Going green or greenwashing? Evidence from a quasi-natural experiment of Chinese Air Quality Monitoring Network

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Abstract

This study investigates the impact of the National Ambient Air Quality Monitoring Network (NAAQMN) on corporate greenwashing behaviour, focusing on Chinese A-share companies from 2009 to 2020. Utilizing a staggered Difference-in-Differences model, we find that the NAAQMN significantly increases greenwashing among firms in a short-run, as the monitoring function and enforcement were limited. Notably, from a geographic distance perspective, firms located farther from monitoring stations are more likely to engage in greenwashing due to reduced deterrence. We find that firms facing high financial constraints, operating in highly competitive markets, and managed by younger executives are particularly prone to greenwashing. The evidence also reveals that high public environmental concern and corporate digital transformation can mitigate firms' greenwashing by enhancing scrutiny and information transparency. This research underscores the need for improved monitoring technologies and public awareness to promote genuine sustainability efforts. These findings contribute to an understanding of the complex interplay among environmental policy, monitoring functions, public attentions and business strategic responses.

1. Introduction

As one of the largest carbon emitters in the world, China's rapid economic development over the past few decades has been accompanied by severe air pollution. In 2011, the US Embassy released $PM_{2.5}$ data for Beijing, with significantly different air quality ratings compared to those officially announced by the Chinese government, which caused a great deal of public concern (Xiong et al., 2023). To address the serious air pollution problem and public concern, China has implemented a milestone environmental regulation policy since 2012, the National Ambient Air Quality Monitoring Network (NAAQMN) (Barwick et al., 2024), as reliable and accurate environmental monitoring is one of the key aspects of achieving improved environmental quality.

The NAAQMN program is regarded as a remarkable milestone (Barwick et al., 2024) in air pollution control in China due to its automatic monitoring function, its pollution data collection and frequent inspections by the central government, and the instant data release to the general public on local air quality (Zhu and Xu, 2022). On the one hand, the NAAQMN is a strong and clear signal from the Chinese central government of the determination to improve information transparency and air quality and is a deterrent for businesses to pay more attention to environmental governance and minimise pollution to meet government expectations. On the other hand, the NAAQMN program cannot monitor direct pollution that each company produces, so does not lead to direct consequences to firms at least in a short run. The NAAQMN program provides a unique setting for us to investigate companies' behaviour after such government regulations, as corporations increasingly become the most active participants under environmental regulations (Zhang, 2022; Wei et al., 2022). Will the NAAQMN program motivate firms to go green or to go greenwashing?

The NAAQMN program was built in 2012 and progressively expanded in 2013 and 2014, eventually encompassing all prefecture-level cities by 2014. Each pilot city established a certain number of nationally controlled air monitoring stations based on its population density and urban area. Each monitoring station serves two primary functions. First, it has the monitoring function (Zhang et al., 2022): the stations typically monitor areas with a radius ranging from 500 meters to 4 kilometres, which can be extended to areas with a radius of up to several tens of kilometres (for instance, in regions with lower pollutant concentrations and less spatial variation). However, the monitoring function cannot be extended to each company. Second, it has the pollution information disclosure function: the stations automatically collect real-time air pollution information and the Air Quality Index (AQI) for various urban areas, which is automatically reported to the central state and released to the publics. The monitoring results of the NAAQMN are the main basis for China's environmental assessment, environmental policymaking, and evaluation of local government governance capacity.

As a common strategy to cope with external environmental shocks (Hu et al., 2023), greenwashing occurs when a firm promotes itself as environmentally friendly but allocates more time and resources to advertising its environmental friendliness than to genuinely developing sustainable practices (Laufer, 2003). Moreover, some firms may mislead investors, shareholders, and the general public by selectively disclosing positive information about their sustainability achievements while omitting negative aspects (Marquis et al., 2016; Nyilasy et al., 2014). Through greenwashing, firms can cultivate a favourable public image, attract more investments, and reduce loan costs (Du, 2015). Whether companies use greenwash as a strategic response to the NAAQMN program is worth investigating.

Corporations are the primary sources of air pollution and energy consumption (He et al., 2016; Du et al., 2022; Chen et al., 2023). However, the overarching goals of environmental friendliness and sustainable finance may conflict with their inherent drive for profit maximization. Transitioning to renewable energy sources and energy-efficient models can incur additional financial and operational costs (Tran, 2022). Despite a significant increase in studies and methods addressing how to achieve sustainability and Environmental, Social, and Governance (ESG) goals, concerns about air pollution and energy consumption persist. One of the most significant reasons for these concerns is "greenwashing". On the one hand, the NAAQMN deters local governments and businesses, signalling a commitment to improving air quality. It reduces data manipulation, enhances governance, and increases transparency, thus reducing greenwashing because of the credible local pollution monitoring and disclosure (Tashman et al., 2019). On the other hand, management myopia leads executives to prioritize short-term gains, driving opportunistic behaviour due to various pressure (Laverty, 1996). Air monitoring stations' limitations and increased transparency expose firms to external scrutiny. Firms, especially those distant from monitors, may greenwash to manage impressions, immediately meet regulatory expectations, and reduce costs.

Our paper investigates how the NAAQMN program implemented by central government, which regarded as a vertical environmental regulation (Du et al., 2022) affect firms greenwashing behaviour. Employing a staggered Difference-in-Differences (DID) model, this study finds that the NAAQMN project, as an exogenous environmental policy shock, significantly increases corporate greenwashing behaviour by using a sample of all A-share listed companies from 2009 to 2020 supporting the management myopia theory. Our baseline results remain robust after a series of robustness checks, including parallel trend tests, placebo tests, and entropy balancing method. Further results show that the distance between firms and the station will impact the greenwashing. Businesses will take advantage of monitoring deficiencies at air monitoring stations, and the further away a business is from a monitoring station, the more likely it is to be greenwashed. However, as time goes by, and the data monitoring and disclosure becomes more transparent, the greenwashing behaviour gradually disappear. Further robustness checks indicate that the increase in corporate greenwashing behaviour is driven by enhanced ESG disclosures without corresponding improvements in actual ESG performance, revealing a discrepancy between rhetoric and action. Mechanism analysis reveals that the positive relationship between the NAAQMN and corporate greenwashing behavior is more pronounced in key environmental protection cities, firms with high financing constraints, and those in highly competitive markets. Furthermore, it indicates that the pressure induced by the NAAQMN is more significant in non-state-owned enterprises and non-pollution industries and firms with relatively younger average executive age. Additionally, we find that public environmental attention and corporate digital transformation have a restraining effect on corporate greenwashing behaviour.

This study makes several important contributions to the literature on environmental policy and corporate behaviour, particularly in the context of greenwashing. First, by establishing a causal link between the NAAQMN implementation, the distance to the monitoring stations and the rise in greenwashing activities in the short-run, this study highlights a critical unintended consequence of well-meaning environmental regulations. This finding extends existing literature by underscoring the need to improve monitoring technologies and optimize the placement of monitoring stations to reduce the incentives and opportunities for greenwashing. The study shows the importance of designing regulatory frameworks that not only set ambitious environmental targets but also include robust verification and enforcement mechanisms to ensure compliance.

Second, this research reveals that firms are enhancing their ESG disclosures without corresponding improvements in actual ESG performance. This discrepancy between rhetoric and action points to a strategic manipulation of information by firms to meet regulatory and market expectations without making substantial investments in genuine sustainability initiatives. This finding aligns with the broader literature on corporate impression management and highlights the need for more stringent and transparent reporting standards to ensure that disclosed information accurately reflects firms' environmental performance.

Third, the heterogeneity analysis in this study reveals significant insights into the conditions under which the NAAQMN intensifies greenwashing behaviour. The positive relationship between the policy and greenwashing is more pronounced in key environmental protection cities, firms with high financial constraints, and highly competitive markets. These findings indicate that intense regulatory scrutiny and market competition heighten the pressure to appear environmentally responsible. High financing constraints make genuine sustainability improvements prohibitive, leading firms to favour greenwashing as a cost-effective alternative. Additionally, non-state-owned enterprises (non-SOEs) and firms with younger executives are more susceptible to greenwashing. Non-SOEs lack the political connections of state-owned enterprises (SOEs), and younger executives, driven by ambition and market trends, strategically employ greenwashing to meet stakeholder expectations and generate profits. These insights contribute to understanding how firm characteristics and leadership demographics shape corporate environmental strategies.

Finally, the study's findings have significant implications for policymakers and regulators. The evidence that digital transformation and public environmental concerns have a restraining effect on greenwashing behaviour suggests that increased transparency and public engagement can serve as effective checks on corporate misconduct. Policymakers should consider incorporating mechanisms that enhance public scrutiny and stakeholder participation in environmental monitoring and reporting processes.

The rest of this paper is structured as follow: Section 2 reviews the relevant literature on environmental policies, and corporate greenwashing and hypothesis development. The data and methodology are outlined in Section 3. Section 4 presents the empirical results and discusses their implications. Section 5 concludes with a summary of findings, and policy recommendations.

2. Policy background and hypothesis development

2.1. Policy background and the development of the National Ambient Air Quality Monitoring Network (NAAQMN)

In the national environmental governance system, local governments play a crucial role in improving the level of environmental infrastructure and clarifying corporate environmental governance responsibilities. However, many local governments share economic interests with polluting enterprises within their jurisdiction, leading them to manipulate environmental quality data to evade central assessments (Ghanem and Zhang, 2014). This has resulted in the neglect of pollution issues to some extent. The development model of local governments, which prioritizes economic growth over environmental protection, has made the cost of non-compliance with pollution regulations extremely low for enterprises (Jin et al., 2016), while engaging in environmental protection activities would incur higher production costs. Based on a cost-benefit analysis, “rational” decision-makers within these enterprises tend to reduce investments in pollution control. Therefore, intensifying supervision of local environmental quality becomes a crucial role to fully utilize the governance role of local governments and alleviate pollution issues in China.

China's ambient air quality standards have undergone three major revisions for he monitored items, methods and scope of monitoring (Zhang et al., 2020) due to the rapid socioeconomic development and technological evolution in recent years. In 1982, China established its first national ambient air quality standards. The main monitoring programs were TSPs, SO_2, and NO_x (Jiang, Li, and Yang, 2020), and the dominant measurement method at the time was manual sampling, which provide a lot of room for local governments to manipulate pollution data, with only 74 national control air monitoring stations.

A 1996 amendment expanded these standards to include coarse particulate matter (PM_{10}). Throughout the 1980s, 1990s, and early 2000s, coal combustion was regarded as the primary threat to air quality, with sulphur dioxide being a major concern. Due to the widespread and evident damage caused by acid rain to crops, forests, and aquatic environments, central environmental regulations focused on controlling acid rain and SO_2 emissions (Yi, Hao, and Tang, 2007). The NAAQMN are rapidly developed during this period and integrated into China's national environmental monitoring network.

Since the early 2000s, emissions from coal-fired power plants have decreased while those from automobiles, manufacturing, and construction have surged, shifting the sources of air pollution from predominantly coal combustion to a mix of sources (Barwick et al., 2024). During this period, pollution regulation followed a federal approach, where the central government set environmental standards to be met by local governments (Ghanem and Zhang, 2014). However, this approach proved ineffective due to the strong incentives for economic growth at the local level clashing with weak oversight and enforcement by the central government—a common issue in developing countries (Greenstone and Hanna, 2014; Duflo et al., 2018; Karplus, Zhang, and Almond, 2018). Extreme air pollution was prevalent in many urban areas.

Consequently, at the beginning of 2012, China dramatically revised and issued a New Ambient Air Quality Standard (GB 3095-2012), updating the monitored items to SO_2, NO_2, CO, O_3, PM_{10}, $PM_{2.5}$, which is the first time in history, set a national standard for $PM_{2.5}$. Moreover, the "New Standard" requires each air monitoring station to use advanced automatic monitoring technology to monitor pollution information in real time and publicize it timely to the central government and the public, effectively preventing local governments from interfering with data initiatives. At the same year, the Ministry of Environmental Protection[1] (MEP) approved a new plan for significantly extending the number of national air quality monitoring station (NAAQMN program). The objective of this plan was to expand the monitoring scope in China to all 338 cities at or above prefectural level and to increase the number of monitoring sites from 661 to about 1400, achieving almost full coverage of the national monitoring network. The specific plan is divided into three steps, with 496 stations in 74 pioneer cities in 2012 in the first step, 449 stations in 116 cities in 2013 in the second step, and 552 monitoring station locations in 177 cities in the third step in 2014, which adopt the "New Standard" in corresponding years[2]. After finishing the three steps, the NAAQMN program in China is the largest in the developing countries, which considered as an important milestone in the history of China's environmental regulations (Barwick et al., 2024).

The establishment of NAAQMN will allow a better understanding of the relationship between emissions and air pollution patterns and enable improved air quality management (Yang et al., 2022). Reliable environmental monitoring is one of the key links to achieving environmental quality improvement. Air quality monitoring data are essential for the public to understand the current state of environmental quality and to protect themselves against heavily polluted weather; they are also the basis for assessing the ambient air quality of a region and provide an important reference for the relevant authorities in formulating policies.

Some scholars investigate how the NAAQMN regulation impact firm's behaviour. For example, Du et al., (2022) demonstrate that the NAAQMN program significantly stimulates corporate green innovation, particularly independent innovation rather than collaborative innovation, making them to seek for real green transformation. Chen (2022) finds that the farther away from the air monitoring station, as the new external monitoring platform, the

[1] Rename the Ministry of Ecology and Environment of the People's Republic of China (MEEPRC) in 2018
[2] https://www.mee.gov.cn/xxgk2018/xxgk/xxgk13/201810/t20181015_662280.html

worse the environmental performance of the firms from a spatial perspective, meaning not all businesses will respond to environmental policies. In addition, Liu et al. (2021) discover from a macro perspective that the establishment of national air quality monitoring stations significantly reduced urban $PM_{2.5}$ levels, with each additional monitoring station leading to a reduction of 0.154 mg/m^3 in local $PM_{2.5}$ concentration, while Wang et al., (2019) indicate that the establishment of the national ambient monitoring station did not reduce the concentrations of $PM_{2.5}$ and SO_2 at city level.

2.2. Hypothesis development

Economic development and environmental improvement are crucial for sustainable development. Moreover, enterprises are the primary agents responsible for both regional economic development and environmental pollution (He et al., 2016). Therefore, governments worldwide have enacted numerous environmental policies to encourage and regulate corporate efforts in addressing pollution issues (Fan et al., 2021). However, consensus regarding the efficacy of traditional environmental regulatory tools remains elusive (Wright and Nyberg, 2017).

The NAAQMN implementation from central government acts as a deterrent to both local government and businesses. If the stakeholder theory holds, we expect firms will reduce greenwashing after the NAAQMN policy, as this policy sends a clear and strong signal that the central government is determined to improve the air quality by setting up the monitoring stations and collecting the data automatically. Since automated monitoring systems significantly reduce the opportunities for local officials to manipulate pollution data, they thereby enhance the environmental governance awareness of the local government (Greenstone et al., 2022). It had been common in all regions to prioritize GDP growth over environmental protection (Zheng and Kahn, 2013). With the central government vertically regulating air quality in most regions, local governments will have greater incentives to focus on environmental protection. They aim to meet the central government's expectations by implementing measures such as accountability. This encourages local firms to increase investment in environmental protection, make real improvements, and reduce “greenwashing” behaviour (Tashman et al., 2019). In addition, the monitoring function of the NAAQMN can enhance the overall transparency of environmental practices (Greenstone et al., 2022). When firms know that their environmental emissions are being monitored and reported by a reliable source, they are less inclined to engage in greenwashing due to the increased risk of being exposed and sanctioned (Gunningham, Kagan, & Thornton, 2003). The availability of credible pollution data motivates firms to undertake genuine efforts to improve their environmental performance to avoid reputational damage and potential legal repercussions (Dahlmann et al., 2019). Thus, both central vertical supervision and the effective monitoring functions of the NAAQMN work synergistically to improve environmental governance and ensure real progress in environmental protection efforts. Based on the above analysis, we propose:

Hypothesis 1a*: The NAAQMN program will reduce corporate greenwashing behaviour.*

However, management myopia theory posits that corporate executives often prioritize short-term gains over long-term sustainability due to pressures from shareholders, market competition, and personal career concerns (Laverty, 1996; Marginson & McAulay, 2008). Policy pressure may potentially drive myopic firms towards opportunistic behaviour like greenwashing in the short term in terms of green initiatives (Kim and Lyon, 2011), where they make unsubstantiated or misleading claims about their environmental efforts to create a greener impression, but in reality, fail to achieve their green commitments (Lyon and Maxwell, 2011; Lyon and Montgomery, 2015; Marquis et al., 2016; Laufer, 2003), as the air monitoring stations have certain limitations on monitoring and data collection function. First, they cannot accurately identify pollution sources. On average, there are 10 air monitoring stations in one pilot city. Second, the monitoring range of these stations is limited, each station has an effective monitoring radius of four to twelve kilometres, providing some firms with opportunities to be hypocrisy even though there is a deterrent from the central government. This implies that firms located further away from the monitoring stations may believe that those closer to the stations need to undertake more substantive green practices.

The NAAQMN also act as a new pollution information disclosure platform, which significantly increase the transparency of local environmental quality. Because information on the quality of the local environment is not available to public until 2012. This sudden change may cause a great deal of concern among external investors and expose the business to a variety of pressures. Sustainability and green transformation are a long-term endeavour requiring significant capital investment, which may temporarily increase the cost and financial burden of these initiatives on businesses (Arouri et al., 2021). So, firms may use strategic greenwashing for impression management to create a misleadingly positive green image (Flammer, 2021; Laufer, 2003; Wu et al., 2020) to immediately meet sustainable performance expectations from regulators, differentiate themselves from competitors (Widyawati, 2020), and reduce financial costs (Dhaliwal et al. 2011). Consequently, based on the above analysis, we propose:

Hypothesis 1b*: The NAAQMN program will increase corporate greenwashing behaviour.*

3. Data and methods

3.1. Data

Our initial sample includes all A-share companies listed in Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) from 2009 to 2020 and then we exclude: (1) financial industries; (2) firms with special treatment; (3) firm-year observations with missing values in the main and control variables. Our data comes from several sources. First, we collect ESG disclosure data and ESG performance data from the Bloomberg database and Huazheng database respectively to construct greenwashing variables. Second, we obtain the geographic coordinates and establishment year of the monitoring stations from the China General Environmental Monitoring Station and the Chinese Ministry of Ecology and Environment. Third, firm-level financial data are from the *China Stock Market and Accounting Research* (CSMAR) database. Finally, regional-level control data are retrieved from the China Statistical Yearbook. The definitions of all variables are described in Appendix A. To alleviate the influence of outliers, we winsorize all continuous variables at the 1% and 99% levels. Our final panel consists of 11,492 firm-year observations, which finally include 1330 firms across 18 different industries in total[3].

3.2. Variables

3.2.1. Greenwashing measures

Following Tan et al., (2024), corporate greenwashing is defined through assessing the disparity between firms' self-disclosed ESG practices and the objectively evaluated performance of actual ESG practices. To gauge the accuracy of companies' ESG disclosures and their performance in ESG practices, we utilize the Bloomberg ESG disclosure scores and the Huazheng ESG scores, respectively. Given that the Bloomberg ESG scores and the Huazheng ESG scores are based on different scales, we standardize them into dimensionless variables and then formulate the greenwashing scores according to Yin et al., (2024), Hu et al., (2023), Zhang et al., (2023) and Lu et al., (2023).

$$GW1_{i,t} = \left(\frac{ESGdisclosure_{i,t} - \overline{ESGdisclosure_t}}{\sigma ESGdisclosure}\right) - \left(\frac{ESGperformance_{i,t} - \overline{ESGperformance_t}}{\sigma ESGperformance}\right)$$

$$GW2_{i,t} = \left(\frac{ESGdisclosure_{i,t} - \min(ESGdisclosure)}{\max(ESGdisclosure) - \min(ESGdisclosure)}\right) - \left(\frac{ESGperformance_{i,t} - \min(ESGperformance)}{max(ESGperformance) - min(ESGperformance)}\right)$$

[3] We include firms with both Bloomberg ESG and Huazheng ESG data in sample. The Bloomberg ESG only covers close to 1,400 firms.

where $ESGdisclosure_{i,t}$ and $ESGperformance_{i,t}$ stand for the corporate ESG disclosure scores and ESG objectively performance scores, respectively. Furthermore, $GW1_{i,t}$ and $GW2_{i,t}$ denote the greenwashing level of a firm based on Z-score[4] and Min-Max normalization measurements, respectively. The greater the disparity between the ESG performance disclosed by a company and the actual performance of its ESG practices, the more pronounced the degree of greenwashing.

3.2.2. Measure of independent variable

By consulting government documents ("Implementation Plan for the First Phase Monitoring of the New Air Quality Standards", "Implementation Scope of the Second Phase of the New Air Quality Standards" and "Implementation Plan for the Third Phase Monitoring of the New Air Quality Standards"), we obtained three waves of pilot policies list of corresponding pilot cities. Next, we collect data on the city where the headquarters[5] address of listed companies is located from the CSMAR database. Then matched the list of pilot cities with data on cities where listed companies are headquartered. Finally, we obtain data on the city pilot policy. The independent variable is measured as the dummy variable, which equals one if the firm is headquartered in the pilot city in the year of policy implementation and after and zero otherwise.

$$NAAQMN_{i,t} = Treat_{i,t} * Post_{i,t}$$

where $Treat_{i,t}$ equals to one if firms' headquarters are located in the pilot city, otherwise, zero and $Post_{i,t}$ equals to one if observation is in the year of policy implementation and after and zero otherwise.

3.2.3. Control variables

[4] A method of standardizing data and eliminating discrepancies to make data from different sources comparable. Different from the Altman Z-score in corporate governance.
[5] Following Chen (2022), we use the registered locations of firms.

Following existing studies (Tan et al., 2024; Zhang, 2023; Zhang et al., 2023), we include a set of control variables which could impact corporate greenwashing behaviour. First, we control the characteristics of firm. Specifically, we control firm age (*Age*) and firm size (*Size*), as these two factors potentially affect greenwashing behaviour (Wang et al., 2024). As for financial indicators, we control leverage (*Lev*), cash ratio (*Cash*), return on total equity (*ROE*), intangible asset (*Intangible*) and sales growth (*Sales Growth*), because firms with high financial risk are keen on greenwashing. In terms of governance dimension, the number of directors (*Board*), independent directors (*Indep*), female directors (*Female*), and the largest shareholding (*Top1*) are included, as numerous researchers reveal that governance mechanisms influence firms' greenwashing behaviour. We also control the industry-level market competition (*HHI*) as scholars suggest the more competitive the market, the more likely companies are to engage in greenwashing (Tan et al., 2024). In addition, we control for macro-level variables to capture changes in regional differences. Specifically, we control the provincial level GDP per capital (*GDPper*) and provincial level foreign direct investment (*FDI*). The specific definitions of all variables are described in Appendix A.

3.3. Model specification

We employ the staggered DID method to test our main hypotheses: the impact of NAAQMN on corporate greenwashing. The specific DID model is displayed below:

$$GW_{i,t} = \alpha + \beta_1 NAAQMN_{i,t} + \gamma Controls_{i,t} + Industry + Year + City + \varepsilon_{i,t}$$

Where $GW_{i,t}$ means the degree of corporate greenwashing behaviour of firm *i* in year *t*; $NAAQMN_{i,t}$ is a dummy variable that equals to one if firm *i* is included in the NAAQMN program in year *t*, and zero otherwise. $Controls_{i,t}$ stands for a set of control variables of firm *i* in year *t*. Additionally, industry, year and city fixed effect are added into the regression to catch the unobserved factor. The standard errors are clustered at the city by year level to deal with potential heteroskedasticity and serial correlation problems within and across cities in a year (Cameron et al., 2011).

4. Empirical results

4.1. Descriptive statistics

Table 1 reports the summary statistical results of the main and control variables of the baseline regression. The mean value of greenwashing based on Z-score, namely, *GW1*, is calculated as -0.004, with a minimum value of -2.444 and a maximum value of 3.555. As for the measure of Min-Max normalised greenwashing (*GW2*), the mean value is -0.333, with a minimum value of -0.643 and a maximum value of 0.132. This information of greenwashing suggest that the level of greenwashing varies widely across the sample firms. The mean value of *DID*, a dummy variable represents the observation subject to the NAAQMN policy shock, is 0.767, meaning that the majority of the firm-year observation is impacted by the NAAQMN policy. In terms of control variables, the average value of firm size (*Size*), financial leverage (*Lev*), cash holding ratio (*Cash*), return on equity (*ROE*), the ratio of intangible asset (*Intangible*), the ratio of sales growth (*Sales Growth*) and the largest shareholding proportion (*Top1*) are 23.040, 0.475, 0.007, 0.090, 0.051,0.173, and 0.338, respectively. The minimum value of the industry competition index (*HHI*) is 0.035 and the maximum value is 1, implying that the level of competition varies greatly between industries. As for regional economic indicator, the difference in GDP per capita (*GDPper*) is not very large, with a standard deviation of 0.506, but the difference in foreign direct investment (*FDI*) is large, with a standard deviation of 1.314, and it has a minimum value of 3.574 and a maximum value of 9.984.

[Insert Table 1 here]

4.2. Correlation matrix

The Pearson correlation coefficient matrix is presented in Table 2 for all baseline regression variables. There is a statistically significant positive correlation of 0.278 ($p < 0.01$) between *DID* and *GW1*, implying the potential sign of our hypothesis development. With the exception of the correlation between *Cash* and *Lev*, none of the variables have a correlation coefficient exceeding 0.6 in absolute magnitude which alleviates concerns regarding multicollinearity.

[Insert Table 2 here]

4.3. Baseline results

Table 3 reports the results of baseline. According to the estimates in column (1) and (3) of Table 3, the implementation of the NAAQMN program spurs corporate greenwashing behaviour. The coefficient of *NAAQMN* is 0.103 which significant at the 5% level, meaning that greenwashing behaviour for treated firms increase 10.3% after the implementation of the NAAQMN program in their city compared to the control group in regions without the program. Thus, Hypothesis H1b is supported based on the management myopia theory. Firms often prioritize short-term gains over long-term sustainability due to pressures from external factor (Laverty, 1996). This theory posits that managers, driven by the need to meet immediate financial targets and enhance career prospects, may engage in greenwashing as a cost-effective strategy to quickly appear compliant with environmental regulations. The NAAQMN program increases public and regulatory scrutiny, creating an environment where firms feel pressured to demonstrate environmental responsibility swiftly. Greenwashing allows firms to manage these external expectations without incurring the substantial costs associated with genuine environmental improvements (Lyon & Maxwell, 2011). This aligns with our baseline results, showing a significant increase in greenwashing behaviour following the implementation of the NAAQMN program. According to columns (2), and (4) of Table 3, our main estimates remain unchanged after changing the fixed effect's structure.

[Insert Table 3 here]

4.4. Entropy balancing method

To better identify how the NAAQMN impact corporate greenwashing and alleviate selection bias, we utilize a robust multivariate matching technique known as entropy balancing (Hainmueller 2012; Chapman et al. 2019). This method ensures proper covariate balance between treated and control samples by weighing observations such that the post-weighing means and variances for treated and control firms are equal for each matching dimension. We match on 14 different dimensions (covariates), which are listed in Panel A of Table 4. The same panel also shows that, after re-weighing the observations, the differences in means of covariates are minimal and statistically insignificant, which suggests that proper entropy balancing was achieved.

[Insert Table 4 here]

Using this balanced sample with the post-weighing observations, we next run the same regressions as in Table 3. We expect that the estimation results from these regressions (presented in Panel B of Table 4) to be free of any major biases, because the distributions of both treated and control observations are identical and whichever biases were affecting these distributions are now removed (Hainmueller 2012; Chapman et al. 2019). Indeed, the results with entropy balancing become economically larger and statistically stronger across all the columns (e.g., the coefficient for *NAAQMN* increases from 0.103 to 0.170 and its significance strengthens from 5% to 1% confidence level). Hence the multivariate entropy balancing technique confirms, and even strengthens, our findings in the previous subsection.

4.5. Robustness tests

4.5.1. Alternative measure of independent variables

Signal theory suggests that differences in geographical distance affect the efficiency of signal transmission (Liu et al., 2022). That is, as a new information disclosure platform, air monitoring stations enable firms to transmit a corporate environmental performance to the outside world and alleviate the information asymmetry between firms and external agencies and stakeholders. Han (2020) analysed the impact of carbon trading pilots on carbon emissions. The cited authors point out that pilot carbon trading cities will signal carbon governance to the outside world, which in turn promotes carbon governance capacity. Lopez-Santamaría et al. (2021) use listed companies in Colombia as a research object, and signalling theory explains that environmental reporting not only contributes to corporate value enhancement but also influences environmental governance (Yousefi et al.,2016, 2021). In our paper, the minimum distance between the enterprise and monitoring station is calculated to measure the distance (*Distance*).

[Insert Table 5 here]

Table 5 shows the result between the NAAQMN and greenwashing behaviour from a geographical perspective. It interestingly indicates that the distance can significantly induce corporate greenwashing behaviour. Column (1) and (2) indicate a positive relationship between distance and greenwashing, which suggests that the air monitoring stations acts as a deterrent to company non-compliance, and that the further away from the stations a company is, the weaker the deterrent effect is, then the more likely the firms are to be greenwashing.

4.5.2. Distinguish ESG disclosure score and ESG performance score

We examine the effects of NAAQMN program on the two components of greenwashing, ESG disclosure scores and actual ESG performance scores. Table 6 shows the estimation results using alternative explained variables. Columns (1) and (3) of Table 6 show the results of the dependent variables normalised by Z-score method, and Columns (2) and (4) of Table 6 show the results of the dependent variables normalised by Min-Max method. Columns (1) and (2) show that the coefficients of *NAAQMN* are significantly positive, while Columns (3) and (4) show that the coefficients of *NAAQMN* are negative, but not significant. The NAAQMN program has improved the ESG disclosure in treated companies but failed to enhance firms' actual ESG performance. These findings are consistent with our baseline estimates that the implementation of NAAQMN can cause companies in treated city to disclose their ESG performance, actually it's "greenwashing untruthfully.

[Insert Table 6 here]

4.5.3. Re-estimating with different samples

We conduct the following three tests to further validate the robustness of our baseline results: (1) we exclude the observations in 2020 to prevent the effect of Covid-19; (2) we use only samples from three years before (2009) to three years after (2017) the policy; (3) we exclude the samples after 2014, considering that NAAQMN covered all the prefectural city after 2014. Table 7 reports the results (Columns 1–6), where the coefficients remain significantly positive.

[Insert Table 7 here]

4.6. Additional tests

DID approach can rule out potential endogeneity problems to a large extent, but we still conduct some additional tests to address the concerns that our results may be driven by unobservable factors.

4.6.1. Parallel-trend test

The parallel trend of the changes in the treatment and control groups before implementing the policy is the premise of using the DID method. If the change trends of the treatment and control groups are not parallel, the exogeneity of the policy cannot be guaranteed, and it is difficult to assess the effect of the policy shock. Therefore, a parallel trend test is conducted for the treatment and control groups, and the results are shown in Table 8. The value of *DID (t = − i)* is 1 when the sample is in the treatment group and in year *i* before the establishment of NAAQMN program, and its value is 0 in other cases. The value of *DID (t = +j)* is 1 when the sample is in the treatment group and in year *j* after the establishment of the NAAQMN program, and its value is 0 in other cases. The coefficients on *DID (t = − 2)* and *DID (t = − 3)* are not significant after controlling for year, city and industry fixed effects and when including all control variables, indicating that the dynamic effect is almost non-existent before the establishment of NAAQMN, and the effect coefficient is not significantly different from 0, which supports the premise of using the DID method.

[Insert Table 8 here]

[Insert Figure 1 here]

4.6.2. Placebo test

To eliminate the pseudo-significant problem caused by the contingency of the NAAQMN, this paper conducts a placebo test. In particular, we randomly assign the treatment status of firms, and the rest of the firms are classified in the control group. After repeating this procedure 500 times, we obtain estimations and plot it in Figure 2 as the orange dot. The red curve is the density of its distribution. The vertical dash line is the real impact of NAAQMN. We find that the distribution of the coefficients in the placebo test is centred close to zero and is normally distributed. The real impact is located on the right side of this curve with the coefficient is 0.103.

[Insert Figure 2 here]

4.7. Dynamic effect

In order to reflect the dynamic effects of the policy, this paper additionally introduces five dummy variables, *Current*, *After1*, *After2*, *After3*, *After4_or_More*, which are taken to be 1 in year 0, 1, 2, 3, 4 and beyond after the implementation of the policy, and 0 for the rest of the time, and their respective interaction terms with *Treat* are included in the regressions in order to reflect the performance of the policy in each of the years after its introduction. From columns (1) and (3) of Table 9, the coefficients of the explanatory variables are significantly positive, reflecting that the policy significantly motivates the greenwashing behaviour of the treatment group. According to Column (2) and Column (4), the positive effect of the policy on greenwashing has a dynamic characteristic of firstly strong and then weak. The strength and significance are relatively strong in the second year after the introduction of the NAAQMN policy, and from the third year onwards, the policy's induction of greenwashing becomes weaker and weaker, and the effect reverses after the fourth year, with the coefficient becoming negative, even if it is not significant. This result is interesting and provides us with evidence that although the NAAQMN motivate firms to greenwash and curb sustainable efficiency in the short-term, in the long-term, this effect is weakened, and the gap between the treatment and control groups is narrowed.

[Insert Table 9 here]

4.8. Mechanism tests

This subsection performs several mechanism analyses in view of the potential heterogeneity that may exist in our sample. Specifically, we categorize the firms into different groups based on various standards, before repeating the baseline analysis. Particularly, we focus on ownership property, regulatory pressure, pollution intensity, market competition, financial constraints, and management average age.

[Insert Table 10 here]

4.8.1. Ownership property

Ownership has a significant effect on firms' behaviour. For example, SOEs have strong political connections, which often result in lower financial costs and political subsidies (Zhang et al., 2023). It is widely agreed that SOEs are generally less financially constrained and demonstrate more corporate social responsibility than privately-owned firms. Because of this, we assume SOEs are less likely to greenwash than non-SOEs facing financial constraints and high financial costs. We hence classify the firms into SOEs and non-SOEs, after which we evaluate whether the influences of NAAQMN vary between firms of different ownerships. This hypothesis is corroborated by the findings presented in Panel A of Table 10, in which the coefficient in Column (2) illustrates a more pronounced effect of NAAQMN on corporate greenwashing behaviour among non-SOE firms, in contrast to its negligible significance in SOEs, as evidenced in Column (1).

4.8.2. Regulatory pressure

This section examines whether there is heterogeneity in the impact of monitoring stations on corporate greenwashing under different environmental regulatory pressure (Du et al., 2022). According to 113 key cities for environmental protection specified by the MEP in 2007, we classify the enterprises according to whether they are located in key cities for environmental protection to measure their environmental regulatory pressure. If an enterprise is located in the key city of environmental protection, the environmental regulatory pressure it faces is high; otherwise, it is low. Column (3) and (4) of Panel A report the corresponding results. Firms are more likely to greenwash when they face higher environmental regulation pressure, which evidenced in column (3).

4.8.3. Pollution intensity

In the context of strict environmental assessment, enterprises in both heavy polluting and non-heavy polluting industries are under varying degrees of pressure to meet requirement (Cao et al., 2022). According to the requirements of Environmental Information Disclosure Guidelines for Listed Companies issued by the MEP in 2010, 16 industries, including thermal power, steel, cement and electrolytic aluminium, are classified as heavy polluting industries, while the rest are non-heavy polluting industries. Columns (5) and (6) of Panel A report the regression results. The coefficient of *NAAQMN* is significant at the 10% level in the non-heavy polluting firm sample group, while the coefficient of *NAAQMN* is insignificant in the heavy polluting firm sample group. The results show that the impact of the NAAQMN on greenwashing in stronger for non-heavy polluting firms. Heavily polluting firms consume large amounts of energy in their production processes and must account for future environmental liabilities. In contrast, non-heavily polluting firms face relatively less environmental pressure (Marquis et al., 2016) during normal production activities, making it easier for them to improve their green image through greenwashing (Kim and Lyon, 2011). Consequently, these firms are more sensitive to the government eco-regulatory policies and pay closer attention to urban monitoring stations than heavily polluting firms.

4.8.4. Financial constraints

Based on resource dependency theory, firms with high financial constraints are more likely to engage in greenwashing under strict environmental policy due to limited resources to invest in genuine environmental improvements. These firms face significant pressure to appear environmentally responsible to attract investors, meet regulatory expectations, and avoid penalties. Greenwashing becomes a cost-effective strategy to quickly enhance their environmental image without incurring the substantial expenses associated with actual sustainability initiatives (Marquis, Toffel, & Zhou, 2016; Kim & Lyon, 2011). The coefficients in columns (1) of Panel B show that the impact of NAAQMN is more pronounced in firms with higher financing constraints with comparison of that in column (2) of Panel B.

4.8.5. Market competition

The impact of NAAQMN on greenwashing behaviour is largely influenced by the degree of competitive incentives of enterprises. It has been shown that firms have strong cost-shifting incentives when they suffer from external shocks of environmental regulation. In highly competitive markets, firms face intense pressure to differentiate themselves from their rivals. This pressure can drive firms to highlight their environmental credentials as a unique selling proposition (Porter & Linde, 1995). Also, firms in competitive markets often focus on short-term financial performance due to shareholder expectations and market pressures. This short-termism can lead to myopic behaviour where firms prioritize immediate gains over long-term sustainability (Laverty, 1996). Therefore, we expect that the higher the degree of market competition, the more pronounced the impact of NAAQMN on greenwashing behaviour. Columns (3) and (4) of panel B present the results of the two subgroups, which demonstrate that the coefficient of the *NAAQMN* is significantly positive in the industry with higher market competition, while the coefficient is not significant in the industry with lower market competition.

4.8.6. Executives' age

Younger managers may prioritize immediate results and visibility to enhance their reputation and career prospects, making greenwashing an attractive strategy to quickly appear environmentally responsible without substantial investment in real environmental improvements (Bansal and Roth, 2000). Therefore, we propose that firms are more likely to engage in greenwashing when the management's average age is young under the NAAQMN due to the younger managers' focus on career advancement and short-term performance.

Columns (5) and (6) in Panel B report the results of management's ambitions measured using the average age of management. The coefficients of NAAQMN in the old management group are insignificant, while the coefficients of NAAQMN in the relatively young group are significantly positive at the 5% level. This shows that the higher the management's ambitions, the stronger the positive effect of the pilot policy on greenwashing.

4.9. Moderating effects

To develop what factors can inhibit corporate greenwashing from the internal and external perspective, we use corporate digital transformation and the public environmental attention to further investigate the relationship.

As for the internal factor, digital transformation discourages corporate greenwashing by enforcing transparency and accountability (Li et al., 2024). Digital data collecting, or analysing capabilities enable stakeholders (e.g., investors and consumers) to identify greenwashing and discrepancies between a company's ESG disclosures and its actual ESG practices. For instance, IKEA's implementation of Akila in its Chinese shops provides stakeholders with transparency to reduce energy consumption and minimize carbon footprint through real-time monitoring of energy consumption[6]. Digital transformation improves the monitoring of internal control deficiencies and information asymmetries (Chen et al., 2022; Jiang et al., 2022). This mitigates corporate greenwashing behaviour related to ESG disclosures. Therefore, we create a variable named *DT*, measures the degree of digital transformation of firms.

In terms of the external factor, high levels of public environmental concern lead to greater scrutiny of corporate environmental claims and actions. Informed and environmentally conscious consumers, activists, and media are more likely to question and investigate the authenticity of corporate green claims, making it harder for firms to engage in greenwashing

[6] Akila is a digital twin and AI platform. Source: https://www.akila3d.com/blog/ikea-collaboration/

without being exposed (Lyon and Montgomery, 2013). So, we construct a variable, *Public*, refers to the number of times specific companies' environmental information has been searched on the Baidu search engine, representing the degree of public concern regarding the environmental practices of these companies.

[Insert Table 11 here]

The results are shown in Table 11. Columns (1) consider digital transformation. We find that digital transformation has a negative moderating effect on greenwashing. The coefficient of the interaction term between *NAAQMN* and *DT* is -0.145, meaning digital transformation offsets corporate greenwashing due to the policy shock. Column (2) reveals public environmental attention has a negative moderating effect at the 5% significance level on greenwashing with the coefficient of -0.062 of interaction term between *NAAQMN* and *Public*. It indicates that as the public becomes more environmentally aware it can effectively curb corporate greenwashing behaviour.

5. Conclusion

This paper leverages the implementation of NAAQMN in China as a quasi-natural experiment and utilizes the divergence between ESG disclosure and ESG performance to measure greenwashing behaviour. We focus on the impact of NAAQMN on corporate greenwashing behaviour and find that NAAQMN markedly incentivize greenwashing behaviour in firms in short run while public environmental concerns can mitigate this effect. Additionally, the impact of NAAQMN to induce greenwashing is more acute in environments of heightened market competition, among Non-SOEs, high regulatory pressure, non-pollution industries, larger financial pressure and lower average management age. Furthermore, we find that the distance between firms and the station is a matter of greenwashing. Businesses will take advantage of monitoring deficiencies at air monitoring stations, and the further away a business is from a monitoring station, the more likely it is to be greenwashed.

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Tables

Table 1. Descriptive statistics

This table reports summary statistics for main variables used in this study. All continuous variables are winsorised at the 1% and 99% levels. The sample includes 1330 firms from 2009 to 2020. The summary statistics of each variable include the number of observations, mean, standard deviation, minimum median and maximum. All variables are defined in Appendix A.

Variables	**(1)** ***N***	**(2)** ***Mean***	**(3)** ***SD***	**(4)** ***Min***	**(5)** ***Median***	**(6)** ***Max***
NAAQMN	11,492	0.767	0.423	0	1	1
ESGdis1	11,492	-0.004	0.981	-1.805	-0.040	3.154
ESGdis2	11,492	0.297	0.140	0.041	0.290	0.747
ESGper1	11,492	0.005	0.971	-2.961	0.070	2.003
ESGper2	11,492	0.631	0.111	0.293	0.640	0.858
GW1	11,492	-0.004	1.239	-2.444	-0.130	3.555
GW2	11,492	-0.333	0.160	-0.643	-0.350	0.132
Age	11,492	2.864	0.355	0	2.940	3.989
Size	11,492	23.040	1.319	20.430	2.200	26.85
Lev	11,492	0.475	0.198	0.072	22.91	0.876
Cash	11,492	0.007	0.010	0.0002	0.490	0.063
ROE	11,492	0.090	0.117	-0.482	0.090	0.405
GDPper	11,492	11.060	0.506	9.782	0.150	12.01
FDI	11,492	7.655	1.341	3.574	11.07	9.984
Board	11,492	2.180	0.206	1.099	0.140	2.890
Indep	11,492	0.375	0.059	0.143	0.110	0.800
Female	11,492	0.165	0.106	0	0.030	0.667
HHI	11,492	0.200	0.186	0.035	0	1
Intangible	11,492	0.051	0.065	0	0.330	0.429
Sales Growth	11,492	0.173	0.386	-0.493	0.360	2.446
Top1	11,492	0.338	0.184	0	7.840	0.770

Table 2. Correlation matrix

This table reports Pearson correlation coefficients for the variables used in this study. All variables are defined in Appendix A. *, **, and *** indicate significance at the 10%, 5% and 1% level respectively.

	GW1	*NAAQMN*	*Age*	*Board*	*Size*	*Lev*	*ROE*	*Female*	*GDPper*	*HHI*	*Sales Growth*	*Intangible*	*Cash*	*Top1*	*Indep*	*FDI*
GW1	1															
NAAQMN	0.278***	1														
Age	0.239***	0.298***	1													
Board	-0.001	-0.101***	0.018*	1												
Size	0.222***	0.158***	0.150***	0.213***	1											
Lev	0.067***	-0.025***	0.110***	0.112***	0.496***	1										
ROE	-0.175***	-0.103***	-0.078***	0.012	0.048***	-0.193***	1									
Female	0.014	0.141***	0.093***	-0.209***	-0.206***	-0.168***	0.038***	1								
GDPper	0.219***	0.413***	0.204***	-0.142***	0.171***	-0.068***	-0.011	0.172***	1							
HHI	0.028***	-0.058***	-0.060***	-0.004	0.016*	-0.005	-0.011	0.022**	0.001	1						
Sales Growth	-0.067***	-0.084***	-0.084***	-0.038***	0.004	0.028***	0.279***	0.023**	-0.043***	0.004	1					
Intangible	0.049***	0.011	0	0.062***	0.011	-0.030***	-0.044***	-0.041***	-0.067***	0.028***	0.001	1				
Cash	-0.100***	-0.018*	-0.125***	-0.086***	-0.286***	-0.579***	0.123***	0.145***	0.022**	0.013	0.001	-0.037***	1			
Top1	-0.077***	-0.097***	-0.003	0.025***	0.084***	0.082***	0.060***	-0.088***	-0.119***	0.005	0.018*	0.005	-0.050***	1		
Indep	-0.001	0.051***	-0.048***	-0.443***	0.085***	0.022**	-0.009	0.039***	0.063***	0.024**	0	-0.029***	0.002	0.006	1	
FDI	0.157***	0.290***	0.177***	-0.132***	0.106***	-0.081***	0.043***	0.133***	0.772***	-0.017*	-0.016*	-0.063***	0.003	-0.113***	0.028***	1

Table 3. Baseline results

This table presents results examining the baseline impact of NAAQMN policy on corporate greenwashing behaviour with different fixed effect. Model (1) and (3) include industry, year, and city fixed effects whereas model (2) and (4) include firm, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Variables	*(1)* *GW1*	*(2)* *GW1*	*(3)* *GW2*	*(4)* *GW2*
NAAQMN	0.103**	0.102**	0.014**	0.013**
	(2.227)	(2.197)	(2.401)	(2.230)
Age	0.135***	-0.290**	0.020***	-0.020
	(3.848)	(-2.360)	(4.579)	(-1.139)
Board	0.007	0.091	0.005	0.013
	(0.113)	(1.042)	(0.617)	(1.251)
Size	0.112***	-0.100***	0.021***	-0.009***
	(9.232)	(-4.159)	(13.094)	(-2.901)
Lev	0.255***	0.498***	0.019**	0.044***
	(3.250)	(4.678)	(1.993)	(3.349)
ROE	-1.254***	-1.120***	-0.135***	-0.124***
	(-12.719)	(-12.004)	(-11.094)	(-10.800)
Female	0.016	0.047	-0.001	0.002
	(0.156)	(0.368)	(-0.085)	(0.138)
GDPper	-0.133	-0.358**	-0.021	-0.053**
	(-0.840)	(-2.174)	(-1.045)	(-2.520)
HHI	0.370***	0.138**	0.044***	0.014*
	(6.076)	(2.141)	(5.841)	(1.772)
Sales Growth	-0.000	-0.067***	-0.000	-0.007***
	(-0.004)	(-3.144)	(-0.041)	(-2.812)
Intangible	0.183	-0.196	0.039**	-0.009
	(1.156)	(-0.695)	(1.997)	(-0.244)
Cash	-0.398	-1.165	-0.023	-0.031
	(-0.321)	(-0.896)	(-0.149)	(-0.194)
Top1	-0.203***	0.195	-0.029***	0.033*
	(-3.456)	(1.352)	(-3.939)	(1.843)
Indep	-0.925***	-0.752***	-0.089***	-0.075**
	(-4.553)	(-3.065)	(-3.483)	(-2.453)
FDI	-0.056	-0.050	-0.006	-0.006
	(-1.553)	(-1.405)	(-1.369)	(-1.237)
Constant	-1.088	6.056***	-0.630***	0.351
	(-0.619)	(3.359)	(-2.817)	(1.491)
Observations	11,492	11,492	11,492	11,492
Adjusted R-squared	0.403	0.660	0.446	0.692
Industry FE	Yes	No	Yes	No
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	No	Yes	No	Yes

Table 4. Entropy balancing

This table presents the impact of NAAQMN on corporate greenwashing behaviour under the entroping balancing method. Panel A compares means along various sample dimensions before and after entropy balancing. Panel B presents the results using the entropy-balanced sample. All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A

	Before				***After***		
	Treat mean	***Control mean***	***Diff***		***Treat mean***	***Control mean***	***Diff***
Age	2.923	2.670	-0.252***	***Age***	2.923	2.923	0.000
Board	2.169	2.218	0.049***	***Board***	2.169	2.169	0.000
Size	23.160	22.660	-0.494***	***Size***	23.160	23.160	0.000
Lev	0.472	0.484	0.012***	***Lev***	0.472	0.472	0.000
ROE	0.084	0.112	0.028***	***ROE***	0.084	0.084	0.000
Female	0.173	0.138	-0.035***	***Female***	0.173	0.173	0.000
GDPper	11.180	10.680	-0.493***	***GDPper***	11.180	11.180	0.000
HHI	0.194	0.220	0.025***	***HHI***	0.194	0.194	0.000
SalesGrowth	0.155	0.232	0.077***	***SalesGrowth***	0.155	0.155	0.000
Intangible	0.051	0.049	-0.002	***Intangible***	0.051	0.051	0.000
Cash	0.006	0.007	0.000*	***Cash***	0.006	0.006	0.000
Top1	0.329	0.371	0.042***	***Top1***	0.329	0.329	0.000
Indep	0.377	0.370	-0.007***	***Indep***	0.377	0.377	0.000
FDI	7.869	6.951	-0.919***	***FDI***	7.869	7.869	0.000

Panel B

Variables	***(1) GW1***	***(2) GW2***
NAAQMN	0.170***	0.024***
	(2.778)	(3.064)
Constant	-2.859	-0.782**
	(-1.176)	(-2.540)
Controls	Yes	Yes
Observations	11,486	11,486
Adjusted R-squared	0.494	0.530
Industry FE	Yes	Yes
Year FE	Yes	Yes
City FE	Yes	Yes

Table 5. Alternative measure of independent variables

This table shows results of the NAAQMN shock on corporate greenwashing from a geographical perspective by using the closest distance between firms headquarter and air monitoring station. This sample only include cities with air monitoring stations (2012-2020). All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Variables	***(1)*** ***GW1***	***(2)*** ***GW2***
Distance	0.022**	0.003*
	(2.140)	(1.892)
Constant	1.313	-0.423
	(0.464)	(-1.200)
Controls	Yes	Yes
Observations	9,055	9,055
Adjusted R-squared	0.363	0.403
Industry FE	Yes	Yes
Year FE	Yes	Yes
City FE	Yes	Yes

Table 6. Distinguish ESG disclosure score and ESG performance score

This table notes the results after replacing the dependent variables. The dependent variable is the firm's ESG disclosure score (Columns 1 and 2), and the dependent variable is the firm's actual ESG score (Columns 3 and 4). All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Variables	*(1)* *ESGdis1*	*(2)* *ESGdis2*	*(3)* *ESGper1*	*(4)* *ESGper2*
NAAQMN	0.069**	0.010**	-0.033	-0.004
	(2.172)	(2.172)	(-0.794)	(-0.794)
Constant	-6.473***	-0.624***	-5.160***	0.043
	(-4.563)	(-3.089)	(-3.198)	(0.233)
Controls	Yes	Yes	Yes	Yes
Observations	11,492	11,492	11,492	11,492
Adjusted R-squared	0.578	0.578	0.265	0.265
Industry FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 7. Re-estimating with different samples

This table reports results for further robustness tests by using different sample period. All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

	(1)	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
Variables	***GW1***	***GW2***	***GW1***	***GW2***	***GW1***	***GW2***
NAAQMN	0.107**	0.014**	0.110**	0.014***	0.095**	0.011**
	(2.385)	(2.561)	(2.566)	(2.737)	(2.276)	(2.212)
Constant	-0.394	-0.539**	-0.134	-0.452*	-2.235	-0.635**
	(-0.228)	(-2.472)	(-0.071)	(-1.889)	(-0.894)	(-2.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,224	10,224	7,796	7,796	4,455	4,455
Adjusted R-squared	0.391	0.432	0.369	0.404	0.229	0.224
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 8. Parallel trend test

This table reports results of parallel trend test between the NAAQMN policy and corporate greenwashing behaviour. All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Variables	*(1)* *GW1*
Treat*Post (t = -3)	-0.047
	(-0.718)
Treat*Post (t = -2)	-0.001
	(-0.016)
Treat*Post (t = 0)	0.102*
	(1.864)
Treat*Post (t = 1)	0.111*
	(1.859)
Treat*Post (t = 2)	0.129**
	(1.975)
Treat*Post (t = 3)	0.064
	(0.955)
	(-1.472)
Constant	-1.034
	(-0.622)
Controls	Yes
Observations	11,492
Adjusted R-squared	0.403
Industry FE	Yes
City FE	Yes
Year FE	Yes

Figure 1

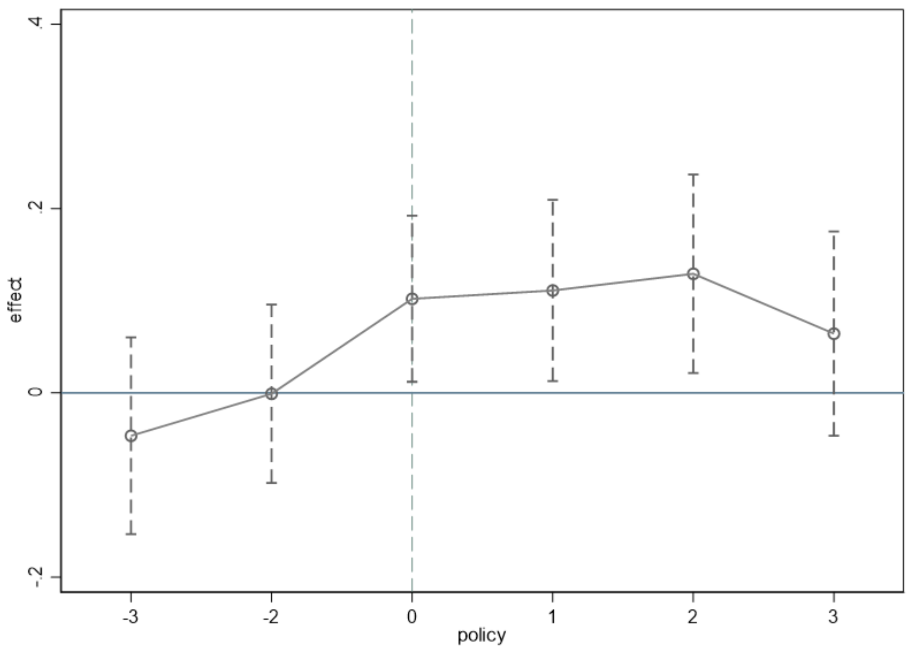

Figure 2. Placebo test

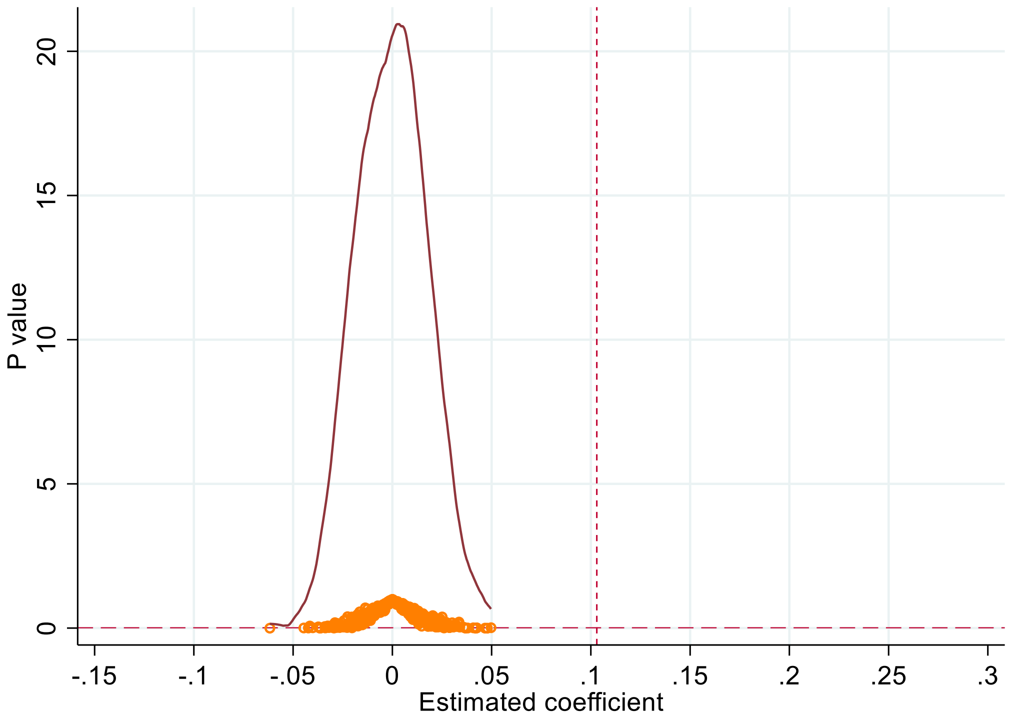

Table 10. Mechanism tests

This table presents the mechanism tests of NAAQMN policy on greenwashing in different subgroups. All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A

Variables	***(1) SOE GW1***	***(2) Non-SOE GW1***	***(3) Key city GW1***	***(4) Non-Key GW1***	***(5) Heavy GW1***	***(6) Non-Heavy GW1***
NAAQMN	0.003	0.194***	0.214**	0.058	0.058	0.133*
	(0.048)	(2.860)	(2.276)	(0.854)	(0.933)	(1.659)
	(-1.484)	(-0.256)	(-0.807)	(-1.492)	(-0.139)	(-1.909)
Constant	0.213	-0.747	-2.760	6.887**	-1.121	2.880
	(0.099)	(-0.245)	(-1.347)	(2.014)	(-0.402)	(1.184)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,878	5,614	9,120	2,372	4,388	7,104
Adjusted R-squared	0.459	0.404	0.375	0.532	0.447	0.409
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B

Variables	***(1) High FC GW1***	***(2) Low FC GW1***	***(3) High MC GW1***	***(4) Low MC GW1***	***(5) Old GW1***	***(6) Young GW1***
NAAQMN	0.096*	0.084	0.126**	0.059	-0.008	0.149**
	(1.699)	(1.091)	(2.158)	(0.780)	(-0.096)	(2.514)
Constant	1.240	-1.455	-1.992	1.778	-0.289	-0.464
	(0.507)	(-0.483)	(-0.913)	(0.574)	(-0.108)	(-0.187)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,456	6,036	7,728	3,764	5,875	5,617
Adjusted R-squared	0.442	0.375	0.407	0.421	0.413	0.429
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 11. Moderating effects

This table shows results of the moderating effect of firm digital transformation and public environmental concern on corporate greenwashing. All models include industry, year, and city fixed effect. The standard errors in parentheses are clustered at city by year level. See Appendix A for variable definitions in detail. All continuous variables are winsorised at the 1st and 99th percentiles. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Variables	***(1)*** ***GW1***	***(1)*** ***GW1***
NAAQMN	0.621	0.362***
	(1.503)	(3.213)
NAAQMN*DT	-0.145	
	(-1.224)	
DT	-0.416***	
	(-3.595)	
NAAQMN*Public		-0.062**
		(-2.331)
Public		0.015
		(0.241)
Constant	0.050	0.715
	(0.020)	(0.302)
Controls	Yes	Yes
Observations	9,879	10,296
Adjusted R-squared	0.385	0.398
Industry FE	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes

Appendix

Appendix A. Variable definition

Variable	*Definition*
GW1	*ESGdis1* minus *ESGper1*
GW2	*ESGdis2* minus *ESGper2*
ESGdis1	$\frac{ESGdisclosure_{i,t} - \overline{ESGdisclosure_t}}{\sigma ESGdisclosure_t}$
ESGdis2	$\frac{ESGdisclosure_{i,t} - \min(ESGdisclosure)}{\max(ESGdisclosure) - \min(ESGdisclosure)}$
ESGper1	$\frac{ESGperformance_{i,t} - \overline{ESGperformance_t}}{\sigma ESGperformance_t}$
ESGper2	$\frac{ESGperformance_{i,t} - \min(ESGperformance)}{max(ESGperformance) - min(ESGperformance)}$
NAAQMN	A dummy variable which equals one if the firm is headquartered in the pilot city in the year of policy implementation and after and zero otherwise
Age	Logarithm of the observation year minus establishment year
Size	The natural logarithm of total assets (Yuan)
Lev	Total liabilities over total assets
Cash	The proportion of cash and cash equivalents held by enterprises in total assets
ROE	Net profit over total equity
GDPper	Logarithm of provincial level GDP per capital
FDI	Logarithm of provincial level foreign direct investment
Board	The natural logarithm of the number of directors
Indep	Ratio of number of independent board directors to the total number of directors
Distance	Logarithm of the minimum distance between the corporate headquarter and air monitoring station
Top1	Ratio of total shares held by the largest shareholder
Intangible	Ratio of intangible asset by the total asset
Sales Growth	The ratio of current year's operating income to last year's operating income minus 1
HHI	Herfindahl-Hirschman Index
Female	Ratio of number of female directors to the total number of directors