Does air pollution prompt corporations to implement green management? Evidence from China

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Abstract

As the *Environmental Protection Law* was revised and media public opinion supervise them, enterprises need to not only undertake more environmental protection responsibilities but also alleviate the contradiction between development and environment. By applying a multiple regression model, this paper studies the impact of air pollution on the management behavior of enterprises using the panel data of China's A-share polluting enterprises listed in the Shanghai and Shenzhen stock markets between 2014 and 2019. The results of this study are as follows: First, air pollution produces a positive impact on the behavior of corporate green management. Second, media reports have brought more attention to corporate pollution and increased the positive impact of air pollution on corporate green management efforts. By further considering the internal and external heterogeneity of enterprises, the impact of air pollution on corporate green management varies when the degree of enterprise pollution and the degree of local governance differ. Moreover, this paper highlights the fact that air pollution can play a significant role in corporate green management, while media attention, as a third party, plays a regulating role in environmental supervision. This provides suggestions for strengthening green management behavior of enterprises and building comprehensive environmental supervision system.

Keywords Air pollution · Green management · Media attention · Pollution level · Local governance level · Environmental protection experience

JEL classification Q53 · M10

Highlights

- The degree of air pollution improves the initiative and enthusiasm of enterprises in green management.
- Media attention can promote the green behavior of enterprises and play a significant regulating role.
- Light-polluting enterprises are more sensitive to green management behavior.
- Executives' environmental experience can promote green management in polluting companies.
- The government can effectively promote the green management of enterprises by strengthening the disclosure of green management information.

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Abbreviations

HHI	Herfindahl-Hirschman Index
GDP	Gross domestic product
AQI	Air Quality Index
ROA	Return on assets
Tobin'Q	Tobin's Q ratio

Introduction

Since the Industrial Revolution, a variety of air pollution problems, including soot pollution and photochemical smog, have increased all over the world, destroying the global ozone layer and causing a greenhouse effect, thus beginning a 100-year process of air pollution control worldwide (Danie and Tobias 2020; Swarup 2017). With the soaring growth of China's economy, air pollution caused by industrial production has become increasingly serious (Mujtaba and Shahzad 2021; Hao et al. 2018). The World Air Quality Report 2019 indicates that Chinese cities account for 47 of the world's 100 most polluted cities, and 98% of Chinese cities exceed the maximum guidelines of the World Health Organization. Air pollution also harms human development. According to data released by the China Statistical Yearbook and the Chinese Center for Disease Control and Prevention, air pollution causes about \$54 billion in economic losses every year, and about 1.24 million people die from it. Moreover, it can be found that air pollution will not only hinder economic development but also undermine social stability and happiness (Cuñado and Perez 2013). Additionally, to win the fight to protect blue skies and facilitate high-quality development in China, the Fifth Plenary Session of the 19th Communist Party of China Central Committee stressed the promotion of green development and increased penalties for corporate pollution. In the face of air pollution, the media plays a regulating role in supervising enterprises' pollution behaviors and guiding them to improve their green management level, causing them to bear the environmental pressure brought by "green management," implement green development strategies, and shift to a green development mode with low pollution and high efficiency.

Therefore, regarding air pollution, the government will constantly improve environmental regulations by promulgating laws and regulations. For instance, the newly revised Environmental Protection Law was promulgated in 2014, and it made enterprises subject to the supervision of formal institutions, thus boosting their sustainable development. Due to the strong externality of environmental problems (Marco 2020), they often attract the attention of both the media and the public, with the media, as the main supervisor of air pollution, playing a particularly significant role. Through the media's positive or negative news exposure, enterprises will advance their green development based on pressures of public opinion

to reduce environmental damage, thereby establishing a positive corporate image (Luo et al. 2019). As the media's exposure to enterprises increases, the more information the media conveys to the external public, and the greater the public pressure on the enterprises. As a result, they often take measures to maintain their reputation and credibility. Overall, green management is a favorable measure for enterprises to maintain sustainable development and establish a high reputation and credibility. A number of scholars believe that green management emerges in the form of corporate social responsibility (CSR), and the implementation of green management reflects the fulfillment of social and environmental responsibilities (Domenico and Micha 2019). It requires enterprises to undertake the responsibility of environmental protection and pollution control, thus achieving the organic unity of economic, environmental, and social benefit. Therefore, will air pollution prompt enterprises toward green management? Does media supervision make the promoting effect more significant? Studying these issues has important theoretical and practical value for clarifying the relationship between macro environmental pollution problems and micro enterprises' development.

In comparison with the existing literature, the main contributions of this paper can be reflected as follows: First, this paper studies the impact of air pollution on corporate green management behavior from the "business process level" and "employee management level." It focuses on several key aspects, such as enterprise project selection, production, and operation, and internal staff management, enriching theoretical research in relevant fields. Second, most of the papers simply studied the polluting enterprises and did not further divide them. However, this paper categorizes the polluting enterprises into light-polluting enterprises and heavy-polluting enterprises and studies the promoting effect on the corporate green management levels of enterprises with different pollution levels in the context of air pollution. Third, this paper not only considers environmental regulations as formal institutions but also selects media attention as a non-formal institution, studies the impact of media attention on the relationship between air pollution and corporate green management from the perspective of external non-formal institutions, discovers the regulating role of the media in environmental supervision, and reveals effective methods of environmental governance. Fourth, this paper not only considers the impact of external environmental policies on corporate behavior but also considers the impact of corporate executives' environmental experience on corporate green management behavior from a behavioral perspective. Fifth, most of the literature has studied the impact of environmental pollution on macroeconomic activities, while few works study the impact of environmental pollution on micro corporate behavior. The relationship between air pollution and corporate

green management is currently unclear, and this paper aims to address this gap.

The rest of this paper is arranged as follows: Part Two is the literature review, which identifies the related literature on air pollution, green management, and media attention. Part Three is the theoretical analysis and research hypothesis, analyzing the theoretical basis of the model. Part Four studies the design and constructs the evaluation model. Part Five is the empirical results and analysis section. Part Six features the robustness test, and Part Seven is the research recommendations and conclusions.

Literature review

Existing studies on air pollution mostly focus on the medium and macro impacts on regional economy and industrial structure (Hao et al. 2018; Zheng and Chen 2020; Zheng et al. 2020), while the sum of the behavior effects of enterprises as micro subjects will not only influence the development of a region, but also affect the environmental policies of relevant government departments. Therefore, it will be more targeted to focus the research object on the pollutant emission source—enterprises—rather than broad regions or industries. Existing literature studies have discovered that air pollution has an impact on corporate behavior decisions. Li and Zhang (2019) found that air pollution will bring additional costs to enterprises, increase additional environmental costs, and lead to a decline in productivity. What's more, high-quality talents are sensitive to air pollution issues and will facilitate their migration out of polluted areas (Qin and Zhu 2017), which will cause the loss of human capital and further reduce production efficiency. When an enterprise is located in an area where air pollution is more serious, the enterprise usually preventatively holds more cash in order to overcome the various risks and uncertainties brought by air pollution to its operation, which results in the misallocation of enterprise funds, thus leading to the low efficiency of its entire operation performance (Tan et al. 2021), which is not conducive to the sustainable development of corporate business. Faced with the growingly severe air pollution problem, the government will use modern Internet technology to strengthen the monitoring of environmental pollution data and require enterprises to disclose environmental information to improve the transparency of information (Lin et al. 2021). To overcome the problems of increasing operating costs and decreasing profit level, enterprises are also forced to carry out internal management, such as conducting internal control quality management and developing green innovation activities (Liu et al. 2019; Wang and Wu 2020).

Compared with traditional corporate management, green management has richer and more advanced connotations. However, there are few studies on the impact of air pollution

on the implementation of green management behavior by enterprises. Sulich and Rutkowska (2020) believe that green management is a management approach which aims to reduce the consumption of natural resources and reduce greenhouse gas emissions. Louis and Mafini (2018) argued that the goal of green management is to achieve the coordinated development of economy, society, and the environment through activities such as R&D, production, and marketing. Therefore, green management integrates the ideas of environmental protection into the entire production and operation (Putri et al. 2020; Rustam et al. 2020; Wu and Chen 2014). The impact of air pollution on corporate green management involves business process level and employee management level. At business process level, enterprises have to start from the acquisition of raw materials and minimize negative impacts on the environment through the varying links of storage, processing, transportation, packaging, recycling, and so on (Raharjo 2019; Bundgaard et al. 2017; Carvalho et al. 2020), and they should give priority to environmental and social factors in investment when they invest in projects (Kong et al. 2020a; Tetyana et al. 2019), guiding their investment in green products and guiding their green development. At the employee management level, employees have become the main driving force in the long-term survival and development of enterprises (Zhang 2019). As to its adverse effects, air pollution affects human health (Rotton and Frey 1985), damaging the nervous system and cognitive function of the brain (Gu et al. 2020). Therefore, aggravated air pollution leads to a decline in cognition and learning ability of employees (Li and Zhang 2019). At this time, enterprises must conduct green employee management so as to make full use of the scarce resource of employees. They should give motivation to foster employees' green behavior and innovation (González et al. 2016), so as to enable enterprises to reduce damage to the environment and increase production efficiency (Douglas et al. 2013).

Media is gradually playing an increasingly important role in capital market, environmental pollution (Su and Fan 2021; Hupp 2018), etc. It, as an information intermediary, can transmit information to the outside world (Su and Fan 2021; Hupp 2018). Existing literature mainly studies the impact of media attention on financial performance and believes that media attention can stimulate the relationship between CSR, corporate performance, and cost of capital (Dyck et al. 2008; Bushee et al. 2010). The role that media reports play in environmental protection cannot be overlooked. Media attention improves the exposure of enterprises and alleviates the information asymmetry between enterprises and stakeholders. Therefore, enterprises will be subject to more external public pressure and government pressure when faced with air pollution. Luo et al. (2019) found that increasing the positive exposure of enterprises by media will enhance the reputation of enterprises. To maintain such a good image, enterprises are willing to disclose environmental information.

It can be seen that the choice of “green management” in each link of an enterprise is inextricably related to the air environment. Media attention plays a regulating role, which is also particularly important. Therefore, it is of broader significance to study the impact of air pollution on green management behavior. However, no one has studied the relationship between the two at this stage. And in the context of air pollution, can the increased exposure of enterprises by the media promote their green management? It also has not been studied whether different attitudes to corporate exposure have different effects. In addition, Kong et al. (2020b) believe that media reports are easier to play a role in developing countries than in developed countries, because the benefits of complying with environmental protection in developing countries are unclear and will lead to poor execution. Therefore, this paper, based on the perspective of a developing country—China, is more conducive to studying the role of media reports on air pollution and corporate green management. This paper studies this issue in the hope of filling the gap of relevant literature.

Theoretical analysis and research hypothesis

Air pollution and green management

Nowadays, environmental pollution is a complex problem, so we select air pollution as an essential characterization variable. With the aggravation of air pollution, polluting enterprises now face greater pressure from external environmental regulation (Du and Li 2019). This kind of supervision includes not only formal environmental regulations such as laws and regulations formulated by the government, but also informal environmental supervision from the public and non-political organizations (Jia et al. 2018). According to the stakeholder theory, an enterprise has an interdependent relationship with a number of roles, including shareholders, employees, suppliers, government, and consumers, and the demands of stakeholders need to be met because they have a variety of scarce resources, such as capital and technology, so corporate behavior will be supervised and impacted by a large number of stakeholders. Therefore, if they want to overcome problems of increase in operating costs and decline in profit levels caused by external supervision, they must conduct green management to achieve sustainable development. The research on the green management motives of enterprises not only can be considered from the perspective of economic theory, but also can be well explained by legitimacy theory in Max Weber's politics. The theory of legitimacy holds that there is a contractual relationship between an enterprise and its stakeholders (Guthrie and Mathews 1985). According to the explicit stipulation of the law or the expectation of the public, this type of contract can be explicit or implicit (Gary et al. 1996). These two types of contracts require that corporate values should be

consistent with social values (Lindblom 1983). To cope with external environmental pressure from the government and the public and to reach the legitimacy of the “threshold,” enterprises are forced to take action to protect the environment and send the signal of abiding by the contract to the outside world. Therefore, it is an important way for enterprises to take the initiative to reduce pollutant emissions and conduct green management to gain social recognition and legal status. Stakeholder theory and legitimacy theory have promoted the application of green management very well. Under the supervision of stakeholders, enterprises implement green management to ease conflicts and comply with legality standards to obtain recognition and support, which builds a good theoretical framework for the research between air pollution and green management.

This paper proposes the following hypothesis:

Hypothesis 1: Air pollution produces a positive impact on the behavior of corporate green management, that is, the more serious the air pollution is, the higher the level of green management of the polluting companies is.

Regulating effect of media attention

The agenda setting theory of journalism believes that mass media will highlight the importance of certain issues through reports, thereby affecting the public's judgment on the event, that is, media reports can guide the public's attention (Mccombs and Shaw 1972). According to the theory of negative media, media often take a negative attitude toward events that are not supported by public opinion, and the content of the report is often “customized” to cater to the public (Dyck et al. 2008). As air pollution becomes serious, local media pay special attention to and report news such as environmental pollution incidents of enterprises in their regions, thereby guiding the public to pay special attention to air pollution by enterprises. Media is a medium for conveying information. First of all, media, boasting a wide range of information channels, can accurately and quickly obtain first-hand information about a variety of enterprises. Secondly, media, having a strong ability to extract and process information, can integrate information and reports on issues people are concerned about in a way that is easy for the public to understand. Media often acts as a “loudspeaker,” which enhances the transparency of corporate information and alleviates information asymmetry. The theory of information asymmetry holds that investors cannot fully understand corporations' environmental information, so investors cannot fully realize the function of supervision (Liu et al. 2020). However, it is useful to dig for information via media and collect, discriminate, sort out, and report events so as to guide the social public opinion to supervise the environmental pollution behavior of

enterprises, force polluting enterprises to save energy and reduce emissions, and achieve green management (Li et al. 2018).

Therefore, media attention plays a regulating role in studying the relationship between air pollution and corporate green management. Media reports are often divided into neutral reports and non-neutral reports based on emotional color. Neutral reports are often unemotional, while positive reports and negative reports, as non-neutral reports, usually incite the emotions of the public, which in turn affects the reputation of corporations. According to the theory of positive media, media reports regulate enterprises through reputation constraints, for reputation theory holds the view that a good reputation will bring more competitive advantages to enterprises and reduce the likelihood of negative events. Therefore, enterprises will be forced to take measures to maintain their corporate image by engaging in green behavior and conducting green management internally, giving impetus to their own green development (Kathuria 2006). Positive reports will enhance the reputation of corporations. To get more praise from media and the public, corporations will voluntarily reduce environmental pollution, while negative reports will damage corporate reputation. Under the pressure of public opinion, enterprises will be forced to take measures to protect the environment and take the initiative to assume social responsibilities in order to restore their corporate image, thereby giving impetus to their own green development. Therefore, agenda setting theory, information asymmetry theory, and theory of reputation have laid a solid theoretical groundwork for the study of media attention's regulating role between air pollution and corporate green management. Based on that, this paper proposes two further hypotheses.

Hypothesis 2: Media reports positively regulate the promoting effects of air pollution on corporate green management; that is, the closer the media scrutiny is, the more significant the impact of air pollution in facilitating corporate green management is.

Hypothesis 3: Only non-neutral media reports have a positive regulating effect, while neutral media reports have an insignificant regulating effect.

Research design

Samples and data sources

Following the method of Lin et al. (2020), this paper selects the mining and manufacturing industries, power and gas production, and supply industry of A-share enterprises listed in Shanghai and Shenzhen stock markets between 2014 and 2019 as the research sample of polluting companies. It collects the average daily AQIs (Air Quality Indices) of the cities where the corporations are located from the China Stock

Market & Accounting Research (CSMAR) data, and collects the total annual number of times that they are mentioned in the newspaper, financial, and news media from the Chinese Research Data Services Platform (CNRDS). This paper mainly processes the samples in accordance with the following principles: (1) winsorize the continuous variables at the levels of 1% and 99%; (2) exclude the samples of ST, *ST, and delisted companies; and (3) eliminate the samples with missing data. Finally, 7334 observed values were obtained. The data in this paper mostly comes from the CSMAR and CNRDS databases.

Model setting and variable description

In order to study the relationship between air pollution and green management of enterprises, the regression model is presented as follows by referring to existing literature research (Tan et al. 2021; Lin et al. 2021; Liu et al. 2019):

$$GREEN_{it} = \beta_0 + \beta_1 AQI_{it} + \beta_2 X_{it} + Year + Industry + \varepsilon_{it} \quad (1)$$

$$GREEN_{it} = \beta_0 + \beta_1 AQI_{it} + \beta_2 Media_{it} + \beta_3 AQI_{it} \times Media_{it} + \beta_4 X_{it} + Year + Industry + \varepsilon_{it} \quad (2)$$

$$GREEN_{it} = \beta_0 + \beta_1 AQI_{it} + \beta_2 Media_1_{it} + \beta_3 AQI_{it} \times Media_1_{it} + \beta_4 X_{it} + Year + Industry + \varepsilon_{it} \quad (3)$$

$$GREEN_{it} = \beta_0 + \beta_1 AQI_{it} + \beta_2 Media_2_{it} + \beta_3 AQI_{it} \times Media_2_{it} + \beta_4 X_{it} + Year + Industry + \varepsilon_{it} \quad (4)$$

In the model, β_0 is a constant; β_1 , β_2 , β_3 , and β_4 are regression coefficients; i and t denote enterprise and year respectively; GREEN denotes the green management level of polluting enterprises; AQI denotes the degree of air pollution of polluting companies; Media denotes media attention; $AQI \times Media$ denotes the multiplication of AQI and Media; $Media_1$ denotes non-neutral media reports; $AQI \times Media_1$ denotes the multiplication of AQI and $Media_1$; $Media_2$ denotes neutral media reports; $AQI \times Media_2$ denotes the multiplication of AQI and $Media_2$; X denotes a range of control variables that affect corporate green management at the enterprise level; Year and Industry are dummy variables for year and industry; and ε is a random disturbance term.

(1) Explained variable: Corporate green management

Following Wang et al. (2021), this paper measures the level of enterprises' implementation of green management using

the index of corporate green social responsibility published by Hexun.com. The higher the score, the higher the degree of green social responsibility and the higher the level of corporate green management.

(2) Explanatory variable: Air pollution index

Following Dong et al. (2019), this paper selects the AQI of all prefecture-level cities in China between 2014 and 2019 from the CSMAR data as an index of air pollution. The index was introduced in Chinese cities in 2014, which replaced the original measurement index API. The advantage of using AQI is that it presents the six indexes of sulfur dioxide, nitrogen dioxide, PM_{2.5}, PM₁₀, carbon monoxide, and ozone using a unified evaluation standard and more comprehensively measures the degree of air pollution in various regions of China. In this paper, the average daily AQI of the city where the company is located is selected as the index to measure the degree of air pollution.

(3) Moderator variable: Media attention

Following the method of Dong et al. (2020), the annual total number of media attention (media) appearing in newspapers and financial news media was selected from CNRDS as media attention (media), which is divided into neutral media reports (Media_2) and non-neutral media reports (Media_1) based on judgment of the tone of the articles. Non-neutral media reports include the number of positive and negative media reports per year. The advantages of choosing this data as an index are that the data covers a wide range and has a high reliability and considerable impact. In addition, the data is the most commonly used data source for China's economic and management research on media issues.

(4) Control variable

Following the methods of Lin (2020) and Wang et al. (2020), this study selects the variables as follows: enterprise size (lnsize), i.e., natural logarithm of total assets; return on total assets (Roa), i.e., net profit/total asset balance; shareholding ratio of the first majority shareholder (largest); size of the board of directors, i.e., natural logarithm of the number of directors; Tobin'Q; separating extent of ownership and the right of control (Sep), i.e., the difference between the right of control and ownership; gross domestic product (GDP), i.e., the gross domestic product of the province where the enterprise is located; market competition intensity (HHI), i.e., the enterprise's main business income accounts for the main business income of the industry; dummy variable of industry (Industry) and dummy variable of year (Year).

Descriptive analysis

Table 1 presents the descriptive statistics of the main variables of this study. The mean value of the scores of corporate green management is 21.013, with the minimum value of −3.36 and the maximum value of 70, which indicates that the green management level of different enterprises varies greatly; and the overall score is low, which means that the corporations as a whole do not pay sufficient attention to their own green management. The mean value of the AQI is 102.441, ranking as “Unhealthy for Sensitive Groups” the third level of the air quality classification standard, with the minimum value of 33 and the maximum value of 172, which indicates that the air pollution levels of different cities vary considerably. The mean value of media reports is 42.301, among which the mean value of negative and positive reports is 26.961, and the mean value of neutral media reports is 15.150. In other control variables, the mean value of enterprise size is 21.867, that of the return on total assets is 0.040, that of the average shareholding ratio of the first majority shareholder is 0.320, that of the average board size is 2.087, that of Tobin'Q is 2.290, that of separating extent of ownership and the right of control is 4.434, that of GDP is 5.026, and that of HHI is 0.103, which is consistent with the existing research. Moreover, it was found through analysis that the air quality in cities with a large number of polluting enterprises is generally poor, and the green management scores of the enterprises are on the rise year by year.

Empirical results and analysis

Correlation analysis

Firstly, variance inflation factor (VIF) test was performed on the model. Upon calculation, VIF values of all variables were

Table 1 Descriptive statistics

Variables	Obs	Mean	Std. dev.	Min
GREEN	7334	21.013	11.506	−3.36
AQI	7334	102.441	60.681	33
Media	7334	42.301	90.835	1
Media_1	7334	26.961	56.076	0
Media_2	7334	15.150	35.918	0
Sep	7334	4.434	7.070	0
lnsize	7334	21.867	1.097	19.703
Roa	7334	0.040	0.071	−0.348
Tobin'Q	7334	2.290	1.492	0.918
largest	7334	0.320	0.130	0.099
lnboard	7334	2.087	0.188	1.609
GDP	7334	5.026	2.772	0.375
HHI	7334	0.103	0.097	0.022

less than 5, so there was no multicollinearity problem. Secondly, a correlation analysis of the main variables was conducted (Table 2) to provide reference for the subsequent model regression. Air pollution, media reports, and corporate green management are significantly positively correlated at a 1% significance level, which indicates that air pollution and media reports can prompt enterprises to conduct green management, which initially verifies Hypotheses 1 and 2. In addition, Insize, ROA, largest, lnboard, SEP, and GDP are all positively correlated at a 1% significance level. This indicates that corporation size, the net interest rate of total assets, board size, concentration of equity, the GDP of the region where the enterprise is located, pollution levels, and corporate green management level are all correlated together, which is consistent with existing research findings. Finally, the clustering robust standard error test was performed on the model, and the empirical results indicated that tests were still significant and there was no heteroscedasticity problem.

Regression results

Table 3 presents the regression results of formulas (1), (2), (3), and (4). Column (1) shows the impact of air quality on corporate green management. The estimated AQI coefficient is significantly positively correlated at a 1% significance level, which indicates that the more serious air pollution is, the more favorable it is for enterprises to conduct green management, thus supporting Hypothesis 1. Column (2) shows the test result of adding the media attention regulating term. The coefficient of the interaction term between media attention and air quality is significantly positive ($\beta=0.041$, $P<0.05$), which indicates that media reports positively regulate the role of air pollution in boosting the green management of polluting corporations. This confirms Hypothesis 2. Columns (3) and (4) show the test results of the regulating terms of non-neutral and neutral media reports. The interaction term between non-neutral media reports and air quality is significantly positive ($\beta=0.073$, $P<0.05$), while the interaction term between neutral media reports and air quality is insignificant, which indicates that only positive and negative media reports have a positive regulating effect, while neutral media reports do not have a regulating effect, which verifies Hypothesis 3.

Further study: heterogeneity of polluting enterprises

Heterogeneity of inherent characteristics of polluting enterprises: pollution level

A company's own pollution level may affect the relationship between air pollution and its green management. Based on the classification criteria of Liu and Liu (2015), this study groups 11 industries of B07, B08, B09, C25, C26, C28, C29, C30, C31, C32, and D44 into the category of heavy polluting

industries, while it takes other industries in the same category at the level of B, C, and D as non-heavy polluting companies or light polluting companies, in accordance with *National Economic Industry Classification 2020* and the *Guide to Environmental Information Disclosure of Chinese Listed Companies*. It defines the pollution level (Industry) as a dummy variable. If a corporation belongs to a heavy polluting category, the value of Industry will be 1; if it belongs to a light polluting category, the value of Industry will be 0. Table 4 presents grouped regression results divided based on pollution level. The AQI of the sample of heavy polluting enterprises is insignificant, and the AQI of the sample of light polluting enterprises is significantly positive at the level of 1%. The results show that air pollution has no significant impact on the green management of heavy polluting companies but produces a significant positive impact on the green management of light polluting companies.

It is generally acknowledged that air pollution causes governments to conduct environmental regulation and usually plays a greater role in boosting green management of heavy polluting enterprises, which are the main consumers of resources and the main emitters of air pollution. However, the empirical results show that air pollution can significantly facilitate the green management of light polluting enterprises. The reason may be that, on the one hand, heavy polluting enterprises do not receive policy support, and they are facing signs of recession and decreasing revenue and profitability; on the other hand, heavy polluting enterprises, as the targets of the penalty effect of Hypothesis 2, face serious financing constraints. In the case of insufficient free cash flow, the green expenditure of heavy polluting enterprises will be hindered and their green management level will be reduced.

To reduce the phenomenon of low corporate green management caused by external factors and to make corporations take the initiative to shoulder more social and environmental responsibility, we will further verify the impact of the environmental protection background of senior executives of heavy polluting enterprises on the green management level of these companies. Following prior established methods such as that of Pan et al. (2019), this study selects members of the management, board of directors, and board of supervisors who have experience in environmental protection, such as working for the government's environmental protection departments or environmental protection associations, obtaining degree certificates related to environmental protection, and participating in environmental protection projects, and determines the value of experience as 1; otherwise, the value of experience is 0. Table 5 presents the results of grouped regression. The AQI of corporations with senior business executives with experience in environmental protection is significantly positive, while the AQI of those without is insignificant. This indicates that when senior business executives have experience in environmental protection, air pollution produces a significant positive impact

Table 2 Correlation analysis

	Green	AQI	Media	Media_1	Media_2	largest	SEP	Insize	Roa	Tobin'Q	Inboard	HHI	GDP
Green	1												
AQI	0.032***	1											
Media	0.157***	-0.074***	1										
Media_1	0.145***	-0.077***	0.971***	1									
Media_2	0.168***	-0.055***	0.913***	0.805***	1								
largest	0.190***	-0.012	0.054***	0.040***	0.064***	1							
SEP	0.079***	0.002	0.076***	0.075***	0.074***	0.151***	1						
Insize	0.116***	0.012	0.345***	0.351***	0.300***	0.019	0.134***	1					
Roa	0.723***	0.019*	0.078***	0.066***	0.092***	0.174***	0.022*	0.074***	1				
Tobin'Q	-0.006	-0.095***	-0.030**	-0.029**	-0.034***	-0.034***	-0.015	-0.496***	0.183***	1			
Inboard	0.054***	-0.016	0.101***	0.101***	0.089***	-0.058***	0.111***	0.211***	0.011	-0.114***	1		
HHI	0.010	0.007	0.017	0.013	0.026**	0.018	0.018	0.054***	-0.007	-0.028**	0.037***	1	
GDP	-0.028**	-0.013	-0.054***	-0.051***	-0.055***	0.051***	-0.050***	-0.003	-0.013	0.009	-0.056***	-0.039***	1

*, **, and *** denote the significance levels at 10%, 5%, and 1% respectively, the same below.

Table 3 Regression results

Variables	Green			
	(1)	(2)	(3)	(4)
AQI	0.007*** (3.89)	0.007*** (3.93)	0.007*** (3.97)	0.007*** (3.87)
lnsize	1.559*** (13.52)	1.349*** (10.96)	1.343*** (10.80)	1.377*** (11.41)
Roa	86.52*** (55.16)	86.32*** (55.10)	86.32*** (55.09)	86.34*** (55.12)
Sep	0.074*** (4.65)	0.076*** (4.79)	0.076*** (4.79)	0.076*** (4.79)
Tobin'Q	−0.352*** (−4.03)	−0.399*** (−4.54)	−0.400*** (−4.56)	−0.390*** (−4.45)
largest	2.234** (2.57)	2.004** (2.30)	2.039** (2.34)	1.997** (2.30)
lnboard	0.256 (0.43)	0.172 (0.29)	0.174 (0.29)	0.184 (0.31)
GDP	−0.012 (−0.38)	−0.011 (−0.29)	−0.011 (−0.29)	−0.012 (−0.29)
HHI	1.667 (1.51)	1.643 (1.49)	1.647 (1.49)	1.624 (1.47)
Media		1.941 (0.80)		
AQI×Media		0.041** (1.99)		
Media_1			2.194 (0.57)	
AQI×Media_1			0.073** (2.19)	
Media_2				7.240 (1.14)
AQI×Media_2				0.083 (1.57)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
_cons	−21.29*** (−5.58)	−16.59*** (−4.22)	−16.43*** (−4.16)	−17.28*** (−4.45)
N	7334	7334	7334	7334
Adjusted R ²	0.3739	0.3760	0.3758	0.3761
F	100.54	97.05	96.99	97.10

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

on the green management of heavy polluting enterprises; otherwise, the impact is insignificant.

Influenced by financing constraints, heavy polluting companies may have less enthusiasm to conduct green management. Psychological characteristics such as values and risk preference of the senior executive team, as the core of business management and supervision, will be affected by the unique experience of members, thus affecting the decision-making

Table 4 Pollution level—grouped sample regression

Variables	Industry=0	Industry=1
AQI	0.005*** (2.45)	0.001 (0.34)
lnsize	1.766*** (10.83)	1.686*** (6.26)
Roa	90.007*** (42.60)	84.59*** (18.21)
Sep	0.065*** (3.34)	0.110** (2.52)
Tobin'Q	0.059 (0.65)	−0.085 (−0.44)
largest	3.689*** (3.65)	−1.346 (−0.69)
lnboard	1.115* (1.67)	−1.386 (−0.95)
GDP	−0.073 (−0.16)	−0.023 (−0.27)
HHI	2.673* (2.11)	−1.505 (−0.65)
Industry	Yes	Yes
Year	Yes	Yes
_cons	−25.702*** (−6.92)	−16.57*** (−2.64)
N	5553	1781
Adjusted R ²	0.3723	0.2685
F	238.74	45.04

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

behavior of enterprises. According to regression results, this paper holds that the possible reasons are: First, senior executives who have experience in environmental protection can recognize the urgency of solving corporations' environmental pollution problems and maintain an eagerness to pursue sustainable development over the long term. Senior executives can shape the concept of environmental protection at the corporations' strategic level, so that employees have a higher awareness of environmental responsibility, which is conducive to the development of green management initiatives. Second, enterprises will face a higher risk of failure when they transform from a traditional management mode to green management. Senior executives who have experience in environmental protection are able to give timely attention to the requirements of national environmental policies and respond to them positively to obtain government support and subsidies, and the team of senior executives who have professional knowledge and experience in environmental protection of the enterprises can help reduce the risk in transformation toward green development. Therefore, senior executives who have experience in environmental protection are able to take

Table 5 Experience in environmental protection of senior executives—grouped sample regression

Variables	Experience =0	Experience =1
AQI	0.005 (0.98)	0.014* (1.70)
lnsize	1.121*** (4.00)	2.231*** (3.92)
Roa	88.245*** (14.63)	92.726*** (11.54)
Sep	0.121** (2.38)	0.170** (2.13)
Tobin'Q	−1.016*** (−4.08)	−0.039 (−0.08)
largest	−1.232** (2.38)	−5.504 (−1.35)
lnboard	−1.920 (−1.14)	−2.869 (−1.01)
GDP	0.010 (−1.01)	0.008 (0.56)
HHI	−2.685 (−1.08)	7.670 (1.62)
Industry	Yes	Yes
Year	Yes	Yes
_cons	10.691 (1.07)	−32.097** (−2.28)
N	1316	465
Adjusted R ²	0.2962	0.4305
F	17.00	9.50

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

the initiative to conduct green management with the support of both policies and experience.

Heterogeneity of the external environment of polluting enterprises: local governance level

Drawing on studies by Pan et al. (2019), this paper refers to *China's Marketization Index* to indicate the governance levels of different regions in order to measure the governance levels of different regions. If the score is higher than 50% quantile, it will be an area with a high local governance level, and the Market value will be 1; if the score is lower than 50% quantile, it will be an area with a low local governance level, and the Market value will be 0. Table 6 presents the results of grouped regression. The AQI of the areas with a high local governance level is positive at a 1% significance level, and the AQI of areas with a low local governance level is insignificant, which indicates that when the local governance level is high, air pollution has a significant positive impact on corporate green management, and when the local governance level is low, the impact of air pollution is insignificant.

Table 6 Local governance level—grouped sample regression

Variables	Market=0	Market=1
AQI	0.001 (0.04)	0.008*** (3.47)
lnsize	1.966*** (10.25)	1.472*** (7.29)
Roa	85.199*** (31.30)	92.937*** (33.97)
Sep	0.037 (1.49)	0.109*** (4.07)
Tobin'Q	0.044 (0.38)	0.050 (0.43)
largest	3.330** (2.54)	1.874 (1.53)
lnboard	0.188 (0.22)	0.666 (0.75)
GDP	0.002 (0.28)	−0.006 (−1.01)
HHI	1.023*** (2.63)	−1.128 (−0.70)
Industry	Yes	Yes
Year	Yes	Yes
_cons	−27.676*** (−6.20)	−17.798*** (−3.94)
N	3736	3,598
Adjusted R ²	0.3411	0.3517
F	135.65	145.51

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In areas with a high local governance level, the public has a higher awareness of environmental protection. In the face of high air pollution, if corporations pollute the environment, they will be forced to conduct green management under the control of the government, the restriction of the law, and the supervision of the public. By contrast, in the areas with a low local governance level, due to the lack of effective supervision it is easy for companies to bribe local governments to reduce restrictions on their pollution, thus forming a “government-enterprise collusion,” which leads to the possibility of rent-seeking. Because of this, in areas with a low local governance level, pollution levels cannot effectively restrain the company's pollution even if it is serious there.

Robustness test

Instrumental variable approach

This paper deals with endogenous problems by taking an instrumental variable approach. Existing studies prove that air

pollution will be affected by a variety of meteorological factors such as wind speed, rainfall, relative humidity, air temperature, and air pressure. Because of this, some studies select a meteorological index as the instrumental variable of AQI (Li and Li 2017). This study selects wind speed and relative humidity from the CSMAR database and the National Meteorological Information Center as the instrumental variables of air pollution. Studies show that air pollution is closely linked to wind speed and relative humidity, but wind speed and relative humidity will not directly affect corporate green management, nor indirectly affect it through a number of factors influencing the behavior of corporate green management. Table 7 presents the test results of instrumental variables. The regression coefficients in columns (1), (2), (3), and (4) are significantly positive, which supports the hypothesis of this paper.

Lag effect test

To test the lag effect of air pollution on corporate green management, the lag one-period term and lag two-period term of air pollution are added in columns (2) and (3) to observe whether air pollution produces a long-term impact on corporate green management. Table 8 presents the test results. The coefficient of the lag one-period term of air pollution produces a significant positive impact at 5%, and the coefficient of the lag two-period term of air pollution at 1%. This indicates that air pollution not only affects corporate green management in the current period, but also produces a long-term impact on corporate green management. What is more, it also proves the robustness of the core conclusion of this paper that “air pollution can boost the green management of polluting enterprises.”

Conclusions and policy implications

Research conclusions

Air pollution impedes economic development. Reducing environmental pollution through implementing green management is the key to achieving high-quality economic development. Taking A-share polluting enterprises listed in the Shanghai and Shenzhen stock markets as the object, this paper deals with the impact of air pollution on corporate green management. The results show that air pollution will force enterprises to conduct green management. Media reports play a significant positive regulating role between air pollution and corporate green management; it is found through the study of different emotional colors of media reports that when they report positively or negatively, media reports will play a significant positive regulating role and guide enterprises to conduct green management. Further studies found that air

Table 7 Instrumental variable approach

Variables	(1) First stage	(2) Second stage	(3) First stage	(4) Second stage
	AQI	GREEN	AQI	GREEN
FS	7.961*** (3.26)			
AQI		0.103* (1.78)		
SD			0.725*** (4.73)	
AQI				0.065* (1.85)
lnsize	−0.116 (−0.09)	1.585*** (5.89)	0.215 (0.16)	1.576*** (6.39)
Roa	12.637 (0.78)	82.782*** (22.89)***	2.356 (0.14)	83.268*** (24.21)
Sep	−0.413** (−2.19)	0.051 (1.17)	−0.464** (−2.50)	0.034 (0.94)
Tobin'Q	−1.145 (−1.31)	−0.048 (−0.27)	−0.803 (−0.90)	−0.089 (−0.56)
largest	5.984 (0.61)	4.547** (2.42)	4.275 (0.43)	5.359*** (3.18)
lnboard	−0.547 (−0.08)	1.105 (0.87)	−4.817 (−0.68)	1.508 (1.24)
GDP	0.019 (0.42)	−0.017* (−1.83)	0.032 (0.70)	0.016** (−2.00)
HHI	20.782* (1.72)	−1.909 (−0.78)	16.886 (1.39)	−1.267 (−0.60)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
_cons	108.784*** (2.91)	−32.836*** (−3.01)	91.399** (2.47)	−29.556*** (−3.41)
N	2330	2330	2273	2273
Adjusted R ₂	0.1735	0.1538	0.1679	0.2856
F	20.71	\	21.49	\
chi2	\	896.34***		999.42***

t statistics in parentheses. **p* < 0.1, ***p* < 0.05, ****p* < 0.01.

pollution produces a significant positive impact on the green management of light polluting enterprises, but it has no significant impact on heavy polluting enterprises. The reason may be that the penalty effect in Hypothesis 2 restricts the financing of heavy polluting enterprises, in which case there are not sufficient funds to support corporate green management. The study also found that heavy polluting enterprises will conduct green management when senior executives have experience in environmental protection. When the governance level of the region where a corporation is located is high, air pollution will facilitate corporate green management.

Table 8 Lag effect test

Variables	Green		
	(1)	(2)	(3)
AQI	0.007*** (3.89)		
L.AQI		0.005** (2.24)	
L2.AQI			0.007*** (3.07)
lnsize	1.559*** (13.52)	1.558*** (11.34)	1.558*** (10.09)
Roa	86.52*** (55.16)	84.90*** (47.46)	79.04*** (42.21)
Sep	0.074*** (4.65)	0.093*** (5.02)	0.088*** (4.21)
Tobin'Q	−0.352*** (−4.03)	−0.422*** (−4.09)	−0.267** (−2.18)
largest	2.234** (2.57)	1.974* (1.92)	2.829** (2.41)
lnboard	0.256 (0.43)	0.0765 (0.11)	0.382 (0.49)
GDP	−0.012 (−0.38)	−0.031 (−0.68)	−0.025 (−0.50)
HHI	1.667 (1.51)	1.682 (1.30)	2.461* (1.69)
_cons	−21.29*** (−5.58)	−16.75*** (−3.42)	−16.52*** (−2.99)
Control	Yes	Yes	Yes
N	7334	5437	3942
Adjusted R ²	0.3739	0.3838	0.4266
F	100.54	79.73	70.81

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Policy recommendations

1. Enterprises, as the main environmental polluter, should enhance their own green management behaviors under the requirements of local governments and the supervision of the public, maintain a sensitive attitude toward external air pollution problems, and take initiative to perceive their pollution behaviors, thereby heightening their sense of environmental and social responsibility.
2. The media is an important supervisor of environmental governance, and empirical studies have shown that media attention plays a significant role in regulating air pollution. In view of this, we should enhance the role of media in air pollution governance. Therefore, media, as a third-party subject (other than the government and enterprises),

should proactively play the role of environmental supervision, take the initiative to assume social environmental responsibilities, and continue to increase the reports on and strengthen the guidance on corporate air pollution behavior, thereby promoting enterprises to improve their green management level. Under the guidance of the positive and negative attitudes of the media, enterprises are encouraged to develop into the green sector and form a supplementary role for government supervision to build a comprehensive environmental supervision system.

3. The government, as the leader of environmental governance, should strengthen the management and supervision of enterprises, including disclosing the level of corporate green management and promoting listed enterprises to proactively disclose information about their social and environmental responsibility so as to enable them to establish a good social image on the one hand and effectively supervise their level of corporate green management on the other hand.
4. Managers, as the main internal driver of corporate green management behavior, should emphasize enterprises' green management, improve their decision-making and action capabilities in green management, and integrate green behavior into their actual business process. Furthermore, they should remain sensitive to the national environmental policy and open up the green market in a timely manner.

Future prospects

Just like all other countries, China is struggling to combat the COVID-19 pandemic. COVID-19 mainly affects the respiratory system of patients, so a small increase in air pollution will lead to a substantial increase in COVID-19 infections and patient mortality (Travaglio et al. 2021). Moreover, a great number of enterprises in various countries are facing production stagnation and shrinking demand for orders as they work to control the spread of COVID-19. Facing such a severe market environment, enterprises should still frequently practice “internal skills” in the future and develop green management to mitigate the increased risk of the COVID-19 pandemic caused by air pollution and boost the sustainable development of enterprises themselves. It is an inevitable requirement in the post-pandemic era to explore the future green governance path of enterprises, thereby alleviating air pollution and reviving the world economy. In addition, our team will carry out qualitative research on green management to improve and enrich the related research methods.

Appendix

Table 9 The abbreviations used in this paper

HHI	Herfindahl-Hirschman Index
GDP	gross domestic product
AQI	Air Quality Index
ROA	Return on Assets
Tobin'Q	Tobin's Q Ratio

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References

- Bundgaard AM, Mosgaard MA, Remmen A (2017) From energy efficiency towards resource efficiency within the ecodesign directive. *J Clean Prod* 144:358–374. <https://doi.org/10.1016/j.jclepro.2016.12.144>
- Bushee BJ, Core JE, Guay W, Hamm SJW (2010) The role of the business press as an information intermediary. *J Account Res* 48:1–19. <https://doi.org/10.1111/j.1475-679X.2009.00357.x>
- Carvalho LS, Stefanelli NO, Viana LC, Vasconcelos DSC, Oliveira BG (2020) Green supply chain management and innovation: a modern review. *Management of Environmental Quality* 31:470–482. <https://doi.org/10.1108/MEQ-12-2019-0283>
- Cuñado J, Perez DGF (2013) Environment and happiness: new evidence for Spain. *Soc Indic Res* 112:549–567. <https://doi.org/10.1007/s11205-012-0038-4>
- Danie T, Tobias W (2020) The impact of environmental innovation on carbon dioxide emissions. *J Clean Prod* 244:118787. <https://doi.org/10.1016/j.jclepro.2019.118787>
- Domenico B, Micha W (2019) “Green” managerial delegation and environmental corporate social responsibility in different market structures. *Central Europe Management Journal* 27:2–22. <https://doi.org/10.7206/cemj.2658-0845.7>
- Dong R, Fisman R, Wang Y, Xu N (2019) Air pollution, affect, and forecasting bias: evidence from Chinese financial analysts. *J Financ Econ* 139:971–984. <https://doi.org/10.1016/j.jfineco.2019.12.004>
- Douglas WS, Tom R, Stuart M (2013) Green human resource management: a review and research agenda. *Int J Manag Rev* 15:1–14. <https://doi.org/10.1111/j.1468-2370.2011.00328.x>
- Du W, Li M (2019) Assessing the impact of environmental regulation on pollution abatement and collaborative emissions reduction: micro-evidence from Chinese industrial enterprises. *Environ Impact Assess* 82:106382. <https://doi.org/10.1016/j.eiar.2020.106382>
- Dyck A, Volchkova N, Zingales L (2008) The corporate governance role of the media: evidence from Russia. *J Financ* 63:1093–1135. <https://doi.org/10.1111/j.1540-6261.2008.01353.x>
- Gary F, Campbell D, Serlin C (1996) African American women. Disparities in health care. *J Fla Med Assoc* 83:489–493
- González X, Miles D, Pázó C (2016) R&D, worker training and innovation: firm-level evidence. *SSRN Electronic Journal* 23:694–712. <https://doi.org/10.2139/ssrn.2689520>
- Gu H, Yan W, Elahi E, Cao Y (2020) Air pollution risks human mental health: an implication of two-stages least squares estimation of interaction effects. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-019-06612-x>
- Guthrie J, Mathews MR (1985) Corporate social accounting in Australasia. *Research in Corporate Social Performance and Policy* 7:251–277
- Hao Y, Peng H, Temulun T, Liu LQ, Mao J, Lu ZN, Chen H (2018) How harmful is air pollution to economic development? New evidence from PM2.5 concentrations of Chinese cities. *J Clean Prod* 172: 743–757. <https://doi.org/10.1016/j.jclepro.2017.10.195>
- Hupp WS (2018) What's in the water? How media coverage of corporate pollution shapes local understanding of risk. *Critical Criminology* 26:289–305. <https://doi.org/10.1007/s10612-018-9389-8>
- Jia X, Yang X, Dong W, Yang F, Liu Q, Li H, Pan L, Shan J, Niu W, Wu S, Deng F, Guo X (2018) Short-term effects of particulate matter in metro cabin on heart rate variability in young healthy adults: impacts of particle size and source. *Environ Res* 167:292–298. <https://doi.org/10.1016/j.envres.2018.07.017>
- Kathuria V (2006) Controlling water pollution in developing and transition countries—lessons from three successful cases. *J Environ Manage* 78:405–426. <https://doi.org/10.1016/j.jenvman.2005.05.007>
- Kong D, Yang X, Liu C, Yang W (2020a) Business strategy and firm efforts on environmental protection: evidence from China. *Bus Strateg Environ* 29:445–464. <https://doi.org/10.1002/bse.2376>
- Kong G, Kong D, Wang M (2020b) Does media attention affect firms' environmental protection efforts? Evidence from China. *Singap Econ Rev* 65:577–600. <https://doi.org/10.1142/S021759081741003X>
- Li C, Li H (2017) The impact of air pollution on corporate inventory—an empirical study based on the data of Chinese manufacturing enterprises. *Management World* 8:95–105. <https://doi.org/10.19744/j.cnki.11-1235/f.2017.08.010>
- Li WB, Zhang KX (2019) The impact of air pollution on corporate productivity: evidence from Chinese industrial companies. *Management World* 35:95–112. <https://doi.org/10.19744/j.cnki.11-1235/f.2019.0134>
- Li L, Xia XH, Chen B, Sun L (2018) Public participation in achieving sustainable development goals in China: evidence from the practice of air pollution control. *J Clean Prod* 201:499–506. <https://doi.org/10.1016/j.jclepro.2018.08.046>

- Lin Y, Huang R, Yao X (2021) Air pollution and environmental information disclosure: an empirical study based on heavy polluting industries. *J Clean Prod* 278:124313. <https://doi.org/10.1016/j.jclepro.2020.124313>
- Lindblom CK (1983) The implications of organizational legitimacy for corporate social performance and disclosure. *American Accounting Association Public Interest Section*.
- Liu YG, Liu MT (2015) Have smog affected earnings management of heavy-polluting enterprise?—based on the political-cost hypothesis. *Accounting research*.
- Liu S, Yang D, Liu N, Liu X (2019) The effects of air pollution on firms' internal control quality: evidence from China. *Sustainability* 11:50–68. <https://doi.org/10.3390/su11185068>
- Liu F, Yang K, Liu L (2020) New media environment, environmental information disclosure and firm valuation: evidence from high-polluting enterprises in China. *J Clean Prod* 277:123253. <https://doi.org/10.1016/j.jclepro.2020.123253>
- Louis RE, Mafini C (2018) Green supply chain management in small and medium enterprises: further empirical thoughts from South Africa. *Journal of Transport and Supply Chain Management* 12:1–12. <https://doi.org/10.4102/jtscm.v12i0.393>
- Luo W, Guo X, Zhong S, Wang J (2019) Environmental information disclosure quality, media attention and debt financing costs: evidence from Chinese heavy polluting listed companies. *J Clean Prod* 231:268–277. <https://doi.org/10.1016/j.jclepro.2019.05.237>
- Marco R (2020) Microeconomic models of a production economy with environmental externalities. *Environ Dev Sustain* 22:2625–2650. <https://doi.org/10.1007/s10668-019-00313-8>
- Mccombs ME, Shaw DL (1972) The agenda-setting function of mass media. *Public Opin Q* 3:89–95. [https://doi.org/10.1016/S0363-8111\(77\)80008-8](https://doi.org/10.1016/S0363-8111(77)80008-8)
- Mujtaba G, Shahzad S (2021) Air pollutants, economic growth and public health: implications for sustainable development in OECD countries. *Environ Sci Pollut Res* 28:12686–12698. <https://doi.org/10.1007/s11356-020-11212-1>
- Pan AL, Liu X, Qin JL, Shen Y (2019) Can green M&A under the pressure of media boost heavy polluting enterprises to accomplish substantial transformation? *China Industrial Economics* 2:174–192. http://en.cnki.com.cn/Article_en/CJFDTotat-GGY201902011.htm
- Putri VW, Ridloah S, Wijaya AP (2020) Strategy for increasing green economic performance of small and medium enterprises based on green business management. *IOP Conference Series: Earth and Environmental Science* 485:012063
- Qin Y, Zhu H (2017) Run away? Air pollution and emigration interests in China. *J Popul Econ* 31:1–32. <https://doi.org/10.1007/s00148-017-0653-0>
- Raharjo K (2019) The role of green management in creating sustainability performance on the small and medium enterprises. *Management of Environmental Quality* 30:557–577. <https://doi.org/10.1108/MEQ-03-2018-0053>
- Rotton J, Frey J (1985) Air pollution, weather, and violent crimes: concomitant time-series analysis of archival data. *J pers soc psychol* 49:1207–1220. <https://doi.org/10.1037/0022-3514.49.5.1207>
- Rustam A, Wang Y, Zameer H (2020) Environmental awareness, firm sustainability exposure and green consumption behaviors. *J Clean Prod* 268:122016. <https://doi.org/10.1016/j.jclepro.2020.122016>
- Su W, Fan Y (2021) Impact of media attention on environmental performance in China. *Environmental Challenges* 4:100133. <https://doi.org/10.1016/j.envc.2021.100133>
- Sulich A, Rutkowska M (2020) Factor analysis of the green management in the context of Poland regions sustainable development. *Experimental and Quantitative Methods in Contemporary Economics*:143–156. https://doi.org/10.1007/978-3-030-30251-1_11
- Swarup S (2017) The effect of technological innovation on production-based energy and CO2 emission productivity: evidence from BRICS countries. *African Journal of Science, Technology, Innovation and Development* 9:503–512. <https://doi.org/10.1080/20421338.2017.1308069>
- Tan J, Tan Z, Chan K (2021) Does air pollution affect a firm's cash holdings? *Pac-Basin Financ J* 67:101579. <https://doi.org/10.1016/j.pacfin.2021.101549>
- Travaglio M, Yu Y, Popovic R, Selley L, Leal NS (2021) Martins LM. Links between air pollution and COVID-19 in England. *Environ pollut* 268:115859. <https://doi.org/10.1016/j.envpol.2020.115859>
- Wang F, Wu M (2020) Does air pollution affect the accumulation of technological innovative human capital? Empirical evidence from China and India. *J Clean Prod* 285:124818. <https://doi.org/10.1016/j.jclepro.2020.124818>
- Wang Y, Lu T, Qiao Y (2021) The effect of air pollution on corporate social responsibility performance in high energy-consumption industry: Evidence from Chinese listed companies. *J Clean Prod* 280:124345. <https://doi.org/10.1016/j.jclepro.2020.124345>
- Wu S, Chen Y (2014) The impact of green marketing and perceived innovation on purchase intention for green products. *International Journal of Marketing Studies* 6. <https://doi.org/10.5539/ijms.v6n5p81>
- Zhang B (2019) Environmental protection responsibility of enterprises: green human resource management. *IOP Conf Ser: Mater Sci Eng* 612:052022. <https://doi.org/10.1088/1757-899X/612/5/052022>
- Zheng W, Chen P (2020) The political economy of air pollution: local development, sustainability, and political incentives in China. *Energy Res Soc Sci* 69:101707. <https://doi.org/10.1016/j.erss.2020.101707>
- Zheng Y, Peng J, Xiao J, Su P, Li S (2020) Industrial structure transformation and provincial heterogeneity characteristics evolution of air pollution: evidence of a threshold effect from China. *Atmospheric Pollut Res* 11:598–609. <https://doi.org/10.1016/j.apr.2019.12.011>

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