$ denotes sulfur dioxide or nitrogen oxide emissions in a province i in year t. $\mathbf{X}$ represents the vector of control variables. Here, we reconstruct our ESG data to match the provincial level panel data. Specifically, we calculate the provincial level ESG investment intensity by adding up and standardizing the ESG score of listed companies in each province. According to Ai et al. (2021), Yang et al. (2020), and Zhang et al. (2019), our control variables included thermal power generation, power consumption, GDP per capita, industrial added value, treatment of waste gas, treatment of wastewater, population, secondary industry share, tertiary industry share, R&D, cars, and the affected area. η_i and τ_t refer to provincial and time-fixed effects, respectively.

4 Empirical results

In this section, we first study whether steel companies' ESG investment affects their financial performance and explore the impact of the "Blue Sky Plan" on the relationship between corporate ESG investment and profitability. We then examine the policy effect of the "Blue Sky Plan" on steel companies' ESG investment decisions; finally, we examine whether the "Blue Sky Plan" reduces air pollutant emissions.

Table 3 reports the empirical results of Eq. 1. For comparison, we also provide conventional panel regression analysis. Case (1) shows that the ESG investment of steel companies will significantly reduce their financial performance. A 1% increase in the company's ESG investment will reduce the stock return by 0.378%, indicating that the ESG investment of steel companies will not bring immediate benefits. On the contrary, the cost of R&D investment related to emission reduction and fixed asset investment will cause significant losses to the enterprise.

Then, following Lins et al. (2017), we quartile the ESG scores before introducing them into the model. Specifically, we divide the annual ESG investment status of steel companies into four equal parts, from high to low. Case (2) shows that the top 50% of companies in the steel industry for ESG investment suffer significant losses in their financial performance. However, the marginal ESG investment loss for Q1 companies is 0.232%, which is much smaller than that for Q2 companies, suggesting that companies with the most ESG investments may already be reaping the benefits.

TABLE 3 Policy effects of the "Blue Sky Plan" on the financial performance of China's steel industry.

Dependent variable: Annual holding period stock return

	Case (1)	Case (2)	Case (3)	Case (4)	Case (5)	Case (6)	Case (7)	Case (8)	Case (9)	Case (10)	Case (11)	Case (12)
ESG	− 0.378**				− 0.556**				− 0.388*			
	(− 2.06)				(− 2.40)				(− 1.97)			
ESGQ1		− 0.232**				− 0.258**				− 0.225**		
		(− 2.36)				(− 2.33)				(− 2.21)		
ESGQ2		− 0.330**				− 0.385**				− 0.317**		
		(− 2.43)				(− 2.36)				(− 2.21)		
ESGQ3		0.077				0.028				0.091		
		(0.36)				(0.11)				(0.39)		
Environment			− 0.377**				− 0.522**				− 0.384**	
			(− 2.38)				(− 2.66)				(− 2.28)	
EnvironmentQ1				− 0.190**				− 0.218**				− 0.187*
				(− 2.18)				(− 2.17)				(− 2.01)
EnvironmentQ2				− 0.226*				− 0.274				− 0.221
				(− 1.79)				(− 1.63)				(− 1.47)
EnvironmentQ3				− 0.030				− 0.080				− 0.025
				(− 0.18)				(− 0.42)				(− 0.14)
BSP2018					0.180	0.109	0.164	0.106				
					(1.24)	(0.70)	(1.16)	(0.71)				
BSP2019									0.020	− 0.052	0.017	− 0.221
									(0.15)	(− 0.36)	(0.12)	(− 0.16)
Market cap	0.777**	0.800**	0.775**	0.795**	0.772**	0.801**	0.769**	0.793**	0.778**	0.796**	0.776**	0.793**
	(2.56)	(2.66)	(2.56)	(2.60)	(2.59)	(2.68)	(2.58)	(2.61)	(2.53)	(2.60)	(2.53)	(2.55)
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R square	0.278	0.286	0.279	0.273	0.276	0.283	0.277	0.270	0.274	0.282	0.274	0.269

Values in parentheses are t-values. *, **, and *** represent for significance at 10%, 5%, and 1%, respectively. Q1, Q2, and Q3 refer to dummy variables for the first, second, and third quarters of ESG, or environmental investment intensity. BSP2018 is the policy effect of the "Blue Sky Plan."

We then replaced the ESG scores with environmental scores and arrived at similar conclusions. Case (3) shows that a firm's environmental investment, such as ESG investment, significantly reduces stock returns. The coefficients of the parameters are very similar to those in Case (1), which indicates that the ESG investments of these steel companies are mainly environmental investments rather than social and corporate governance investments.

Similarly, Case (4) shows that the top 50% of companies with environmental investment suffer significant financial losses. Q1 companies suffer less than Q2 companies, suggesting that the companies with the largest environmental investments may have already gained from them.

Cases (5–8) perform a heterogeneous timing difference-in-differences analysis to study the policy effect of the "Blue Sky Plan." Case (5) suggests that a 1% increase in ESG investment will reduce the stock return by 0.556%, indicating that the coefficient of – 0.378 in case (1) is underestimated. Actual losses from ESG investments are much higher. After the implementation of the "Blue Sky Plan," companies received compensation for their ESG investments. These compensations include, but are not limited to, the government's ESG investment subsidies: the reduction in pollutant emission taxes: and the benefits of emission allowance trading after companies' emission reductions. Collectively, these gains do not compensate for corporate losses in ESG investment. The average compensation amount is approximately one-third of the losses caused by ESG investment.

Case (6) showed similar results. The marginal losses from ESG investments are much larger than those in Case (2). This is consistent with the results obtained in case (5). However, we also find that Q1 companies suffer fewer financial losses than Q2 companies, suggesting that the ESG investment has already yielded.

TABLE 4 Policy effects of the “Blue Sky Plan” on ESG investment in China’s steel industry.

Dependent variables

	Case (1) ESG	Case (2) environment	Case (3) ESG	Case (4) environment	Case (5) ESG	Case (6) environment
BSP2018			0.364***	0.357***		
			(8.31)	(8.04)		
BSP2019					0.323***	0.317***
					(8.50)	(7.83)
Market cap	5.462**	5.043*	2.536	2.174	6.456***	6.022***
	(2.07)	(1.93)	(1.37)	(1.26)	(3.50)	(3.38)
Cash holdings	27.996	19.339	4.068	4.125	27.365	18.719
	(1.22)	(0.86)	(0.32)	(− 0.32)	(1.40)	(0.97)
Short-Term Debt	− 16.965	− 16.050	− 8.881	− 8.122	− 14.443	− 13.567
	(− 1.15)	(− 0.98)	(− 1.09)	(− 0.83)	(− 1.27)	(− 1.03)
Long-Term Debt	− 42.960	− 37.329	− 7.870	− 2.918	− 21.25	− 15.966
	(− 1.18)	(− 1.04)	(− 0.25)	(− 0.10)	(− 0.64)	(− 0.49)
Profitability	− 4.333	− 5.030	− 1.245	− 2.003	− 0.921	− 1.674
	(− 0.54)	(− 0.58)	(− 0.18)	(− 0.25)	(− 0.13)	(− 0.22)
Book to market	− 4.029	− 5.398	− 2.890	− 4.281	− 3.321	− 4.701
	(− 1.14)	(− 1.45)	(− 0.87)	(− 1.17)	(− 0.97)	(− 1.28)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R square	0.624	0.592	0.757	0.719	0.682	0.648

Values in parentheses are t-values. *, **, and *** represent for significance at 10%, 5%, and 1%, respectively. BSP2018 is the policy effect of the “Blue Sky Plan.”

From case (7), it can be seen that each 1% increase in environmental investment reduces the stock return by 0.552%. First, this indicates that the coefficient of the variable Environmental in case (3) − 0.377 is underestimated. Second, through the closeness of the coefficients in cases (7, 5), it is confirmed that the main part of the ESG investment of steel companies is environmental investment, which is consistent with the comparison results from cases (1, 3). Case (8) shows that Q1 companies suffer significant losses from environmental investment. A 1% increase in environmental investment reduces the stock return by 0.218%, which is larger than that in case (4).

Overall, from the comparison of cases (5–8), (1–4), we find that the “Blue Sky Plan” cannot significantly change the status quo of the decline in corporate financial performance caused by the ESG investment of steel companies. Corporate ESG investments cause significant declines in stock returns. After the implementation of the “Blue Sky Plan,” companies that invested heavily in ESG achieved certain benefits through subsidies, emission taxes, and emissions allowance trading. Therefore, we conclude that the “Blue Sky Plan” may play a role in promoting corporate ESG investment and green transformation.

One may suspect that there should be a time-lag between the implementation of the policy and its impact occurred. Since the time-lag of policy effect may lead to endogeneity, we delay the effect of the “Blue Sky Plan” to 2019, and report these results in case (9–12). Similarly, ESG investment significantly reduce the stock returns of steel companies. However, these estimates are much closer to case (1–4) than case (5–8), suggesting that the impact of the “Blue Sky Plan” has been quickly absorbed, and the steel industry rebalanced production and environmental protection in a short time.

We then investigate whether the “Blue Sky Plan” stimulates ESG investments. Table 4 presents the results of Eq. 2. Case (1) shows that the larger the market cap of a company, the more ESG investments it has made, indicating that large steel companies are more willing to make ESG investments. On the one hand, large enterprises have sufficient capital to invest in fixed assets and R&D. On the other hand, large enterprises are more likely to obtain emission reduction subsidies and tax relief and are more likely to benefit from emissions trading. In case (2), we substituted environmental scores for ESG scores and obtained similar results to case (1).

Case (3) shows that the “Blue Sky Plan” significantly affects enterprises’ ESG investment. After the introduction of policy effects, the coefficient of the market cap no longer becomes significant, indicating that after the implementation of the policy, companies started to make ESG investments regardless of their size. Combining case (1), we can argue that the policy played a

TABLE 5 Provincial-level policy effects of the “Blue Sky Plan” on air pollutants emissions.

	Dependent variables							
	(1) SO_2	(2) NOx	(3) SO_2	(4) NOx	(5) SO_2	(6) NOx	(7) SO_2	(8) NOx
ESG	0.29***	− 0.11			0.22**	− 0.09		
	(2.68)	(− 1.61)			(2.14)	(− 1.39)		
Environment			0.304***	− 0.112			0.23**	− 0.09
			(2.70)	(− 1.64)			(2.16)	(− 1.43)
BSP2018	− 2.31***	− 1.41***	− 2.30***	− 1.41***				
	(− 6.31)	(− 3.54)	(-6.30)	(− 3.56)				
BSP2019					− 2.42***	− 1.38***	− 2.41***	− 1.38***
					(− 5.89)	(− 3.53)	(− 5.87)	(− 3.54)
ESG×BSP2018	− 0.17***	0.04						
	(− 3.11)	(1.25)						
ESG×BSP2019					− 0.10**	0.02		
					(− 2.06)	(0.49)		
Environment×BSP2018			− 0.17***	0.04				
			(− 3.13)	(1.26)				
Environment×BSP2019							− 0.10**	0.02
							(− 2.08)	(0.53)
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R square	0.894	0.516	0.895	0.516	0.888	0.513	0.888	0.513

Values in parentheses are t-values. *, **, and *** represent for significance at 10%, 5%, and 1%, respectively. BSP2018 is the policy effect of the “Blue Sky Plan.”

significant role in promoting ESG investment in small firms. Similar to Case (3), Case (4) shows that the policy has a significant effect on stimulating the environmental investment of enterprises. In general, the “Blue Sky Plan” has a significant positive impact on ESG and environmental investment, especially for relatively small-scale enterprises. In case (5, 6), the impact of the policy is supposed to be delayed. Obviously, the “Blue Sky Plan” still has significantly impact on corporate ESG investment.

Finally, we examined whether the “Blue Sky Plan” could reduce air pollutant emissions. Table 5 presents the results of Eq. 3. Case (1) shows that ESG investment positively related to SO_2 emission, since both of them are positively correlated with industrial level. However, the estimates of the “Blue Sky Plan” and its product with ESG investment are significantly negative, indicating that the implementation of the “Blue Sky Plan” has a significant inhibitory effect on SO_2 emissions. Similarly, case (2) shows that the “Blue Sky Plan” also significantly reduced NOx emissions. We replace ESG by environmental investment in case (3, 4), and obtain similar results. In case (5–8), the policy effect of the “Blue Sky Plan” is supposed to be delayed. Similarly, we still find that SO_2 and NOx emissions are significantly reduced after the implementation of the “Blue Sky Plan”. Overall, our results suggest that the “Blue Sky Plan” has significantly alleviated China’s air pollution problems and gradually achieved the policy goals.

5 Conclusion

With the rapid development of China’s economy, environmental pollution, especially air pollution, has seriously affected the quality of life of Chinese residents, arousing government concern. As the world’s largest producer and exporter of crude steel, the pollution generated by China’s steel industry has surpassed that of the power industry, ranking first among China’s highly polluting industries. In this context, the Chinese government launched the Three-Year Action Plan to Win the “Blue Sky War,” which aims to solve problems such as promoting the green transformation of high-polluting industries and curbing air pollution. This study is the first to examine the policy effects of the “Blue Sky Plan” on China’s steel industry. We first analyze the impact of the “Blue Sky Plan” on steel companies’ ESG investment and financial performance. We then examine the effects of the “Blue Sky Plan” on air pollution.

From the perspective of the ESG investment of steel enterprises, the ESG-related investment of listed steel enterprises has a significant negative impact on their financial performance, especially for those companies that heavily invest in ESG. This is because these investments cost a large amount of capital in R&D and fixed assets. The "Blue Sky Plan" has compensated for the ESG investment losses of steel companies to a certain extent, with an average rate of about one-third. Additionally, we found that the "Blue Sky Plan" significantly stimulated steel companies' ESG investments. Finally, the "Blue Sky Plan" has significantly reduced emissions of sulfur dioxide and nitrogen oxides, which has played a positive role in improving air pollution problems.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary Material.

Author contributions

PL conducted the empirical analysis and wrote the paper. Conceptual design is performed by PL, SH, and ST.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2022.955906/full#supplementary-material

References

Ai, H., Zhou, Z., Li, K., and Kang, Z. Y. (2021). Impacts of the desulfurization price subsidy policy on SO_2 reduction: Evidence from China's coal-fired power plants. *Energy Policy* 157, 112477. doi:10.1016/j.enpol.2021.112477

Bo, X., Jia, M., Xue, X., Tang, L., Mi, Z., Wang, S., et al. (2021). Effect of strengthened standards on Chinese ironmaking and steelmaking emissions. *Nat. Sustain.* 4, 811–820. doi:10.1038/s41893-021-00736-0

Chen, R., Yin, P., Meng, X., Liu, C., Wang, L., Xu, X., et al. (2017). Fine particulate air pollution and daily mortality. A nationwide analysis in 272 Chinese cities. *Am. J. Respir. Crit. Care Med.* 196, 73–81. doi:10.1164/rccm.201609-1862OC

Chen, Z., Kahn, M. E., Liu, Y., and Wang, Z. (2018). The consequences of spatially differentiated water pollution regulation in China. *J. Environ. Econ. Manage.* 88, 468–485. doi:10.1016/j.jeem.2018.01.010

Drempetic, S., Klein, C., and Zwergel, B. (2020). The influence of firm size on the ESG score: Corporate sustainability ratings under review. *J. Bus. Ethics* 167, 333–360. doi:10.1007/s10551-019-04164-1

Gillan, S. L., Koch, A., and Starks, L. T. (2021). Firms and social responsibility: A review of ESG and csr research in corporate finance. *J. Corp. Finance* 66, 101889. doi:10.1016/j.jcorpfin.2021.101889

Gu, A., Teng, F., and Feng, X. (2018). Effects of pollution control measures on carbon emission reduction in China: Evidence from the 11th and 12th five-year Plans. *Clim. Policy* 18, 198–209. doi:10.1080/14693062.2016.1258629

Lin, C., Shao, S., Sun, W., and Yin, H. (2021). Can the electricity price subsidy policy curb NOX emissions from China's coal-fired power industry? A difference-in-differences approach. *J. Environ. Manage.* 290, 112367. doi:10.1016/j.jenvman.2021.112367

Lins, K. V., Servaes, H., and Tamayo, A. (2017). Social capital, trust, and firm performance: The value of corporate social responsibility during the financial crisis. *J. Finance* 72, 1785–1824. doi:10.1111/jofi.12505

Liu, M., Shadbegian, R., and Zhang, B. (2017). Does environmental regulation affect labor demand in China? Evidence from the textile printing and dyeing industry. *J. Environ. Econ. Manage.* 86, 277–294. doi:10.1016/j.jeem.2017.05.008

Peng, M., Zhang, H., Evans, R. D., Zhong, X., and Yang, K. (2019). Actual air pollution, environmental transparency, and the perception of air pollution in China. *J. Environ. Dev.* 28, 78–105. doi:10.1177/1070496518821713

Yang, C., Wang, Y., and Dong, Z. (2020). Evaluating the impact of denitrification tariff on energy-related NOx generation in China: Policy effects and regional disparities. *Energy Policy* 142, 111520. doi:10.1016/j.enpol.2020.111520

Yuan, X., Li, Z., Xu, J., and Shang, L. (2022). ESG disclosure and corporate financial irregularities – evidence from Chinese listed firms. *J. Clean. Prod.* 332, 129992. doi:10.1016/j.jclepro.2021.129992

Zhang, W. W., Sharp, B., and Xu, S. C. (2019). Does economic growth and energy consumption drive environmental degradation in China's 31 provinces? New evidence from a spatial econometric perspective. *Appl. Econ.* 51, 4658–4671. doi:10.1080/00036846.2019.1593943

Zhang, X., Zhao, X., and Qu, L. (2021). Do green policies catalyze green investment? Evidence from ESG investing developments in China. *Econ. Lett.* 207, 110028. doi:10.1016/j.econlet.2021.110028

Zhao, C., Guo, Y., Yuan, J., Wu, M., Li, D., Zhou, Y., et al. (2018). ESG and corporate financial performance: Empirical evidence from China's listed power generation companies. *Sustainability* 10, 2607. doi:10.3390/su10082607