Energy Economics 130 (2024) 107320

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Energy related public environmental concerns and intra-firm pay gap in polluting enterprises: Evidence from China

Kung-Cheng Ho [a,e], Cheng Yan [b], Giray Gozgor [c,f], Yan Gu [d,*]

[a] Fuzhou University of International Studies and Trade, 350200, China
[b] School of Economics, Zhejiang University of Technology, Hangzhou 310023, China
[c] University of Bradford, BD7 1DP, UK
[d] Fanhai International School of Finance, Fudan University, Shanghai 200433, China
[e] Innovation and Talent Base for Digital Technology and Finance, Zhongnan University of Economics and Law, 430073, China
[f] Adnan Kassar School of Business, Lebanese American University, P.O. Box 13-5053, Beirut, Lebanon

A R T I C L E I N F O

JEL classification:
G11
G32
N72

Keywords:
Public environmental concerns
Intra-firm pay gap
Polluting enterprises
PM2.5 surge
Emerging economies

A B S T R A C T

This study empirically investigates the impact of energy related public environmental concerns on the pay gap within polluting companies. It uses the extreme environmental event of the PM2.5 surge at the end of 2011, which led to an upsurge in energy related public environmental concerns in China, as a quasi-natural experiment. According to our findings, energy related public environmental concerns lead to a significant increase in the executive–employee pay gap of polluting companies compared to that of non-polluting companies, owing to a significant increase in executive compensation and no significant change in employee income. The effect of energy related public environmental concerns on increasing the pay gap within polluting companies is more significant in samples with high agency costs, poor information transparency, less analyst follow-up, and fewer institutional investors' shareholding. Furthermore, as energy related public environmental concerns exacerbate the polluting firms' internal pay gap, their total factor productivity and investment efficiency fall significantly. In summary, energy related public environmental concerns not only widen the wage gap within polluting enterprises but also worsen their operational and investment efficiency, which has important policy implications for emerging market economies seeking to balance environmental protection and economic development.

1. Introduction

The frequent occurrence of extreme climatic events worldwide has drawn public attention to environmental issues in recent years. In July 2021, The Intergovernmental Panel on Climate Change (IPCC), the Climate Science Agency of the United Nations, released the first report of the sixth assessment cycle titled 'Climate Change 2021: The Physical Science Basis' (IPCC, 2021). According to the IPCC (2021), limiting global warming to 1.5 °C or even 2 °C is impossible unless greenhouse gas emissions are reduced immediately, rapidly, and on a large scale. As global warming worsens, extreme weather events, including intense rainfall, floods, and high temperatures, are likely to occur.

Although it is widely acknowledged that measures like reducing energy consumption and pollution and protecting the environment are critical, there are still many difficulties in assessing and addressing environmental problems due to regional disparities in economic development. Market economies must strike a balance between economic growth and environmental protection (Narayan and Narayan, 2010; Narayan et al., 2016; Musa and Maijama'a, 2020). These economies are still in the early stages of economic development, and extensive industrial structures and production models inevitably lead to high energy consumption and pollution (Wang and Zhang, 2020; Hawitibo and Tenaw, 2022). However, with a general increase in public environmental awareness due to extreme climate events and a large number of studies indicating that environmental pollution will cause several diseases that will severely harm physical and mental health (Chen et al., 2013; Ebenstein et al., 2017), emerging market economies have begun to focus on the public's environmental demands.

This dilemma raises the important issue of determining how to address energy-related public environmental concerns and the growth of polluting enterprises (Fan et al., 2021). China, the largest emerging market economy worldwide, has experienced rapid economic growth. It

* Corresponding author.
E-mail addresses: g.gozgor@bradford.ac.uk (G. Gozgor), gyapple2006@126.com (Y. Gu).

https://doi.org/10.1016/j.eneco.2024.107320
Received 29 December 2022; Received in revised form 19 December 2023; Accepted 9 January 2024
Available online 15 January 2024

is inextricably linked to its long-term support of heavily polluting and high-carbon industries such as steel and coal. These industries require immediate adjustment and transformation. Environmental economics has traditionally promoted the transition to cleaner production in heavily polluting industries. However, most studies have primarily focused on the impact of environmental regulations. Numerous studies, based on theories such as "expensive regulation," "pollution haven," and Porter's hypothesis, have empirically explored the impact of environmental regulation on the production, operation, and export behavior of polluting enterprises (Porter and Linde, 1995; Shadbegian and Gray, 2005; Shi and Xu, 2018). However, the empirical research on the impact of public environmental concerns on polluting industries is limited.

This study examines the impact of energy-related public environmental concerns on the executive–employee pay gap in polluting firms.[1] Unlike environmental regulations, which generally impose hard constraints on enterprises' pollution emissions, energy-related public environmental concerns influence corporate management indirectly through soft constraints such as public opinion pressure and consumer boycotts, which impact corporate decision-making. Compensation is the most direct incentive enterprises provide to management, and the impact of energy-related public environmental concerns on management is likely reflected in executive compensation. Given the differences in the operating environments of different industries and companies, the impact of energy-related public environmental concerns on the executive–employee pay gap can be thoroughly investigated by considering the impact of energy-related public environmental concerns on an organization's compensation structure. The executive–employee pay gap is an important manifestation of the income distribution gap (Kong et al., 2020), which has widened globally. This study examines the impact of energy-related public environmental concerns on the executive–employee pay gap in polluting enterprises. The pay gap is also an important extension of environmental justice.

Given the difficulty of measuring energy-related public environmental concerns (Gu et al., 2021), this study uses the extreme environmental event of the PM2.5 surge 2011 as a quasi-natural experiment. It uses a difference-in-difference model to investigate the impact of energy-related public environmental concerns on pay gaps within heavily polluting enterprises in China. According to the empirical findings, energy-related public environmental concerns cause a significant increase in the executive–employee pay gap in polluting companies compared to non-polluting businesses. This widening gap is primarily due to a significant increase in executive compensation without a corresponding change in employee income. Furthermore, the impact of energy-related public environmental concerns on the pay gap among polluting companies is more significant in samples with high agency costs, poor information transparency, fewer analyst follow-ups, and fewer institutional investor shareholdings. Moreover, as energy-related public environmental concerns exacerbate the internal pay gap in polluting firms, their factor productivity and investment efficiency decrease significantly. Therefore, this study demonstrates that energy-related public environmental concerns drive a widening wage gap within polluting enterprises and further deterioration of operating and investment efficiency.

This study makes two main contributions to the literature. First, it expands the research on the impact of soft institutional constraints on the governance of polluting enterprises. Compared with the hard institutional constraints of environmental regulation, the impact of soft institutional constraints on environmental governance has received increasing attention (Liu et al., 2022; Zhao et al., 2022). With the frequent occurrence of extreme climate events worldwide, many studies have focused on the impact of public environmental attention on polluting enterprises (Liu and Mu, 2016; Wu et al., 2019; Gu et al., 2021, 2022). This study explores the impact of public environmental attention on the compensation gap between executives and employees in polluting enterprises. It provides new evidence on how public environmental attention affects the governance of polluting enterprises.

Second, this study provides new empirical evidence on the driving forces influencing intra-firm pay gaps, which have long been an important topic in income distribution, especially in emerging market economies. Owing to limited data (Faleye et al., 2013), previous studies on mature markets such as the United States have mostly focused on the pay gap within management teams (Lee et al., 2019; Fernandes and Ferreira, 2021; Homroy and Mukherjee, 2021). As the Chinese Securities Regulatory Commission has detailed disclosure requirements for employee and executive compensation, the results of this study are unaffected by selective disclosure bias. The results suggest that energy-related public environmental concerns significantly increase the executive–employee pay gap, which expands the research on the driving forces of the intra-firm pay gap from an environmental governance perspective.

The conclusions have important implications for emerging market economies facing economic development and environmental protection dilemmas. Based on a sample of Chinese enterprises, this study finds that energy-related public environmental attention widens the compensation gap between executives and employees within polluting enterprises and worsens enterprise efficiency. This implies that energy-related public environmental attention can lead to an asymmetric increase in labor costs for polluting enterprises in emerging market economies, resulting in a dual loss of fairness and efficiency. Considering that many polluting enterprises are important for the economic development of emerging market economies, balancing growing public environmental demands with the development of polluting enterprises requires a more comprehensive examination and policy design.

2. Institutional background and hypotheses development

Following decades of rapid economic growth, energy scarcity and environmental pollution have emerged as major concerns that affect global economic and social development (Wang et al., 2020). Since 2014, the United Nations Climate Science Agency has conducted six global climate assessments. The IPCC released the third report of the sixth assessment cycle, "Climate Change 2022: Mitigation of Climate Change," in April 2022 (IPCC, 2022). Based on IPCC (2021), IPCC (2022) comprehensively summarizes the current status and changing trends of global greenhouse gas emissions and emphasizes that unless all sectors worldwide immediately and drastically reduce emissions, global warming will be limited to a temperature of 1.5 °C. The control target will not be achieved.

Although environmental protection has become a global concern and its strong positive externalities are evident, challenges regarding the synchronous promotion of environmental protection on a global scale remain because of significant differences in economic development and industrial structures in different countries and regions worldwide. Therefore, emerging market economies face the most significant challenges. In the short-term, economic growth in emerging market economies is inextricably linked to economic sectors with high energy consumption and pollution. Moreover, frequent outbreaks of extreme environmental events such as floods, high temperatures, and smog have increased energy-related public concerns in emerging market economies, and governments are required to focus on environmental issues such as energy shortages and environmental pollution.

As the second-largest economy and the largest emerging market worldwide, China's approach to the relationship between economic development and environmental protection is particularly intriguing. For the first time, China's State Council included requirements for total pollutant emissions in its Eleventh Five-Year Plan issued in 2006. Based on the evaluation results, different requirements were proposed for 31

[1] We discuss the public environmental concern caused by PM2.5 large. As PM2.5 mainly comes from power generation, industrial production, and automotive exhaust, and is highly related to energy, we classify it to be an energy related public environmental concern.

provinces. Since then, China's central and local governments have implemented environmental protection policies. At the same time, China's public environmental awareness is constantly improving, especially after extreme environmental events such as the PM2.5 surge in 2011. In the fourth quarter of 2011, severe haze occurred in many parts of China, with PM2.5 values exceeding the upper limit of instrument measurements (500). The severe haze experience and much media feedback sparked significant attention to the issue of air pollution, leading to a surge in environmental attention among the Chinese public.

Notably, industries with high energy consumption and pollution, such as coal and steel, continue to constitute a large proportion of China's current industrial structure, and the impact of environmental protection on polluting enterprises is worth considering. Compared to several studies that have examined the impact of hard constraints, such as environmental regulations on polluting companies (Li et al., 2022; Tian and Feng, 2022), few studies have investigated the impact of soft constraints, such as energy-related public environmental concerns on such companies. Considering that energy-related public environmental concerns influence corporate decision-making through management, this study investigates the impact of energy-related public environmental concerns on the executive–employee pay gap within enterprises. Given that compensation is an incentive for executives and employees and a labor cost borne by enterprises, the impact of energy-related public environmental concerns on the compensation structure is an important factor that further influences an organization's operating efficiency. Furthermore, the executive–employee pay gap is an important manifestation of the income distribution gap, making it a valuable consideration for environmental justice.

Ordinary employee salaries are typically stable, whereas executive salaries are closely related to corporate performance. Therefore, the executive–employee salary gap should positively correlate with corporate operating performance. Polluting businesses experience greater operational challenges due to the public's growing environmental concern. An increase in energy-related public environmental concerns will increase consumers' propensity to purchase environmentally friendly products (Ensslen et al., 2020; Tong et al., 2020) while decreasing their propensity to purchase products from polluting companies. Therefore, an increase in energy-related public environmental concerns is likely to worsen the operating conditions of polluting enterprises, resulting in a decline in their operating performance. Given the positive relationship between executive–employee pay disparities and business performance, increased energy-related public environmental concerns should reduce the executive–employee pay gap in polluting companies. Therefore, we propose the following hypothesis:

H1a. *Following the PM2.5 surge, the executive–employee pay gap in polluting companies has significantly decreased compared to non-polluting companies.*

However, while corporate performance is critical in determining executive compensation, the labor market's supply-demand environment is a more direct factor. According to Gu et al. (2021), as the operating pressure on polluting companies increases with energy-related public environmental concerns, the possibility of executives choosing to leave increases. Although the demand for executives remains constant, an increased turnover rate reduces the supply of executives to polluting companies. Therefore, companies must pay higher wages to retain or hire executives to maintain normal operations. However, ordinary employees have a higher level of skill substitutability than senior executives. In general, changes in employee supply to polluting enterprises are expected to be minor. Businesses are not expected to pay higher wages to hire ordinary employees, at least compared to executives. Therefore, from the perspective of labor market supply-demand, energy-related public environmental concerns should widen the executive–employee pay gap in companies. Therefore, we propose the following hypothesis, which contradicts Hypothesis 1a.

H1b. *Following the PM2.5 surge, the executive–employee pay gap in polluting companies has significantly increased compared to non-polluting companies.*

3. Research design

3.1. Sample

This study focuses on the years leading up to and following the PM2.5 surge in 2011, 2007–2015, and selects China's A-share listed companies as the initial sample for this period. To increase industry comparability between the experimental and control groups, we restrict the sample to industrial enterprises by considering the industry distribution of polluting firms. In China, autumn and winter are the seasons with the highest occurrence of smog. Given that the PM2.5 surge occurred in the fourth quarter of 2011 and that it is challenging to evaluate how it affected business decisions that year, we excluded 2011 from our sample (Chen et al., 2018). Samples with negative primary business income, leverage above one, a listing date later than 2011, and the main missing variables were eliminated and finally obtained 9819 enterprise–year observations for the eight-year sample period. We classify industries based on the "Guidelines for the Industry Classification of Listed Companies" promulgated by the China Securities Regulatory Commission in 2001. While enterprise-level data are sourced from the Cathay Pacific China Stock Market & Accounting Research (CSMAR) database, haze data are sourced from the comprehensive estimation data released by Dalhousie University, based on National Aeronautics and Space Administration (NASA) satellites and ground monitoring stations (Van Donkelaar et al., 2015, 2019). All continuous variables were winsorized at the upper and lower 1% levels) to exclude the influence of extreme values.

3.2. Methodology

We construct the following difference in differences (DID) model to test our hypotheses:

$$PayGap_{it} = \beta_0 + \beta_1 Treat_i{*}Post_t + \beta_2 Treat_i + \beta_3 Post_t + \sum Controls + \sum Year + \sum Ind + \varepsilon_{it} \tag{1}$$

where the explained variable *PayGap* is the pay gap between executives and employees. Based on the available data, we define executive compensation in two ways: the average compensation of the top three executives, denoted as *Com_TOP3*, and the average compensation of all paid executives (*Com_AVG*), calculated as total executive compensation divided by the difference between total and unpaid executives. Following Kong et al. (2020), employee compensation (*Wage*) was calculated as Wage = (cash paid to employees and paid for employees + employee compensation payable at the end of the year, employee compensation payable at the beginning of the year, total executive compensation) / (number of employees–number of actually paid executives). The pay gap between executives and employees is the average executive compensation divided by the average employee compensation (Firth et al., 2015); that is, *PayGap1* = *Com1/Wage, PayGap2* = *Com2/Wage*.

The interaction term *Treat* × *Post* is the explanatory variable, and *Treat* is the treatment group indicator. Based on the Ministry of Environmental Protection's "Guidelines for Environmental Information Disclosure of Listed Companies" (Draft for Comments) issued on September 14, 2010, we classify ten air pollution-related industries, namely, thermal power, steel, cement, electrolytic aluminum, coal, metallurgy, chemical industry, petrochemical industry, building materials, and mining industry as the polluting industries and treat them as the experimental group, which is assigned the value one. The remaining industries were classified as a control group and assigned a value of zero. *Post* is an event indicator variable that takes the value of one after 2011

Table 1
Summary statistics.

Variables	N	Mean	Median	1st Quantile	3rd Quantile	SD
PayGap1	9819	6.989	5.359	3.452	8.518	5.803
PayGap2	9819	2.511	1.974	1.252	3.115	1.974
Treat	9819	0.242	0	0	0	0.428
Post	9819	0.622	1	0	1	0.485
Size	9819	21.86	21.71	20.99	22.55	1.222
Leverage	9819	0.454	0.456	0.299	0.613	0.204
Tang	9819	0.275	0.246	0.152	0.379	0.166
ROA	9819	0.0454	0.0362	0.0109	0.0752	0.0701
Growth	9819	0.103	0.0935	−0.0500	0.232	0.324
Dual	9819	0.218	0	0	0	0.413
Board	9819	8.938	9	8	9	1.817
Independent	9819	0.369	0.333	0.333	0.4	0.0530
SOE	9819	0.380	0	0	1	0.485
Top1	9819	0.361	0.343	0.242	0.468	0.152

and zero before 2011. As *Treat* is an industry-level variable, we use industry-clustering standard errors. According to this DID model, if Hypothesis 1a holds, coefficient β1 of the explanatory variable *Treat* × *Post* is significantly negative. Conversely, if Hypothesis 1b holds, coefficient β1 of the explanatory variable *Treat* × *Post* is significantly positive.

Following Firth et al. (2015) and Kong et al. (2020), we include the following control variables: *Size* (enterprise size calculated as the natural logarithm of total assets), *Leverage* (financial leverage calculated as total liabilities/total assets), *Tang* (proportion of fixed assets calculated as fixed assets/total assets), *ROA* (return on total assets calculated as net profit/total assets), *Growth* (operating income growth rate calculated as [current year's operating income/previous year's operating income]-1), *Dual* (accounts for the combination of two positions; if the chairman and the general manager are the same person, the variable equals one, and zero otherwise), *Board* (size of the board of directors calculated as the total number of directors on the board), *Independent* (proportion of independent directors calculated as the number of independent directors / the total number of directors on the board), *SOE* (accounts for state-owned enterprises; if an industry is state-owned, the variable equals one, and zero otherwise), and *Top1* (proportion of shares held by the largest shareholder calculated as the number of shares held by the largest shareholder/total number of shares). Finally, dummy variables for year and industry were included in the model.

3.3. Descriptive statistics of main variables

Table 1 presents the descriptive statistics of the main variables. The mean values of *PayGap1* and *PayGap2* are 6.989 and 2.511, respectively, indicating that the average salary of the top three executives in the sample firms is nearly seven times the average salary of employees and that the average salary of all executives is 2.5 times. This implies that executive compensation is significantly higher than that of employees, and the pay gap between executives is also significant. The mean value of *Treat* is 0.242, indicating that air-polluting industries account for 24% of our sample and that nearly a quarter of the experimental group accounts for the validity of the DID model. Furthermore, the average financial leverage of the sample, average return on total assets, and average sales revenue growth rate are 45%, 4.5%, and 10%, respectively, indicating that the profitability and growth of Chinese listed companies are generally good, and the level of debt is acceptable.

4. Empirical results and analysis

4.1. Benchmark regression results

Table 2 presents the benchmark regression results of our DID model; the explained variables in columns 1 and 2 are *PayGap1* and *PayGap2*, respectively. The coefficients of *Treat* × *Post* are all significantly positive at the 5% level for both measures of executive–employee pay gap. This indicates that following the PM2.5 surge 2011, the executive–employee pay gap in polluting companies increased significantly compared to non-polluting firms, thereby supporting Hypothesis 1b. After the PM2.5 surge incident, the executive–employee pay gaps, PayGap1 and PayGap2, in polluting enterprises increased by 10.8% (=0.757/6.989), 8.7% (=0.757/6.989), and 8.7% (= 0.218/2.511), respectively.

Table 2
Baseline regression.

	(1)	(2)
	PayGap1	*PayGap2*
Treat* × *Post	**0.757****	**0.218****
	(0.294)	**(0.109)**
Treat	−2.289***	−0.761**
	(0.861)	(0.360)
Size	1.756***	0.668***
	(0.155)	(0.0622)
Leverage	−0.0971	−0.0314
	(0.491)	(0.183)
Tang	1.177	0.633**
	(1.042)	(0.305)
ROA	16.29***	4.397***
	(1.356)	(0.507)
Growth	−0.864***	−0.232***
	(0.246)	(0.0673)
Dual	0.456**	−0.372***
	(0.228)	(0.0618)
Board	0.0103	−0.0591**
	(0.0840)	(0.0237)
Independent	−0.227	−0.728
	(1.383)	(0.443)
SOE	−1.638***	−0.483***
	(0.317)	(0.0873)
Top1	−5.651***	−1.957***
	(0.930)	(0.322)
Year FEs	Yes	Yes
Industry FEs	Yes	Yes
R^2	0.182	0.183
Observations	9819	9819

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 3
Test for parallel trends.

	(1)	(2)
	PayGap1	*PayGap2*
Treat* × *Year-3	**−0.0668**	**−0.0461**
	(0.353)	**(0.143)**
Treat* × *Year-2	**0.321**	**0.0954**
	(0.336)	**(0.107)**
Treat* × *Year-1	**0.304**	**0.150**
	(0.391)	**(0.152)**
Treat* × *Year* + *1	**0.751**	**0.289***
	(0.458)	**(0.147)**
Treat* × *Year* + *2	**0.856****	**0.280***
	(0.399)	**(0.146)**
Treat* × *Year* + *3	**0.879****	**0.230**
	(0.409)	**(0.152)**
Treat* × *Year* + *4	**1.155****	**0.296***
	(0.462)	**(0.172)**
Controls	Yes	Yes
Year FEs	Yes	Yes
Industry FEs	Yes	Yes
R^2	0.182	0.183
Observations	9819	9819

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4
Placebo test with fictitious events.

	(1)	(2)	(3)	(4)	(5)	(6)
	PayGap1			*PayGap2*		
Treat × Post08	**0.172**			**0.0606**		
	(0.306)			**(0.114)**		
Treat × Post09		**0.304**			**0.129**	
		(0.254)			**(0.0978)**	
Treat × Post10			**0.153**			**0.111**
			(0.311)			**(0.116)**
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.169	0.169	0.169	0.158	0.158	0.158
Observations	3713	3713	3713	3713	3713	3713

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

4.2. Robustness checks

4.2.1. Parallel trend test

Passing the parallel-trend assumption is critical to the validity of the DID model. We used 2011 as the base year and defined *Year-3, Year-2, Year-1, Year + 1, Year + 2, Year + 3*, and *Year + 4* to represent the occurrence of relative PM2.5. For each year, we replaced the original *Treat × Post* with the interaction term of *Treat* and the corresponding year's dummy variable and regressed the DID model. Table 3 presents the parallel trend test results, revealing that the coefficients of *Treat ×Year-3, Treat ×Year-2,* and *Treat ×Year-1* are not significant. However, the coefficients of *Treat ×Year + 1, Treat ×Year + 2, Treat ×Year + 3*, and *Treat ×Year + 4* are significantly positive. These findings indicate that the benchmark regression results passed the parallel-trend test.

4.2.2. Placebo test

Other economic policy shocks or random factors in the same period may also have had differential effects on the experimental and control groups, which were further excluded through placebo tests. First, we consider the sample period before the actual event (2007–2010) and assume that the event occurred in 2008, 2009, and 2010. Table 4 presents the results of the placebo test with fictitious events, which reveals that the coefficients of *Treat × Post08, Treat × Post09,* and *Treat × Post10* for the regression of fictitious events are statistically insignificant at conventional levels (i.e., 5%).

Secondly, we randomly selected the same proportion of enterprises to form the "pseudo-experimental group" and generated the pseudo-treatment group variable. Model 1 was then regressed using the dummy treatment grouping variables, and this process was repeated 500 times. Fig. 1 illustrates the distribution of T values for the explanatory variables.

The T-value distribution obtained from the pseudo-processing grouping variable corresponds to a normal distribution. Additionally, no more than 5% of the T-values are higher than those obtained from the actual processing of the grouping variable. This indicates that the benchmark regression results are unlikely to have occurred by chance; they have passed the placebo test using the random sampling experimental group.

4.2.3. Propensity score matching (PSM) test

Enterprises in polluting and non-polluting industries will likely have a systematic bias. We performed a PSM test based on pre-event characteristics. We adopted the 1:1 nearest neighbor matching method and conducted a robustness test based on the PSM-matched samples. Table 5 presents the test results, which reveal that the coefficient of *Treat × Post* remained significantly positive, thereby proving the robustness of the primary findings.

4.2.4. Robustness checks for confounding events

One main challenge faced when using the difference-in-differences model is the presence of confounding events, which we will now focus on. Firstly, in 2009, China implemented a credit stimulus of 4 trillion USD, with funds primarily flowing into asset-heavy sectors such as infrastructure and real estate. To exclude the impact of this event, we added the interaction of whether a firm belongs to an asset-heavy industry and whether the observation is after 2009 in the model.

Secondly, in 2013, China's Environmental Protection Department issued the "Announcement on the Implementation of Special Emission Limits for Air Pollutants," proposing emission limit requirements for 19 provinces and municipalities, including Beijing and Shanghai. To address this confounding event, we added the interaction of whether a firm is located in the emission limit area and whether the observation is after 2013.

Thirdly, in 2009, the Chinese government issued a salary limit order for executives of central enterprises, which could directly affect the pay gap between executives and employees (Bai et al., 2019). To account for this event, we introduced the interaction between whether a firm is a central state-owned enterprise (SOE) and whether the observation is after 2009.

Fourthly, in 2010, China announced the launch of low-carbon city pilot projects in five provinces and eight cities, followed by a second batch of pilot projects in 2012. To address the impact of these pilot projects, we added a dummy variable for firms listed in the pilot cities and during the pilot period.

The results reported in Table 6 indicate that, even after controlling for the influence of the aforementioned confounding events, the coefficient of Treat × Post remains significantly positive.

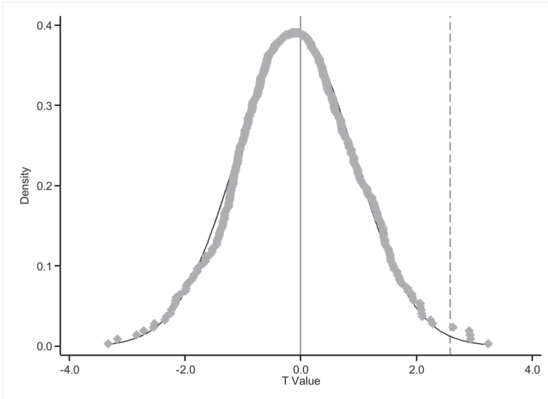
4.2.5. Other robustness checks

Firstly, in the benchmark regression, the industry fixed effect is based only on the 2-digit industry classification. In order to test the robustness of our results, we adjust the analysis to the finer 5-digit industry classification.

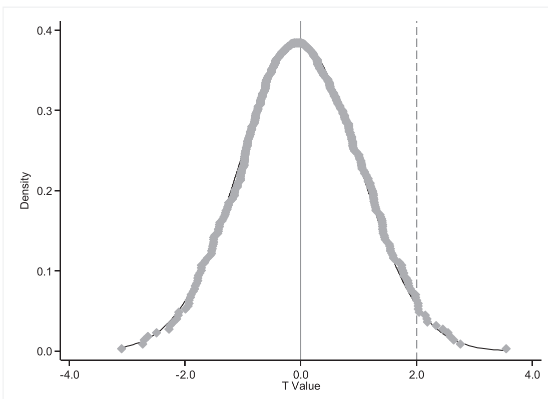
Secondly, as the benchmark regression uses a relative pay gap definition, we conduct a robustness test using an absolute pay gap definition, which involves taking the natural logarithm of the difference between executive pay and employee earnings.[2]

Thirdly, in the benchmark regression, the treatment growth is defined based on whether the air-polluting industry is included. In the robustness test, we adjust the definition to include all polluting industries.

[2] As public environmental concern increases, the increase in cash pay for executives in polluting enterprises could be the compensation for the decrease in stock. We find that, although public environmental concern will lead a decrease of polluting enterprises' stock return, it has no significant impact on the equity compensation of executives.



a. Placebo test with random treatment group: *PayGap1*



b. Placebo test with random treatment group: *PayGap2*

Fig. 1. a. Placebo test with random treatment group: *PayGap1*. b. Placebo test with random treatment group: *PayGap2*.

Fourthly, we exclude the water pollution industry from the robustness test.

Finally, to account for the impact of regional macro factors, we introduce province × year fixed effects in the robustness testing.

Table 7 presents the results of the robustness tests, and it is worth noting that the coefficient of Treat × Post remains significantly positive.

4.3. Impact of energy-related public environmental concerns on executive compensation and employee wages

The empirical results demonstrate that energy-related public environmental concerns increase the executive–employee pay gap in polluting enterprises. This section investigates the impact of energy-related public environmental concerns on executive and employee compensation. Specifically, we replace the original executive–employee pay gap with the natural logarithm of executive compensation and employee earnings. We examine the impact of energy-related public environmental concerns based on our DID model. According to the findings presented in Columns 1 to 3 in Table 8, the coefficient of *Treat* × *Post* is significantly positive for executive compensation and insignificant for employee wages. Following 2011 PM2.5, polluting firms' executive compensation increased significantly compared to non-polluting firms, whereas employee earnings witnessed no significant changes.

Notably, a possible alternative explanation is that pollution has led to a decline in the total number of employees; the enterprise has reduced the total salary payment but not the per capita salary. Thus, we also replace the original executive–employee pay gap with the natural logarithm of the number of executives and employees and examine the impact of energy-related public environmental concerns on them based on our DID model. According to the findings in Columns 4 and 5 of Table 8, the coefficients of *Treat* × *Post* are insignificant.

Table 5
PSM sample.

	(1)	(2)
	PayGap1	*PayGap2*
Treat* × *Post	**0.896*****	**0.224***
	(0.328)	**(0.124)**
Controls	Yes	Yes
Year FEs	Yes	Yes
Industry FEs	Yes	Yes
R^2	0.211	0.195
Observations	5000	5000

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

The significant increase in executive compensation may explain why energy-related public environmental concerns have widened the executive–employee compensation gap in polluting companies.

4.4. Moderate effects of internal governance and external oversight

Although a moderate internal pay gap can motivate executives and employees to work harder (Kong et al., 2020), increasing executive compensation due to increasing energy-related public environmental concerns may aggravate the operating pressure of polluting companies. We first consider the impact of internal governance, focusing on agency costs and information transparency. Agency costs are calculated by dividing management fees by total assets, and information transparency is calculated as the absolute value of accrual earnings management. Table 9 summarizes the group test results based on these two indicators. The coefficient of *Treat* × *Post* is significantly positive for firms with poor internal governance (high agency costs and poor information transparency). In contrast, it is insignificant for firms with good internal governance (low agency costs and good information transparency).

Next, we consider the impact of external supervision by focusing on analyst attention and institutional investor shareholdings. Analyst attention is calculated as the natural logarithm of the number of corporate forecast reports tracked and released by analysts. However, institutional investor shareholding is the ratio of the shares held by institutional investors to the total number of outstanding shares. Table 10 summarizes the group test results based on these two indicators. The coefficient of *Treat* × *Post* is significantly positive in firms with weak external supervision (low analyst attention and fewer institutional investors). However, it is significantly negative in firms with strong external supervision (high analyst attention and more institutional investors) in the sample with more shares.

Energy-related public environmental concerns have led to a greater pay gap in polluting companies with poor internal governance (high agency costs and low information transparency) and weak external supervision (low analyst attention and low institutional investor shareholding).

4.5. Economic consequences of a widening pay gap

In addition to the pressure on environmental governance induced by energy-related public environmental concerns, an increase in executive compensation is likely to worsen the operating conditions of polluting enterprises. To test this hypothesis, we follow Lin et al. (2022) and use a triple-difference model to examine the economic consequences of energy-related public environmental concerns, leading to a widening pay gap in polluting enterprises.

Specifically, we used total factor productivity and investment efficiency to assess firm performance. Total factor productivity is estimated using the semi-parametric linear parametric (LP) method, and

Table 6
Robustness checks for confounding events.

	(1)	(2)	(3)	(4)	(5)
	Credit stimulus in 2009	Emission Limits in 2013	Compensation restriction	Low carbon pilot	All
Panel A. *PayGap1*					
Treat* × *Post	**0.738****	**0.755****	**0.766****	**0.833*****	**0.809*****
	(0.297)	**(0.296)**	**(0.294)**	**(0.300)**	**(0.301)**
Controls	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes
R^2	0.182	0.183	0.182	0.183	0.185
Observations	9819	9819	9819	9819	9819
Panel B. *PayGap2*					
Treat* × *Post	**0.201***	**0.217***	**0.217***	**0.241****	**0.219***
	(0.110)	**(0.109)**	**(0.109)**	**(0.111)**	**(0.111)**
Controls	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes
R^2	0.184	0.185	0.183	0.184	0.187
Observations	9819	9819	8217	9819	9819

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 7
Other robustness checks.

	(1)	(2)	(3)	(4)	(5)
	5-digital industry	Relative pay gap	All Polluting industries	Exclude water-polluting industries	Province × Year FEs
Panel A. *PayGap1*					
Treat* × *Post	**0.700****	**0.0813*****	**0.998*****	**0.960*****	**0.665****
	(0.291)	**(0.0286)**	**(0.232)**	**(0.288)**	**(0.322)**
Controls	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes
R^2	0.206	0.389	0.182	0.181	0.218
Observations	9819	9819	9819	8344	9819
Panel B. *PayGap2*					
Treat* × *Post	**0.215****	**0.132*****	**0.276*****	**0.273****	**0.247****
	(0.107)	**(0.0485)**	**(0.0882)**	**(0.109)**	**(0.117)**
Controls	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes
R^2	0.204	0.279	0.183	0.186	0.224
Observations	9819	8217	9819	8344	9819

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

investment efficiency is estimated using the inefficient investment proposed by Richardson (2006) as a reverse measure. Columns 1 and 2 of Panels A and B of Table 11 present the results of this test. The coefficient of *Treat* × *Post* × *PayGap* is significantly negative for total factor productivity and significantly positive for inefficient investments. This implies that productivity and investment efficiency are significantly reduced as energy-related public environmental concerns widen the wage gap in polluting enterprises.

From the above results, a possible conjecture is that public environmental concerns lead to increased executive compensation expenses, crowding out important expenses, such as innovation. We use R&D investment as the economic outcome variable for testing. Columns 3 and 4 of Panel A of Table 11 present the results, and the coefficient of *Treat* ×

Table 9
Moderate effect of internal governance.

	(1)	(2)	(3)	(4)
	Agency cost		Information transparency	
	High	Low	Poor	Good
Panel A. *PayGap1*				
Treat* × *Post	**1.293*****	**0.266**	**0.906****	**0.609***
	(0.280)	**(0.409)**	**(0.394)**	**(0.308)**
Controls	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes
R^2	0.185	0.190	0.175	0.199
Observations	4807	5012	4895	4924
Panel B. *PayGap2*				
Treat* × *Post	**0.428*****	**0.0229**	**0.326****	**0.0949**
	(0.129)	**(0.147)**	**(0.133)**	**(0.152)**
Controls	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes
R^2	0.192	0.182	0.175	0.201
Observations	4807	5012	4895	4924

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 8
Impact on executive compensation and employee wages.

	(1)	(2)	(3)	(4)	(5)
	LnCom_Top3	*LnCom_AVG*	*LnWage*	*LnMAN_NUM*	*LnEMP_NUM*
Treat* × *Post	**0.0840*****	**0.0806*****	**0.0180**	**0.0053**	**0.0248**
	(0.0282)	**(0.0293)**	**(0.0340)**	**(0.0124)**	**(0.0494)**
Controls	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes
R^2	0.397	0.399	0.311	0.254	0.624
Observations	9819	9819	9819	9819	9819

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 10
Moderate effect of external oversight.

	(1)	(2)	(3)	(4)
	Analyst following		Institutional ownership	
	High	Low	High	Low
Panel A. *PayGap1*				
Treat* × *Post	**0.547**	**1.182*****	**0.237**	**1.438****
	(0.411)	**(0.327)**	**(0.390)**	**(0.589)**
Controls	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes
R^2	0.207	0.090	0.197	0.172
Observations	5973	3846	5310	4509
Panel B. *PayGap2*				
Treat* × *Post	**0.154**	**0.347*****	**0.0246**	**0.457****
	(0.134)	**(0.127)**	**(0.141)**	**(0.204)**
Controls	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes
R^2	0.202	0.117	0.189	0.189
Observations	5973	3846	5310	4509

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 11
Economic consequences of a widening pay gap.

Panel A. TFP and R&D Investment				
	(1)	(2)	(3)	(4)
	TFP		*RD*	
Treat* × *Post* × *PayGap1	**−0.0184*****		**−0.0002**	
	(0.0059)		**(0.0001)**	
Treat* × *Post* × *PayGap2		**−0.0281***		**−0.0009****
		(0.0151)		**(0.0004)**
Treat × *Post*	0.190***	0.138**	−0.0001	0.0009
	(0.0576)	(0.0556)	(0.0018)	(0.0018)
Controls	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes
R^2	0.748	0.748	0.300	0.300
Observations	9804	9804	9819	9819

Panel B. Investment efficiency						
	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample		Over-investment		Under-investment	
Treat* × *Post* × *PayGap1	**0.0010****		**0.0017***		**0.0006****	
	(0.0004)		**(0.0009)**		**(0.0003)**	
Treat* × *Post* × *PayGap2		**0.0020***		**0.0027**		**0.0017****
		(0.0012)		**(0.0025)**		**(0.0008)**
Treat × *Post*	−0.0082**	−0.0064	−0.0142*	−0.0093	−0.0056**	−0.0059**
	(0.0040)	(0.0041)	(0.0082)	(0.0081)	(0.0028)	(0.0027)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.077	0.077	0.122	0.122	0.084	0.084
Observations	9043	9043	3342	3342	5701	5701

Noted: Robust standard errors clustered by industry are reported in parentheses. ***, **, * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Post × *PayGap* is significantly negative. Simultaneously, we examine the impacts of over-investment and under-investment. We use inefficient investment as the economic outcome variable and distinguish between over-investment and under-investment samples for testing. Columns 3–6 of Panel B of Table 11 present the results; the coefficient of *Treat* × *Post* × *PayGap* is significantly positive in the under-investment sample and significantly negative in the over-investment sample. In short, as public environmental concerns increase the pay gap of polluting firms, firms significantly reduce their investments, especially in innovation.

5. Conclusions

Continuous and frequent extreme environmental events in recent years have led the public to pay increasing attention to environmental issues. Based on a sample of Chinese listed companies and a quasi-natural experiment using China's PM2.5 surge in 2011, this study empirically analyzed the impact of energy-related public environmental concerns on the executive–employee pay gap in polluting companies. The results show that energy-related public environmental concerns lead to a significant increase in the executive–employee pay gap in polluting companies compared to non-polluting companies, mainly because of the significant increase in executive compensation. However, there is no significant change in employee income. Among the samples with high agency costs, poor information transparency, less analyst follow-up, and less institutional investor shareholding, the effect of energy-related public environmental concerns on increasing the pay gap among polluting companies was more significant. In addition, as energy-related public environmental concerns exacerbate the internal pay gap of polluting firms, their total factor productivity and investment efficiency decrease significantly. In summary, energy-related public environmental concerns lead to a widening wage gap within polluting enterprises and worsen operational and investment efficiency.

The findings have strong policy implications for coordinating economic development and environmental protection in emerging economies.[3] In response to the increasing energy-related public environmental concerns, polluting enterprises supposed to increase their environmental protection expenditures have hired management teams with high salaries, thereby intensifying their operations and production pressure. However, polluting firms continue to contribute to the growth of most emerging markets. Therefore, government departments in emerging market economies should provide the necessary support for polluting firms' green transformation and explore the use of long-term financing tools such as green loans and green bonds. Simultaneously, good internal governance and external supervision can limit the impact of energy-related public environmental concerns on widening the pay gap for polluting enterprises. Therefore, regulatory authorities can encourage external supervision, such as analysts and institutional investors, to urge polluting enterprises to adopt cleaner production methods; promote polluting enterprises to strengthen environmental, social, and corporate governance (ESG)-related information disclosure; and enhance corporate governance.

Funding

The authors wew funded by NSFC number (71903199), Fujian Pro vincial Federation of Social Sciences (FJ2023BF045), Guangdong Phi losophy and Social Sciences Project (GD23XYJ08), the Innovation and Talent Base for Digital Technology and Finance (B21038), and "the Fundamental Research Funds for the Central Universities", Zhongnan Univeristy of Economics and Law (2722023EJ002).

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

CRediT authorship contribution statement

Kung-Cheng Ho: Writing – original draft. **Cheng Yan:** Writing – review & editing. **Giray Gozgor:** Supervision, Writing – review & editing. **Yan Gu:** Data curation, Formal analysis.

Declaration of competing interest

All authors declare that he has no conflict of interest.

Data availability

Data available on request from the authors.

Acknowledgments

This manuscript was edited by Editage.

[3] China is a rapidly developing emerging economy, especially during the sample period of this study. Therefore, the conclusions based on Chinese listed companies may not be suitable for all other emerging economies. Further discussion is needed based on the actual situation of each country.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2024.107320.

References

Bai, M., Wang, R., Yu, C.F., Zheng, J., 2019. Limits on executive pay and stock price crash risk: evidence from a quasi-natural experiment. Pac. Basin Financ. J. 55, 206–221.

Chen, Y.Y., Ebenstein, A., Greenstone, M., Li, Hf.B., 2013. Evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River policy. Proc. Natl. Acad. Sci. 110 (32), 12936–12941.

Chen, Y.C., Hung, M., Wang, Y., 2018. The effect of mandatory CSR disclosure on firm profitability and social externalities: evidence from China. J. Account. Econ. 65 (1), 169–190.

Ebenstein, A., Fan, M., Greenstone, M., He, G., Zhou, M., 2017. New evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River Policy. Proc. Natl. Acad. Sci. 114 (39), 10384–10389.

Ensslen, A., Gnann, T., Jochem, P., Plotz, P., Dutschke, E., Fichtner, W., 2020. Can product service systems support electric vehicle adoption? Transp. Res. A Policy Pract. 137, 343–359.

Faleye, O., Reis, E., Venkateswaran, A., 2013. The determinants and effects of CEO-employee pay ratios. J. Bank. Financ. 37 (8), 3258–3272.

Fan, Q., Qiao, Y., Zhang, T., Huang, K., 2021. Environmental regulation policy, corporate pollution control and economic growth effect: evidence from China. Environ. Challenges 5, 100244.

Fernandes, A., Ferreira, P., 2021. Executives' gender pay gap and financing constraints. J. Econ. Behav. Organ. 192, 381–404.

Firth, M., Leung, T.Y., Rui, O.M., Na, C., 2015. Relative pay and its effects on firm efficiency in a transitional economy. J. Econ. Behav. Organ. 110, 59–77.

Gu, Y., Ho, K.C., Yan, C., Gozgor, G., 2021. Public environmental concern, CEO turnover, and green investment: evidence from a quasi-natural experiment in China. Energy Econ. 100, 105379.

Gu, Y., Ho, K.C., Xia, S., Yan, C., 2022. Do public environmental concerns promote new energy enterprises' development? Evidence from a quasi-natural experiment. Energy Econ. 109, 105967.

Hawitibo, A.L., Tenaw, D., 2022. The disaggregated environmental effects of growth and distributional heterogeneity: evidence from emerging markets economies. J. Clean. Prod. 369, 133293.

Homroy, S., Mukherjee, S., 2021. The role of employer learning and regulatory interventions in mitigating executive gender pay gap. Finance 71, 101857.

IPCC, 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://doi.org/10.1017/9781009157896. In press.

IPCC, 2022. Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA. https://doi.org/10.1017/9781009157926.

Kong, G., Kong, T.D., Lu, R., 2020. Political promotion incentives and within-firm pay gap: evidence from China. J. Account. Public Policy 39 (2), 106715.

Lee, G., Cho, S.Y., Arthurs, J., Lee, E.K., 2019. CEO pay inequity, CEO-TMT pay gap, and acquisition premiums. J. Bus. Res. 98, 105–116.

Li, X., Du, K., Ouyang, X., Liu, L., 2022. Does more stringent environmental regulation induce firms' innovation? Evidence from the 11th five-year plan in China. Energy Econ. 112, 106110.

Lin, C., Liu, H., Ni, C., Zhang, B., 2022. State controlling shareholders and payout policy. J. Financ. Quant. Anal. https://doi.org/10.1017/S0022109022001132.

Liu, X., Mu, R., 2016. Public environmental concern in China: determinants and variations. Glob. Environ. Chang. 37, 116–127.

Liu, Y., She, Y., Liu, S., Lan, H., 2022. Supply-shock, demand-induced or superposition effect? The impacts of formal and informal environmental regulations on total factor productivity of Chinese agricultural enterprises. J. Clean. Prod. 380, 135052.

Musa, K.S., Maijama'a, R., 2020. Economic growth, energy consumption and environmental pollution in Nigeria: evidence from ARDL approach. Energy Econ. Lett. 7 (2), 61–73.

Narayan, P.K., Narayan, S., 2010. Carbon dioxide emissions and economic growth: panel data evidence from developing countries. Energy Policy 38 (1), 661–666.

Narayan, P.K., Saboori, B., Soleymani, A., 2016. Economic growth and carbon emissions. Econ. Model. 53, 388–397.

Porter, M.E., Linde, C.V.D., 1995. Toward a new conception of the environment-competitiveness relationship. J. Econ. Perspect. 9 (4), 97–118.

Richardson, S., 2006. Over-investment of free cash flow. Rev. Acc. Stud. 11, 159–189.

Shadbegian, R.J., Gray, W.B., 2005. Pollution abatement expenditures and plant-level productivity: a production function approach. Ecol. Econ. 54 (2), 196–208.

Shi, X., Xu, Z., 2018. Environmental regulation and firm exports: evidence from the eleventh Five-Year Plan in China. J. Environ. Econ. Manag. 89, 187–200.

Tian, Y., Feng, C., 2022. The internal-structural effects of different types of environmental regulations on China's green total-factor productivity. Energy Econ. 113, 106246.

Tong, Q.M., Anders, S., Zhang, J.B., Zhang, L., 2020. The roles of pollution concerns and environmental knowledge in making green food choices: evidence from Chinese consumers. Food Res. Int. 130, 108881.

Van Donkelaar, A., Martin, R.V., Brauer, M., et al., 2015. Global fine particulate matter concentrations from satellite for long-term exposure assessment. Environ. Health Perspect. 123, 135–143.

Van Donkelaar, A., Martin, R.V., Li, C., et al., 2019. Regional estimates of chemical composition of fine particulate matter using a combined geoscience-statistical method with information from satellites, models, and monitors. Environ. Sci. Technol. 53 (5), 2595–2611.

Wang, Q., Zhang, F., 2020. Does increasing investment in research and development promote economic growth decoupling from carbon emission growth? An empirical analysis of BRICS countries. J. Clean. Prod. 252, 119853.

Wang, C., Zhao, Y., Wang, Y., Wood, J., Kim, C.Y., Li, Y., 2020. Transportation CO2 emission decoupling: an assessment of the Eurasian logistics corridor. Transp. Res. Part D: Transp. Environ. 86, 102486.

Wu, J., Liao, H., Wang, J.W., Chen, T., 2019. The role of environmental concern in the public acceptance of autonomous electric vehicles: a survey from China. Transport. Res. F: Traffic Psychol. Behav. 60, 37–46.

Zhao, L., Zhang, L., Sun, J., He, P., 2022. Can public participation constraints promote green technological innovation of Chinese enterprises? The moderating role of government environmental regulatory enforcement. Technol. Forecast. Soc. Chang. 17, 121198.