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*Title Page*

Greening through centralization of environmental monitoring?

*Special Issue on “Extreme Events” of Energy Economics*

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## Research Highlights

- Examining the link between environmental governance and greenwashing practices.
- Environmental monitoring centralization reduces greenwashing practices.
- Privately-owned firms with high pollution and technology intensity are motivated to reduce greenwashing practices.
- Providing useful insights to promote sustainable growth through effective environmental regulations.

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# Greening through centralization of environmental monitoring?

## Abstract

This paper investigates the impact of China's environmental monitoring centralization on firms' greenwashing practices, by examining the causal relationship between environmental governance at the local level and effective environmental regulations for sustainable growth. Using a difference-in-difference (DID) model, we analyze data from Chinese-listed firms over a period spanning from 2010 to 2019. Our results show that environmental monitoring centralization can significantly reduce greenwashing practices, particularly in cases where there is a high level of environmental decentralization. Furthermore, we find that privately-owned firms with high levels of pollution and technology intensity are particularly motivated to reduce greenwashing practices as environmental decentralization levels increase due to the centralization of environmental monitoring policies. Finally, our study reveals that the centralization of environmental monitoring policy shock can effectively curb greenwashing practices by strengthening environmental regulation levels. These findings provide valuable insights for policymakers seeking to promote sustainable growth through effective environmental regulations.

**Keywords:** Environmental monitoring centralization; Environmental decentralization; Greenwashing

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# Greening Through the Centralization of Environmental Monitoring?

## 1. Introduction

Thanks to the progress created by China's adoption of the reform and open-door policy, over the past thirty years China has experienced skyrocketing economic growth as well as a tremendous rate of financial development. China has been actively participating in global value chains, too, by taking advantage of low-cost labor and an integrated industrial system that covers agriculture, industry and service sectors. However, the sustained and rapid development of a country's economy and financial model is always accompanied by excessive energy consumption and serious environmental pollution ([Zhang & Jin, 2021](#)). For China, the clearest evidence of this is that the growth rate of their CO<sub>2</sub> emissions went up 320% between 1992 and 2021. Additionally, Chinese CO<sub>2</sub> emission volume accounted for 38.72% of the world's total CO<sub>2</sub> emission volume in 2021, which is significantly higher than the 14.59% these emissions counted for in 1992.

Facing environmental and climate challenges, many developed and developing countries have promised to control greenhouse emissions and have converted to a sustainable growth model ([Barnett et al., 2020](#); [Giglio et al., 2021](#)). Under these challenging conditions, China is especially pursuing energy conservation and emission reduction goals. Recently, China has committed to promoting the deal, which includes a historic provision, agreed to at the 27<sup>th</sup> United Nations Climate Change Conference, to create a fund to help poorer countries face the harm caused by climate change. China will also better control its total energy consumption and cut the energy consumption per unit of gross domestic product by 13.5% by 2025 (compared with the 2020 level), in accordance with the five-year plan on energy conservation and emission reduction released by the State Council. Essentially, China will scale up its Intended Nationally Determined Contributions by adopting more vigorous policies and measures. China aims to have CO<sub>2</sub> emissions peak before 2030 and achieve carbon neutrality before 2060.

Policymakers and market regulators have passed numerous laws and regulations to achieve sustainability, and companies have gradually become the most active participants working towards this goal ([Zhang, 2022b](#)). However, even with a dramatic rise in the number of methods and studies published on how to achieve the United Nation's Sustainable Development Goals and Environment, Social and Governance (ESG) targets, concerns about air pollution and energy consumption remain. One of the most significant reasons for these remaining concerns is greenwashing. From the firm perspective, the general aim of environmentally friendly and sustainable finance may conflict with their inherent need to maximize profit. Shifting to renewable and energy-efficient models could bring additional financial and operational costs.

Greenwashing occurs when a firm promotes itself as environmental friendliness but spends more time and money on advertising its environmental friendliness than on actually developing any genuine sustainability efforts ([Laufer, 2003](#)). Additionally, some firms could mislead investors, shareholders and the general public by only disclosing positive information about their sustainable achievements and ignoring the negative aspects ([Marquis et al., 2016](#); [Nyilasy et al., 2014](#)). Through greenwashing, firms

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can create a positive public image for themselves, attracting more investments and decreasing loan costs (Du, 2015).

Because of greenwashing, China's relevant authorities and government departments have sought a more efficient strategy to improve sustainable development and remediate firms' greenwashing behavior. Recently, an innovative, new environmental management system has been proposed. The heart of this new system is environmental monitoring, which emphasizes decentralization. In other words, the new environmental management system seeks to allocate authority over environmental management affairs to different levels of government (Wu et al., 2020). Supporters of environmental decentralization believe it can help local governments design stricter and more targeted regulations to improve their local environments (Chang et al., 2014; Goel et al., 2017). Supporters also suggest that the decentralization of environmental supervisory power will not significantly lower the intensity of local environmental monitoring or affect local law enforcement (Grooms, 2015; Sjöberg & Xu, 2018).

Environmental decentralization could negatively impact environmental regulation and monitoring, however. Wu et al. (2020) have proven that environmental decentralization can increase the negative effect environmental regulation has on green total factor energy efficiency. Additionally, a higher degree of environmental decentralization can increase the restraining effect environmental regulation has on green total factor energy efficiency. In China, the method of decentralizing environmental monitoring, due to the interference of objective factors such as a performance assessment, has led to some local governments' falsifying environmental monitoring data. As such, China can't guarantee the authenticity, comprehensiveness, scientific rigor or objectivity of environmental monitoring data. Additionally, the authority and credibility of the central Chinese government could be negatively affected by local governments' ecological environment quality monitoring and evaluation systems being incomplete or irregular. The same is true if environmental monitoring information release channels are not unified, or if published standards are inconsistent, and so on. To solve these problems, in 2020, the Ministry of Environmental Protection of China reached an agreement with the Ministry of Finance concerning the national environmental quality and monitoring authority. Their decision returns (centralizes) the power of environmental quality monitoring to the central government, which has led to the national assessment and national monitoring of environmental quality.

The centralization of environmental monitoring can be viewed as an extreme political event. The transfer of authority from local governments to the central government creates an enormous challenge for companies that now need to learn the rules and regulations that exist under the new monitoring system. Firms will also need to adjust their production and management strategies. Investigating the inter-connectivity that exists between this extreme political event of the re-centralization of environmental monitoring and of firms' sustainable efficiency can bring essential contributions to sustainable finance area as policy uncertainty can significantly shock the environmental risk and firms' sustainable efficiency is more and more subject to the effect of environmental monitoring (Zhang, 2022a). Existing studies mention little about the centralization of environmental monitoring and its effect on firms' green behavior. Therefore, having successfully identified a research gap, this paper seeks to answer the question of what has a greater effect on a firm's sustainable behavior—the centralization of environmental monitoring or decentralization?

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To answer this research question, this paper's study employs a difference-in-difference (DID) model to estimate the effect China's centralization of environmental monitoring has had on firms' greenwashing behavior. To identify the causal relationship, an unbalanced panel dataset of Chinese listed firms spanning from 2010 to 2019 was constructed, which contained fundamental firm-level characteristics information, ESG disclosure and rating data, and industry-level controls. By doing this, several important empirical findings can be determined. Firstly, environmental monitoring centralization can significantly curb firms' greenwashing behaviors with the condition of environmental decentralization. Secondly, by considering the heterogeneities elements, privately-owned, high-polluting and high-tech firms are shown to be strongly motivated to curb greenwashing behaviors with an increased environmental decentralization level caused by the centralization of environmental monitoring policy. Thirdly, the centralization of environmental monitoring policy is demonstrated to curb greenwashing behaviors by strengthening environmental regulation levels. Lastly, this paper's study's findings are proven valid by excluding other policy shock effects and solving potential endogeneity problems.

This study contributes to the existing literature on the relationship between environmental regulation and firm performance in three important ways. The first of these is that the study offers evidence that enriches the existing research on how to evaluate how environmental regulations affect firm performance (as this study's research framework was designed from an inverse policy shock of implementation of centralization of environmental monitoring, rather than the general exploration in environmental decentralization). This study's second important contribution is that it adds a new dimension to companies' greenwashing behavior, differing from firm productivity or profitability, and it also provides the hypocritical sustainable perspective required to understand how firms make their decisions. This study's third important contribution is it provides rich dimensions to account for the difference between groups, including firm and industry heterogeneities, using efficient instrument variables to make its results reliable. The study demonstrates rich and valid findings that explore the impact of the implementation of centralization of environmental monitoring on firms' sustainable growth.

The rest of the paper is developed as follows: section two discusses the existing literature on environmental monitoring, greenwashing and company efficiency; sections three and four describe the paper's data, its model specification and its findings; section five presents robustness tests and contains the discussion; and finally, section six reviews the main findings of this study and describes its practical and social implications. Section six also offers ideas for future research.

## **2. Literature review and hypothesis development**

According to the neo-classical economics framework, it is widely agreed that the nature of firms is to maximize profits and that increased production will cause increased environmental pollution, which is referred to as a negative externality (Friedman, 2004). In recent years, with the continuous deterioration of the global ecological environment, green development has inevitably become a way for firms to achieve green transformation under resource constraints (Crifo et al., 2015). Sustainable development and green transformation require significant capital investment, however, which can increase the cost and financial burden these initiatives place on firms (Arouri et al., 2021). At present, the evaluation standards of firm environmental performance in China are not uniform and the cost of counterfeiting is too low.

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Because of this, low-cost, pseudo-social responsibility behaviors are widely used by firms, such as greenwashing behavior. [Yu et al. \(2020\)](#) define "greenwashing" as the selective disclosure of ESG information by companies with poor ESG performances to present themselves as environmentally sustainable and friendly, which is essentially false. These firms overstate their performance in regards to environmental protection, and they deliberately conceal how much they have polluted the environment without providing any substantial ecological improvements ([Zhang, 2022](#)). As consumer demand for green products and services grows, greenwashing will further intensify. Eventually, greenwashing will interfere with investors' ability to accurately judge companies, which, in turn, will distract the market, leading to adverse selection in the market as a whole and, eventually, the misallocation and waste of resources ([Netto et al., 2020](#)).

Regarding the motivations and influencing factors that underpin firms' greenwashing behaviors, stakeholder theory and resource dependence theory suggest that these firms must rely on external resources such as policy legitimacy ([Berrone et al., 2017](#)) and external financing ([Slaba et al., 2018](#)) to survive in the market in the long run. In addition, investors and consumers are the most important stakeholders of firms and, in the context of green consumption, investors and consumers not only pay attention to the economic performance of firms but also to their environmental performance. A firm's high ESG rating reflects an environment-friendly image, which can bring better financing opportunities, while a low ESG rating can drag down a firm's stock price and make financing more difficult ([Zhang, 2022](#)). Many firms, therefore, tend to misrepresent their environmental performance and ESG information in sustainability development reports in order to seek additional external resources, alleviate financing constraints, and improve their image. This is especially true among highly leveraged and polluting firms ([Zhang, 2022](#)). Effective environmental regulation can not only inhibit firm pollution emissions ([Wu, 2020](#)), but it can also play an important role in the supervision and punishment of firms' greenwashing. Stronger environmental regulatory pressure increases the cost of falsification and thus discourages firm greenwashing ([Netto et al., 2020](#)).

Because greenwashing does not really improve the quality of the environment, external diseconomies still exist and can cause serious ecological harm ([Lyon and Montgomery, 2015](#)). Scholars in the field of environmental economics have not only focused on government environmental protection decisions on the micro level but also at the macro level. By doing this, they have formed a basic, preliminary consensus regarding the research process: that the reasonable division of environmental protection functions between central and local governments (i.e., environmental decentralization) is conducive to solving environmental pollution problems ([Fredriksson and Wollscheid, 2014](#); [Wang et al., 2021](#)). However, unlike the looser environmental federalism in the West, in China, due to the centralized political power of the central government, environmental decentralization is a top-down distribution of power where lower-level governments are only responsible for higher-level governments, which ignores some of their region's social problems ([Ran et al., 2017](#)). As a result, some scholars have questioned the impact environmental decentralization has actually had. Advocates of environmental centralization argue that as the level of environmental decentralization increases, the "promotion tournament" of GDP causes local governments to excessively pursue economic benefits, intensify local protectionism, and, due to mutual competition, begin an environmental regulation "race to the bottom," ignoring social issues such as the environment and people's livelihoods. As this continues, eventually, the ecological environment will deteriorate ([Zou et al., 2019](#)).

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Since the 18th National Congress of the Communist Party of China, in order to solve the problem of mutual competition and prevent the “race to the bottom” effect, the central government has begun to retract the environmental monitoring authority from local governments. The Ministry of Environmental Protection has issued a series of policies, including the Implementation Plan for National Ecological Environment Quality Monitoring Centralization. This policy is regarded as an important manifestation of environmental centralization (Zhang and Li, 2022). Before the implementation of this policy, the environmental patterns of “centralization” and “decentralization” were different in different regions, so the impact of the policy was heterogeneous. Some researchers have studied the impact of central environmental inspections, and their empirical results show that the central government’s monitoring and intervention in local governments’ environmental protection behaviors improved local environmental benefits (Feng et al., 2022). Deng et al. (2022) found that inspections improved the environmental performance of heavily polluting firms by reducing agency costs. There is a significant, inverted, U-shaped relationship between environmental regulation and China’s green total factor energy efficiency, and its effect is dependent on the type of environmental decentralization involved. For regions with a high level of environmental decentralization, the inhibitory effect of environmental regulation is strengthened (Wu et al., 2020).

After the promulgation of the Implementation Plan for National Ecological Environment Quality Monitoring Centralization, the quality of China’s ecological environment is supervised and regulated by the central government, which effectively prevents local governments from interfering with monitoring data, ensuring that the data is reliable. In addition, this central government supervision can also prevent local governments from aiding firms’ greenwashing efforts, which often happens because of local governments’ goal of maximizing GDP, resulting in the phenomenon of “government-firm collusion”. The above discussion suggests the fundamental hypothesis of our research.

***Hypothesis 1: the policy of environment quality monitoring authority retraction can inhibit firms’ greenwashing behaviors under the environmental decentralization system.***

In other words, if the environmental decentralization degree is higher, the inhibition effect of policy shock is stronger. Furthermore, firms’ motivation for greenwashing might be primarily driven by external, environmental regulatory pressure. Local environmental decentralization and central government environment quality monitoring perform together to strengthen environmental regulation and impact firms’ greenwashing behaviors. As previous research demonstrates, environmental regulations imposed by governments work by exerting coercive pressure on target firms, forcing these firms to adopt appropriate environmental-oriented practices, address sustainable performance, and maintain legitimacy issues (Li and Ramanathan, 2018). Some firm-level studies have documented the positive impacts environmental regulations have had on firm environmental responsibility. Tightening regulatory requirements might cause better environmental performance not only in relation to pollution reduction but also for corporate social sustainability (Kagan et al., 2003). Similarly, additional regulator inspections can reduce manufacturing firms’ pollution emissions (Feres and Reynaud, 2012). Therefore, the environmental centralization monitoring policy can help shed light on how increasing the regulation pressure on target firms improves green performance. This leads to the paper’s mechanism hypothesis.

***Hypothesis 2: the policy of environment quality monitoring authority retraction can inhibit firm’s***

### 3. Basic model and data source

#### 3.1 Basic empirical model

To empirically identify the proposed hypothesis of whether the policy shock of environmental monitoring rights can hinder firms' greenwashing behaviors under environmental decentralization, this paper follows [Qian's methodology \(2008\)](#) and constructs a basic, continuous DID framework to solve the potential endogeneity problem of the original panel's data model framework. For firms, the policy of environmental monitoring centralization is an exogenous shock. Thus, the policy implementation can be regarded as a quasi-natural experiment with stochastic impact, and there is no reverse causality problem for the policy intervention. Therefore, we can use the DID method to accurately estimate the effect of policy intervention on firms' greenwashing behaviors. In addition, in the standard DID model, treatment is used a dummy variable, but in fact, there is no strict division between the environmental decentralization system and the centralization system in China. The level of environmental decentralization is a series of continuous data, and the level of environmental decentralization varies in different regions. As a result, firms' degree of exposure under the policy shock also varies. In order to capture more variation in the data, a continuous measure of the intensity of treatment (i.e., environmental decentralization) is used. The above-mentioned method is the difference between this paper's estimates and a standard DID strategy. To summarize, the continuous DID framework is conducive to this paper's assessment of the effect of the policy shock under China's environmental system. The following continuous DID model is constructed and then the interaction coefficient captures the effect the policy implementation has had on firms' greenwashing behavior under different levels of environmental decentralization.

$$Greenwash_{i,t} = \beta_0 + \beta_1 * Post_t * ED_{i,t} + \beta_i * \Gamma_{i,t} + \delta_t + \mu_j + \varepsilon_{i,t}, (1)$$

where subscript  $i$  indicates the firm-individual and  $t$  refers to the time spanning 2010–2019. This paper's study focuses on greenwashing as the dependent variable. Following the example set by [Zhang \(2022\)](#), the difference between the ESG performance disclosed by firm executives and the objectively assessed real ESG performance is used to measure the greenwashing level of firms. The larger the gap between the disclosed and the real ESG performance, the higher the level of greenwashing level. The data are normalized in order to eliminate the effect of dimension. The calculation method is as follows:

$$Greenwash_{i,t} = \left( \frac{ESG_{i,t}^{dis} - \overline{ESG_{i,t}^{dis}}}{\sigma_{dis}} \right) - \left( \frac{ESG_{i,t}^{rate} - \overline{ESG_{i,t}^{rate}}}{\sigma_{per}} \right), (2)$$

where  $ESG_{i,t}^{dis}$  and  $ESG_{i,t}^{rate}$  denote the firm's ESG disclosure score and real ESG performance score, respectively; and  $\overline{ESG_{i,t}^{dis}}$ ,  $\overline{ESG_{i,t}^{rate}}$  and  $\sigma_{dis}$ ,  $\sigma_{per}$  represent the mean value and the standard deviation.

$Greenwash_{i,t}$  represents the firm's greenwashing level.  $Post_t$  is a dummy variable that determines whether the policy is issued or not. It takes 1 if time is after 2015, or else it takes 0.  $ED_{i,t}$  represents the environmental decentralization level. Additionally,  $\Gamma_{i,t}$  are a range of control variables involved in our basic empirical model, including firm-level characteristics and industry-level characteristics. Within the details, referring to Luo et al. (2019), environmental protection expenditure is used to construct

environmental decentralization indicators. Environmental protection expenditure is an important government action, which is a good reflection of the contribution and efforts made by the central government or local governments towards environmental management issues. Environmental protection expenditure can also reflect the division of environmental management affairs among different levels of government.  $[1 - GDP_{it}/GDP_t]$  is deflator, which can alleviate possible endogenous problems to a certain extent. The specific measurement is provided in Eq. (3).

$$ED_{it} = \left[ \frac{Env_{it}/POP_{it}}{Env_t/POP_t} \right] \times \left[ 1 - \frac{GDP_{it}}{GDP_t} \right], \quad (3)$$

where,  $Env_{it}$  and  $POP_{it}$  denote the environmental protection expenditure and the population of province  $i$  in year  $t$ , respectively;  $Env_t$  and  $POP_t$  represent the national environmental protection expenditure and the national total population in year  $t$ .

Additionally, several firm control variables are employed in the empirical analysis. From the firm's perspective, the control variables selected in this paper include the firms' size ( $Size_{jt}$  is the logarithm of total assets of firms); firms' age measured by the logarithm of the company's founding years; financial leverage (Leverage) measured using the ratio of total liabilities to total assets of the firms; profitability (ROA), measured using the return on assets of a company, which is calculated by dividing the company's net profit by the company's total assets; firms' vitality (Inventory), measured using the ratio of inventory to total assets; firms' value, measured using the firm's Tobin's Q, which is calculated as the ratio of market value to net worth; and the proportion of independent directors (Independence), which is measured using the ratio of the number of independent director seats to the total number of board seats.  $\delta_t, \mu_j$  are the time and industry fixed effect,  $\varepsilon_{i,t}$  are also introduced into our model. The detailed definition and measurement of variables are presented in [Appendix 1](#).

### 3.2 Data

We employ an unbalanced panel dataset of listed, Chinese firms for the period of 2010–2021 to investigate the underlying effect the policy impact of environmental decentralization has had on greenwashing, yielding a total of 12,000 observations. The basic variables are collected from the China Stock Market & Accounting Research Database (CSMAR). Besides the basic, firm-level information, the industry-level data was accessed via the China Industrial Statistics Yearbook. Additionally, the greenwashing measurement construction that required ESG performance and rating indicators are taken separately from Bloomberg's ESG Database and Huazheng's ESG Rating Database ([Zhang, 2022](#); [Zhang, 2023](#)). Notably, other ST and financial firms are excluded from our samples.

### 3.3 Summary statistics

[Table 1](#) displays the summary statistics of the main indicators of this paper. In the second column, the mean value of greenwashing is shown to be -0.002. This value is less than zero, which indicates that the firm does have greenwashing behavior, but the overall degree of greenwashing is low. In addition to greenwashing, the mean values of environmental decentralization and fiscal decentralization are 1.109 and 6.636, respectively. Under the general background of China's political system, a complete fiscal incentive mechanism has been created, but there is a lack of an effective environmental incentive

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mechanism. Because of the assessment goal of GDP, local governments are more inclined to pursue economic performance rather than environmental performance, which causes a "race to the bottom" effect. Therefore, the level of environmental decentralization is low, while the level of fiscal decentralization is high.

[Insert Table 1 Here]

Figure 1 illustrates greenwashing performance and environmental decentralization trends. It shows that the level of environmental decentralization, on average, remains relatively stable and does not obviously change between 2010 and 2021. The data quality is high and the series is stationary. Contrary to this, before the policy shock, the greenwashing values are greater than zero between 2010 and 2014. After the policy shock, though, there is an overall, downward trend. As a preliminary proof of this paper's hypothesis, the environment quality monitoring authority retraction is demonstrated to be capable of inhibiting firms' greenwashing behaviors.

[Insert Figure 1 Here]

## 4. Empirical results discussion

### 4.1. Baseline regression

Table 2 reports our baseline regression results. Column 1 is the result following Eq. (1) without incorporating control variables. The results of introducing the firm-level and industry-level control variables into the estimations are shown in columns 2-3. The coefficient focused on for this study is  $\beta_1$ , which can capture the effect of environmental monitoring centralization on firms' greenwashing behaviors under the Chinese environmental decentralization system. Table 2 makes clear that with the increasing environmental decentralization level, environmental monitoring centralization has a significant and negative association with a firm's greenwashing behavior (at the 5% significant level in column 1 and the 10% significant level in column 3). Therefore, the baseline regression results indicate that the policy of environmental monitoring centralization can inhibit greenwashing behaviors. If the level of environmental decentralization is higher, the degree of inhibition is stronger. Hypothesis 1 is valid and the conclusion is supported.

In quantitative terms, if the result from Column (3) is taken as a reference, the estimates from Eq. (1) indicate that for every 1 % increase in environmental monitoring decentralization, a firm on average decreases its greenwashing behavior by 2.6%. As a result, the direction and magnitude of all the main regressions fit Hypothesis 1.

Existing literature only focuses on the relationship between environmental decentralization and firms' greenwashing behavior, ignoring the effects of policy shock under environmental federalism. The results of this paper's study further indicate that policy shock influences firms' greenwashing behaviors by shifting the effect towards local governments' environmental governance, which has a higher degree of inhibition on firms' greenwashing behaviors under the environmental decentralization system than under the centralized system. Environmental monitoring centralization is conducive to building a vertical

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governmentalization system leading from central government to local governments, and it also helps the central government supervise the green behavior of firms and their pollution levels. This proves that policy shock is effective at improving the environmental governance system and the environmental monitoring function of government at all levels.

[Insert Table 2 Here]

**4.2. Heterogeneous effects analysis**

Development in China, including ownership, culture and institution, is spatially unbalanced, such differences might cause a heterogeneous impact on local firms' responses to environmental monitoring decentralization. Therefore, we introduce a series of estimations to check whether our baseline regression results keep consistent across different groups of heterogeneities.

**4.2.1 Heterogeneous effects on ownership**

Ownership has a significant effect on firms' behavior because SOEs have strong political connections, which often result in lower financial costs and political subsidies. Because of this, SOEs are less likely to greenwash than non-SOEs facing financial constraints and high financial costs. As a result, it is widely agreed that SOEs are generally less financially constrained and demonstrate more corporate social responsibility than privately-owned firms. As for environmental decentralization, which is recognized as a distribution of environmental regulation rights between the local governments and the central authority (Fredriksson and Millimet, 2002), local officials might control more risks and care more about political connections. Therefore, SOEs might gain more financial resources through better environmental performances than privately-owned firms would. This would mean that environmental monitoring centralization might play a significant role in preventing privately-owned firms' greenwashing.

Table 3 contains the estimations between SOEs and privately-owned firms when evaluated for the policy shock effects caused by environmental decentralization. This paper's findings show that the policy shock does not significantly affect SOEs' greenwashing behaviors (columns 1-2), but it does significantly curb privately-owned firms' greenwashing behavior with a certain environmental decentralization level at the 5% significant level (column 4).

[Insert Table 3 Here]

**4.2.2 Heterogeneous effects on industries**

Firm behavior in responding to environmental regulations performs very similarly across different industries. Because a large number of compliance costs are emerging from stricter environmental regulations, firms will improve their production processes and the management system they use to reduce pollution, and they will also improve green TFP (Berman and Bui, 2001; Peuckert, 2014). As polluting firms are highly invested in pollution reduction projects and green innovation activities. Additionally, due to the stringent environmental regulations, high-polluting firms are more likely to be withdrawn from the market and are, therefore, more likely to greenwash. Polluting firms might do much less to curb

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greenwashing behaviors following the implementation of environmental monitoring centralization, too.

Table 4 shows the regression results found by dividing our samples into high-polluting and low-polluting firms. The estimations for high-polluting firms are in columns 1-2, and the estimations for low-polluting firms are in columns 3-4. This detailed information shows that both these types of firms are curbed to greenwash, while high-polluting firms in particular decrease their greenwashing behaviors with a smaller marginal effect brought on by policy decentralization.

[Insert Table 4 Here]

4.2.3 Heterogeneous effects on high-technology levels

This paper further explores whether technology might impact the relationship between the implementation of environmental monitoring centralization and greenwashing behaviors. It is well known that technological progress can greatly help pollution reduction, and that pollution abatement technologies involving cleaner factors or processes decrease pollution intensity and improve sustainable production (Sun et al., 2021).

In this context, this paper proves that high-tech firms’ greenwashing behaviors can also be decreasingly affected by environmental monitoring centralization. Table 5 presents the estimated coefficients of DID effects, which are negatively significant at 10% and 5% in the high-technology (columns 1-2) and low-technology groups (columns 3-4). Additionally, the DID estimated coefficient of high-tech firms is  $-0.040$ , but  $-0.036$  for non-high-tech firms, indicating that the curbing of the greenwashing effect is stronger for high-tech firms.

[Insert Table 5 Here]

4.3 Regulation strength mechanism explorations

To provide a clear picture of the mechanisms that affect how the implementation of environmental monitoring centralization can significantly curb firms’ greenwashing behaviors accompanied by the environmental decentralization level, this paper discusses external mechanism-regulation strength in order to show the transfer paths.

It is agreed that strong environmental regulation can improve sustainable performance and curb greenwashing behaviors (Zhang, 2022). Therefore, this paper tries to bridge the link between environmental regulation strength and greenwashing to uncover how the implementation of environmental monitoring centralization can significantly curb firms’ greenwashing behaviors.

Table 6 shows the two-step estimation results. An important thing to note is that the implementation of environmental monitoring centralization has a positive and significant role in strengthening the environmental regulation level (columns 1-2), which illustrates that policy shock makes firms highly regulate themselves. Table 6 also shows that the environmental regulation level significantly decreases greenwashing behaviors (columns 3-4). These findings support the environmental regulation

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strength clue and clearly explain how firms curb their greenwashing behaviors to cope with the implementation of the environmental monitoring centralization policy.

Furthermore, this paper evaluates the marginal effects of environmental regulation strength on greenwashing drawn by policy shock, and the results consistently support the findings that the performance of high-environmental regulated firms face a significant and negative impact (column 5), but that this is not the case for low-environmental regulated firms (column 6).

[Insert Table 6 Here]

**5. Robustness tests**

A wide-ranging set of robustness tests were performed to validate this paper’s results and findings. The Placebo test was introduced, and this paper’s study considered other potential policy shock effects in its regressions. To make the paper’s results more reliable, the results were validated with alternative variables of greenwashing. Lastly, the potential endogeneity problem was considered, and 2SLS with an instrument variable was employed to identify the paper’s findings.

**5.1 Robustness test: Placebo test**

It was necessary to check whether there are potential trend effects for group-specific before implementation of the policy, or else, this paper’s estimation results might be false. Following [Bell et al. \(1999\)](#), the potential for pretreatment trend effects was determined through two tests. First, the fact that the policy happens one year ahead was preserved. A dummy variable taking a value of 1 after 2014, or 0 otherwise, was defined. By introducing the preserved DID effect into Eq.(1), and this paper’s estimation results are presented in columns 1-2 of Table 7. The estimations show that the preserved DID effects are insignificant, while the DID effects are negatively associated with greenwashing as they were previously. These findings demonstrate that the greenwashing behaviors are eventually curbed by the implementation of environmental monitoring centralization.

[Insert Table 7 Here]

Apart from the implementation of the environmental monitoring centralization policy, other policies might have also misled this paper’s estimation results, such as the carbon emission trading policy issued in 2013. Because the dynamic effects of the carbon emission trading policy could have contributed to firms’ greenwashing behaviors, this paper further considered whether the joint effects of the emission trading policy and environmental centralization can ease firms’ greenwashing behaviors. This was done by including a new dummy variable that took a value of 1 after 2013, or 0 otherwise. The coefficients of the interaction between the environmental centralization and the dummy variables are insignificantly different from 0, and the DID effects are significant during the pretreatment period (columns 3-4). The two preserved issues were then considered with the estimation model, and the findings are consistent with our basic results (columns 5-6).

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### 5.2 Robustness test: Alternatives of ESG measurement

To show that this paper’s results have nothing to do with the measurement of greenwashing, the ESG disclosure score and the third-party rating ESG score were used to objectively measure self-disclosure motivation and real ESG performance. [Table 8](#) shows the estimation results that were found by using these alternative measurements to indirectly evaluate greenwashing behaviors.

The estimation coefficients of the environmental decentralization and post-dummy are all negative and significant for self-disclosure motivations (columns 1-3). However, the interactors of the environmental decentralization and post-dummy are all insignificant for the third-party rating ESG score (columns 4-6). The paper’s findings indicate that the implementation of the environmental monitoring centralization policy causes stress for firms when it comes to truthfully reporting their ESG performance and curbing their greenwashing behaviors.

[\[Insert Table 8 Here\]](#)

### 5.3 Robustness test: Endogeneity problems by instrument variable method

The potential endogeneity problem caused by the reverse causalities, such as the worse environmental performance firms intensive regions might be strengthened and better regulated by the environmental monitoring centralization policy, might present a biased estimation of the policy effect on greenwashing behaviors. To prevent this, 2SLS with an instrument variable design was introduced to solve the endogeneity problem to make this paper’s findings reliable. Following [Chen et al. \(2022\)](#), the original straight-line distance between the firm’s location and the Supervision Centers for Environmental Protection (SCEPs) was recorded. The logarithm of distance was then taken as our instrument variable (the distance data is extracted from the AutoNavi Map API). There are two reasons why it is reasonable to use distance as an effective instrument variable. Firstly, the SCEPs are closely related to environmental decentralization, as the supervision centers’ settings are direct and basement for environmental decentralization. Secondly, the SECPs have been set since 2001, which is a historical event and cannot affect the current firm behaviors. In addition, the SECPs setting is a kind of central government behavior, while the distance is a geographical factor, which meets the exogenous condition as well. The empirical findings are presented in [Table 9](#). Columns 1-2 and 4-5 show the first stage where the instrument variable distance was regressed with environmental decentralization. The coefficients of the instrument variable and interactors of the post and instrument variable were both shown to be positive and significant at the 1% significant level, which demonstrates that there is a significant direct relationship between distance and environmental decentralization. It was also found through the second stage that used distance as an instrument to estimate the basic regressions that the DID effects are negative and significant as well (columns 3 and 6), which is consistent with this paper’s basic findings.

[\[Insert Table 9 Here\]](#)

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## 6. Conclusions and policy implications

### 6.1 The main research conclusions

The vital issue to be solved in environmental federalism theory is how to optimize the vertical environmental supervision structure. Because it is not only the degree of supervision firms face and what decisions they make on sustainable growth that matter, but also addresses the implementation of vertical government regulation motivation and working mechanism. Abundant empirical evidence has shown the impact environmental decentralization has on pollution reduction and firm performance. However, it remains unclear how environmental centralization impacts firms' behaviors. In response to this research question, and to help bridge the research gap, this paper employs a continuous difference-in-difference (DID) estimation method to evaluate the effects China's centralization of environmental monitoring has had on firms' green behavior. To explore whether greenwashing behaviors can or cannot be inhibited by environmental monitoring centralization, the paper uses an unbalanced panel dataset of Chinese-listed firms spanning 2010 to 2019. This data contained detailed information such as fundamental firm-level characteristics, ESG disclosure and rating data, and industry-level controls. Accordingly, some important empirical findings are shown here.

Firstly, environmental monitoring centralization can significantly inhibit firms' greenwashing behaviors with the condition of environmental decentralization. Secondly, when the heterogeneous effects of different companies (in terms of ownership and industry type) are considered, the results of the heterogeneous effects test show that privately-owned, high-polluting and high-tech-intensive firms are strongly induced to inhibit greenwashing behaviors when faced with an increasing environmental decentralization level caused by the centralization of environmental monitoring policy. Thirdly, this paper demonstrates that the centralization of environmental monitoring policy shock inhibits greenwashing behaviors by strengthening environmental regulation levels. Lastly, this paper excludes other policy shock effects and solves the potential endogeneity problems, making its results valid.

### 6.2 Policy implications and recommendations

Environmental monitoring is the basis for achieving green development and inhibiting firms' greenwashing behaviors. In reality, though, the division of environmental monitoring authority among governments, firms, and society is not clear enough, and there are phenomena such as administrative interference in monitoring data and inadequate implementation of responsibilities that have a negative impact on the objective evaluation of environmental performance along with other factors. This paper puts forward the following policy recommendations, based on its findings and conclusions.

First off, in the context of China's environmental system reform, the government should create a well-designed vertical governmentalization system extending from the central government to local governments, which helps stimulate green production and good, sustainable growth models. The specific measures recommended are as follows: the central government should appropriately take back the authority for monitoring ecological environment quality in order to eliminate administrative intervention and accurately grasp and objectively evaluate the overall situation of the firms' green behaviors and

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environmental quality. Meanwhile, some local administrative departments may interfere with environmental quality monitoring data due to assessment pressures, which may affect the authenticity and accuracy of firms' environmental data. The centralization of environmental monitoring will help prevent individual, local governments from falsifying monitoring data through administrative interference, ensuring the authenticity and objectivity of this data and also enhancing the scientific reliability and authority of monitoring data. At the same time, the central government should also clarify the environmental rights and responsibilities of different departments that are required to achieve consistency in environmental monitoring and expenditure responsibilities at all government levels. Governments should strengthen the accountability mechanism, too, and improve the monitoring and evaluation system of ecological quality and firms' environmental behaviors, which will help ensure that the policies and measures are put into practice and will eventually make the whole environmental monitoring system more effective.

Secondly, when governments formulate environmental regulation policies, they should focus on the heterogeneous effects of firms within an appropriate range, monitoring pollution emissions and curbing corporate greenwash. The environmental protection department mainly supervises privately-owned, high-polluting and high-tech-intensive firms, monitoring their pollution emissions in order to inhibit greenwashing behaviors.

Thirdly, this paper's research findings show that the centralization policy of environmental monitoring mainly affects firms' greenwashing behaviors by enhancing environmental regulations. Therefore, the central government and local governments should open up this channel, improve relevant environmental laws and regulations, and enhance environmental supervision and governance effectiveness. A well-designed government system can monitor the environmental regulation policy works efficiently. It can effectively fill this gap and will reach the environmental regulation targets of China, ultimately achieving a win-win situation of environmental performance and economic development.

Lastly, the central and local governments can work together to build a big data platform to proclaim the environmental monitoring information, interconnect and share various monitoring data systems, and provide strong support to further promote environmental system construction. Environmental protection departments at all levels should also actively undertake firms' environmental quality monitoring, environmental law enforcement monitoring, environmental early warning and other functions. Through big data and modern technology, environmental protection departments can strengthen their inspections and seriously investigate intentional violations of environmental monitoring or tampering with and falsifying monitoring data.

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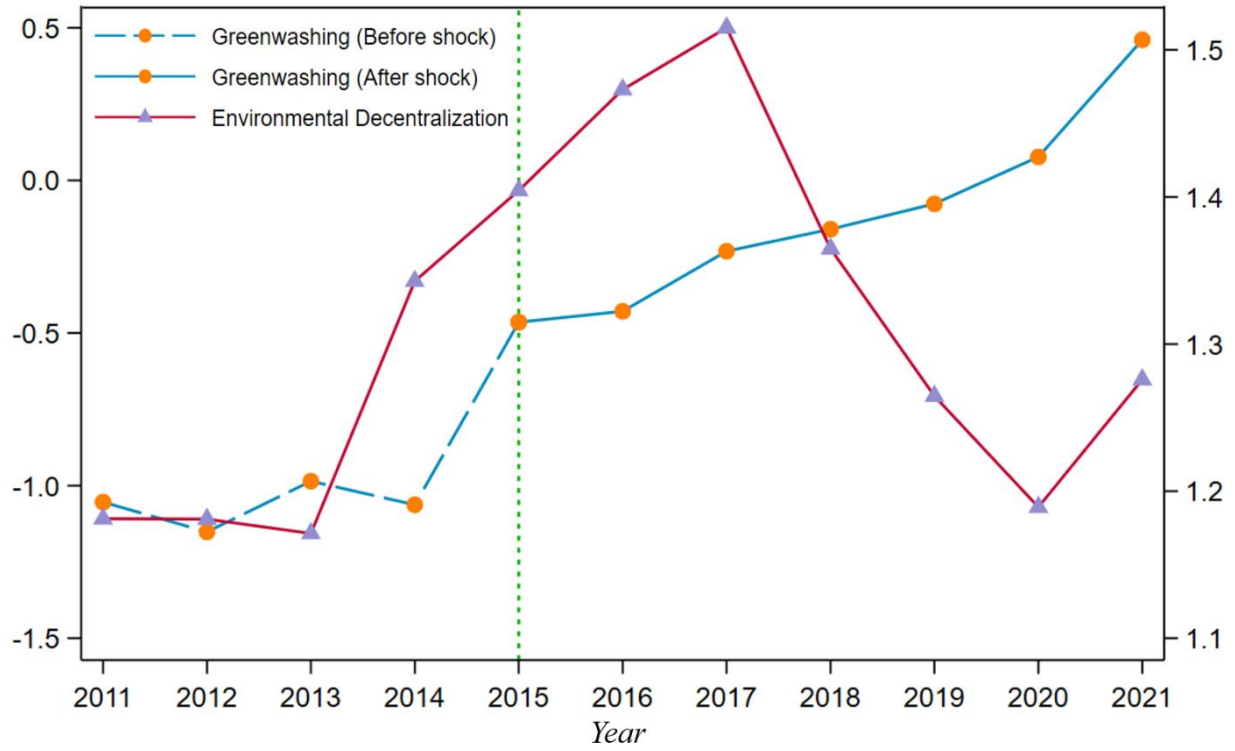
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Figure 1. The environmental decentralization and greenwashing level



**Table 1.** Summary statistics

| Variables       | (1)   | (2)    | (3)       | (4)    | (5)    |
|-----------------|-------|--------|-----------|--------|--------|
|                 | Obs   | Mean   | Std. Dev. | Min    | Max    |
| GW              | 12024 | -0.383 | 1.133     | -3.305 | 4.358  |
| Post*ED         | 12024 | 0.814  | 1.032     | 0.000  | 5.425  |
| ED              | 12024 | 1.312  | 0.987     | 0.378  | 5.503  |
| Post            | 12024 | 0.608  | 0.488     | 0.000  | 1.000  |
| Leverage        | 11002 | 0.475  | 0.201     | 0.031  | 0.925  |
| ROA             | 11002 | 0.050  | 0.065     | -0.398 | 0.254  |
| Independence    | 11002 | 0.376  | 0.055     | 0.286  | 0.600  |
| Inventory       | 10936 | 0.151  | 0.148     | 0.000  | 0.772  |
| Tobin's Q       | 10838 | 1.990  | 1.455     | 0.802  | 17.729 |
| Age             | 11002 | 2.922  | 0.342     | 1.386  | 3.611  |
| Size            | 11002 | 23.176 | 1.287     | 19.551 | 26.430 |
| SOE dummy       | 12024 | 0.491  | 0.500     | 0.000  | 1.000  |
| Pollution dummy | 11880 | 0.693  | 0.461     | 0.000  | 1.000  |
| High-tech dummy | 12024 | 0.323  | 0.468     | 0.000  | 1.000  |
| Regulation      | 10671 | 1.249  | 0.654     | 0.052  | 3.716  |

Notes: Table 1 presents the statistics information of the main variables used in this paper, and we provide the observation numbers, mean, standard deviation, and minimum and maximum values.

**Table 2.** Baseline regression results

| Variables                | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  | (7)                  | (8)                  |
|--------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                          | GW                   | GW                   | GW                   | GW                   | GW                   | GW                   | GW                   | GW                   |
| Post_ED                  | -0.117***<br>(0.000) | -0.129***<br>(0.000) | -0.129***<br>(0.000) | -0.130***<br>(0.000) | -0.130***<br>(0.000) | -0.129***<br>(0.000) | -0.133***<br>(0.000) | -0.133***<br>(0.000) |
| ED                       | 0.005<br>(0.856)     | 0.017<br>(0.584)     | 0.017<br>(0.579)     | 0.018<br>(0.569)     | 0.017<br>(0.574)     | 0.018<br>(0.563)     | 0.020<br>(0.526)     | 0.020<br>(0.527)     |
| Age                      |                      | 0.307*<br>(0.076)    | 0.311*<br>(0.076)    | 0.313*<br>(0.074)    | 0.313*<br>(0.074)    | 0.301*<br>(0.087)    | 0.293*<br>(0.096)    | 0.293*<br>(0.098)    |
| Lev                      |                      |                      | -0.017<br>(0.876)    | -0.037<br>(0.750)    | -0.034<br>(0.770)    | -0.063<br>(0.599)    | -0.055<br>(0.656)    | -0.058<br>(0.661)    |
| ROA                      |                      |                      |                      | -0.120<br>(0.623)    | -0.119<br>(0.626)    | -0.205<br>(0.402)    | -0.154<br>(0.540)    | -0.157<br>(0.541)    |
| Indep                    |                      |                      |                      |                      | 0.240<br>(0.426)     | 0.259<br>(0.390)     | 0.328<br>(0.285)     | 0.328<br>(0.284)     |
| INV                      |                      |                      |                      |                      |                      | 0.240<br>(0.226)     | 0.254<br>(0.215)     | 0.254<br>(0.214)     |
| TobinQ                   |                      |                      |                      |                      |                      |                      | -0.004<br>(0.769)    | -0.003<br>(0.781)    |
| Size                     |                      |                      |                      |                      |                      |                      |                      | 0.002<br>(0.950)     |
| cons                     | -0.295***<br>(0.000) | -1.208**<br>(0.017)  | -1.212**<br>(0.017)  | -1.202**<br>(0.018)  | -1.295**<br>(0.013)  | -1.288**<br>(0.014)  | -1.292**<br>(0.014)  | -1.333<br>(0.113)    |
| Time fixed effect        | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Individual fixed effects | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| N                        | 12000                | 10969                | 10969                | 10969                | 10969                | 10900                | 10735                | 10735                |
| R <sup>2</sup>           | 0.297                | 0.303                | 0.303                | 0.303                | 0.303                | 0.304                | 0.307                | 0.307                |

*Notes:* Table 2 presents the causal effect of policy shock on greenwashing behaviors. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

**Table 3.** Heterogeneous effects analysis: ownership

| Variables                | State-owned         |                      | Private-owned        |                      |
|--------------------------|---------------------|----------------------|----------------------|----------------------|
|                          | (1)                 | (2)                  | (3)                  | (4)                  |
| Post*ED                  | -0.075**<br>(0.049) | -0.065*<br>(0.066)   | -0.158***<br>(0.000) | -0.136***<br>(0.000) |
| ED                       | 0.015<br>(0.781)    | -0.010<br>(0.841)    | 0.021<br>(0.584)     | 0.012<br>(0.746)     |
| Constant                 | 0.247<br>(0.827)    | -0.251***<br>(0.000) | -2.516*<br>(0.054)   | -0.350***<br>(0.000) |
| Controls                 | Yes                 | No                   | Yes                  | No                   |
| Time fixed effect        | Yes                 | Yes                  | Yes                  | Yes                  |
| Individual fixed effects | Yes                 | Yes                  | Yes                  | Yes                  |
| Obs                      | 5373                | 5891                 | 5362                 | 6109                 |
| R-squared                | 0.325               | 0.316                | 0.285                | 0.275                |

*Notes:* Table 3 presents the heterogeneous effects of ownership on the causal effect of policy shock on greenwashing behaviors. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

**Table 4.** Heterogeneous effects analysis: type of pollution

| Variables                | heavy pollution      |                      | non-heavy pollution  |                      |
|--------------------------|----------------------|----------------------|----------------------|----------------------|
|                          | (1)                  | (2)                  | (3)                  | (4)                  |
| Post*ED                  | -0.149***<br>(0.000) | -0.147***<br>(0.000) | -0.135***<br>(0.000) | -0.110***<br>(0.000) |
| ED                       | -0.004<br>(0.943)    | -0.010<br>(0.849)    | 0.034<br>(0.379)     | 0.015<br>(0.684)     |
| Constant                 | 0.651<br>(0.735)     | -0.288***<br>(0.000) | -2.092**<br>(0.035)  | -0.295***<br>(0.000) |
| Controls                 | Yes                  | No                   | Yes                  | No                   |
| Time fixed effect        | Yes                  | Yes                  | Yes                  | Yes                  |
| Individual fixed effects | Yes                  | Yes                  | Yes                  | Yes                  |
| Obs                      | 3483                 | 3624                 | 7216                 | 8195                 |
| R-squared                | 0.323                | 0.315                | 0.305                | 0.296                |

*Notes:* Table 4 presents the heterogeneous effects of industry types on the causal effect of policy shock on greenwashing behaviors. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

| <b>Table 5. Heterogeneous effects analysis: type of technology</b> |                       |                      |                           |                      |
|--------------------------------------------------------------------|-----------------------|----------------------|---------------------------|----------------------|
| Variables                                                          | high-tech enterprises |                      | non-high-tech enterprises |                      |
|                                                                    | (1)                   | (2)                  | (3)                       | (4)                  |
| Post*ED                                                            | -0.177***<br>(0.000)  | -0.169***<br>(0.000) | -0.123***<br>(0.000)      | -0.104***<br>(0.000) |
| ED                                                                 | 0.153***<br>(0.008)   | 0.141**<br>(0.014)   | -0.031<br>(0.406)         | -0.037<br>(0.268)    |
| Constant                                                           | -1.828<br>(0.201)     | -0.397***<br>(0.000) | -1.271<br>(0.238)         | -0.259***<br>(0.000) |
| Controls                                                           | Yes                   | No                   | Yes                       | No                   |
| Time fixed effect                                                  | Yes                   | Yes                  | Yes                       | Yes                  |
| Individual fixed effects                                           | Yes                   | Yes                  | Yes                       | Yes                  |
| Obs                                                                | 3765                  | 3873                 | 6970                      | 8127                 |
| R-squared                                                          | 0.317                 | 0.312                | 0.305                     | 0.292                |

*Notes:* Table 5 presents the heterogeneous effects of technology on the causal effect of policy shock on greenwashing behaviors. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

**Table 6.** Mechanism test: environmental regulation

| Variables    | (1)                  | (2)                  | (3)                  | (4)                  | (5)                          | (6)                         |
|--------------|----------------------|----------------------|----------------------|----------------------|------------------------------|-----------------------------|
|              | regulation           | regulation           | Greenwash            | Greenwash            | Greenwash<br>Regulation high | Greenwash<br>Regulation low |
| Post*ED      | 0.068***<br>(0.000)  | 0.067***<br>(0.000)  | -0.128***<br>(0.000) | -0.114***<br>(0.000) | -0.176***<br>(0.000)         | -0.074<br>(0.434)           |
| ED           | -0.063***<br>(0.000) | -0.055***<br>(0.000) | 0.012<br>(0.719)     | 0.017<br>(0.628)     | 0.055<br>(0.326)             | 0.107<br>(0.353)            |
| regulation   |                      |                      | -0.131***<br>(0.000) | -0.135***<br>(0.000) |                              |                             |
| Constant     | 0.683*<br>(0.052)    | 1.272***<br>(0.000)  | -0.585<br>(0.530)    | -0.232***<br>(0.000) | -1.533<br>(0.468)            | -1.048<br>(0.541)           |
| Controls     | No                   | Yes                  | No                   | Yes                  | Yes                          | Yes                         |
| fixed effect | Yes                  | Yes                  | Yes                  | Yes                  | Yes                          | Yes                         |
| Obs          | 9517                 | 10620                | 9517                 | 10620                | 2163                         | 3034                        |
| R-squared    | 0.744                | 0.740                | 0.287                | 0.276                | 0.408                        | 0.382                       |

*Notes:* Table 6 presents the mechanism exploration of environmental regulation on the causal effect of policy shock on greenwashing behaviors. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

**Table 7. Placebo test**

| Variables                | (1)                | (2)                 | (3)                | (4)                 | (5)                | (6)                 |
|--------------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|
| Post*ED                  | -0.026*<br>(0.090) | -0.037**<br>(0.012) | -0.026*<br>(0.093) | -0.036**<br>(0.015) | -0.027*<br>(0.088) | -0.037**<br>(0.012) |
| Pre(1)*ED                | -0.041<br>(0.873)  | 0.124<br>(0.663)    |                    |                     | 0.239<br>(0.488)   | 0.317<br>(0.347)    |
| Pre(2)*ED                |                    |                     | -0.280<br>(0.269)  | -0.043<br>(0.876)   | -0.477<br>(0.177)  | -0.309<br>(0.281)   |
| ED                       | 0.058<br>(0.825)   | -0.092<br>(0.750)   | 0.298<br>(0.248)   | 0.076<br>(0.786)    | 0.255<br>(0.352)   | 0.025<br>(0.935)    |
| Constant                 | 0.985<br>(0.552)   | 1.440***<br>(0.388) | 0.570<br>(0.730)   | 1.278***<br>(0.002) | 0.660<br>(0.692)   | 1.315***<br>(0.002) |
| Controls                 | Yes                | No                  | Yes                | No                  | Yes                | No                  |
| Time fixed effect        | Yes                | Yes                 | Yes                | Yes                 | Yes                | Yes                 |
| Individual fixed effects | Yes                | Yes                 | Yes                | Yes                 | Yes                | Yes                 |
| Obs                      | 12,768             | 14,230              | 12,768             | 14,230              | 12,768             | 14,230              |
| R-squared                | 0.402              | 0.413               | 0.402              | 0.413               | 0.402              | 0.413               |

*Notes:* Table 7 presents the Placebo test to provide our robustness tests. Robust standard errors are reported in parentheses;

\*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

**Table 8.** The alternative indicators of ESG

| Variables    | (1)                  | (2)                  | (3)                   | (4)                   |
|--------------|----------------------|----------------------|-----------------------|-----------------------|
|              | ESG Disclosure Score | ESG Disclosure Score | ESG Performance Score | ESG Performance Score |
| Post*ED      | -0.135***<br>(0.000) | -0.138***<br>(0.000) | 0.020<br>(0.200)      | 0.037**<br>(0.019)    |
| ED           | 0.022*<br>(0.096)    | 0.027**<br>(0.050)   | 0.023<br>(0.279)      | -0.003<br>(0.875)     |
| Constant     | 0.081***<br>(0.000)  | -4.271***<br>(0.000) | -0.047**<br>(0.039)   | -4.479***<br>(0.000)  |
| Controls     | No                   | Yes                  | No                    | Yes                   |
| fixed effect | Yes                  | Yes                  | Yes                   | Yes                   |
| Obs          | 12000                | 10735                | 11559                 | 10475                 |
| R-squared    | 0.826                | 0.829                | 0.546                 | 0.566                 |

*Notes:* Table 8 shows the alternative indicators of ESG as dependent variables analysis for robustness tests. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

**Table 9.** Instrumental variable test

| Variables                                      | (1)                                | (2)                  | (3)                  | (4)                                | (5)                  | (6)                  |
|------------------------------------------------|------------------------------------|----------------------|----------------------|------------------------------------|----------------------|----------------------|
|                                                | Post*ED                            | ED                   | Greenwash            | Post*ED                            | ED                   | Greenwash            |
| (Post*ED) <sub>IV</sub>                        |                                    |                      | -0.869***<br>(0.045) |                                    |                      | -0.863***<br>(0.032) |
| ED <sub>IV</sub>                               |                                    |                      | -0.724***<br>(0.067) |                                    |                      | -0.704***<br>(0.054) |
| Post*IV                                        | 1.122***<br>(0.037)                | -0.029<br>(0.044)    |                      | 1.406***<br>(0.036)                | -0.033<br>(0.041)    |                      |
| IV                                             | -1.052***<br>(0.038)               | -0.524***<br>(0.044) |                      | -1.264***<br>(0.041)               | -0.574***<br>(0.043) |                      |
| Constant                                       | -3.639***<br>(0.213)               | -0.572***<br>(0.214) | -1.128***<br>(0.337) | 0.933***<br>(0.014)                | 1.479***<br>(0.014)  | -0.162*<br>(0.067)   |
| Controls                                       | Yes                                | Yes                  | Yes                  | No                                 | No                   | No                   |
| Fixed effect                                   | Yes                                | Yes                  | Yes                  | Yes                                | Yes                  | Yes                  |
| weak<br>instruments<br>test [C-D<br>Wald F]    |                                    | 220.93               |                      |                                    | 289.94               |                      |
| weak<br>instruments<br>test [K-P rk<br>Wald F] |                                    | 167.95               |                      |                                    | 213.21               |                      |
| Underidentific<br>ation test<br>[Hansen J]     | 0.000(equation exactly identified) |                      |                      | 0.000(equation exactly identified) |                      |                      |
| Underidentific<br>ation test [p-<br>value]     |                                    | 398.484<br>[0.000]   |                      |                                    | 535.277<br>[0.000]   |                      |
| Obs                                            | 10,773                             | 10,773               | 10,773               | 12,024                             | 12,024               | 12,024               |
| R-squared                                      | 0.167                              | 0.068                | /                    | 0.114                              | 0.046                | /                    |

Notes: Table 9 presents the Instrumental variable test to show the robust of our causal effect. Robust standard errors are reported in parentheses; \*, \*\* and \*\*\* denotes significance at the ten, five and one percent level respectively.

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*Appendix 1: Definition and measurement of variable***Appendix 1.** Definition and Measurement of Variable

| Variables                      | Symbol       | Dimension        | Definition and Measurement                                                                                                                   |
|--------------------------------|--------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Greenwashing degree            | GW           | Firm level       | Firm's self-disclosure standardized ESG score minus rating standardized ESG score                                                            |
| Environmental decentralization | ED           | Provincial level | Local government's per capita environmental protection expenditure over central government's per capita environmental protection expenditure |
| Policy shock time              | Post         | Time series      | Post is a dummy variable that equals one if time is after 2015, or else equals zero                                                          |
| DID effect                     | Post×ED      | Provincial level | Environment decentralization multiplied by post variable                                                                                     |
| Firm age                       | Age          | Firm level       | The logarithm of firm's observation year minus establishment year                                                                            |
| Firm size                      | Size         | Firm level       | The logarithm of the firm's total assets                                                                                                     |
| Firm profitability             | Profit       | Firm level       | The firm's net profit over total assets (ROA)                                                                                                |
| Firm vitality                  | Inventory    | Firm level       | The ratio of inventory to total assets                                                                                                       |
| Growth potential               | Tobin's Q    | Firm level       | The ratio of market value to net value                                                                                                       |
| Financial leverage             | Leverage     | Firm level       | The ratio of total liabilities to total assets                                                                                               |
| Independent directors          | Independence | Firm level       | The ratio of the number of independent director seats to the total number of board seats                                                     |
| Environmental regulation       | Regulation   | Provincial level | Use the entropy method to calculate a composite index of environmental regulation based on the emissions of three wastes for each province   |

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## ***Appendix 2: The methodology to develop greenwashing***

In our study, greenwashing is the dependent variable we focus on. According to the definition of greenwashing behavior (Yu et al., 2020), firms will subjectively and selectively disclose more favorable ESG information in order to show their environmental image and over-assess their ESG score, which is not in line with the actual situation. However, the third-party rating agencies can objectively assess a firm's ESG score and reflect its actual environmental performance. If a firm's subjective disclosure of ESG performance is much higher than its actual ESG performance, then it reflects that this firm has a high degree of greenwashing. Referring to this logic, we use the difference between ESG score disclosed by firm executives and objectively assessed real ESG score to measure the greenwashing level of firms. If the gap is larger, greenwashing level is higher. The data are normalized in order to eliminate the effect of dimension. The specific steps are as follows: the specific steps are as follows: first, based on the Bloomberg ESG database, construct firms' self-assessed ESG scores and standardize them. Second, we construct firms' other-assessed ESG scores and standardize them according to the Huazheng ESG rating database. Third, we use the self-assessed ESG score to subtract the other-assessed ESG score, and use the gap to measure the degree of firms' greenwashing behaviors.

$$Greenwash_{i,t} = \left( \frac{ESG_{i,t}^{dis} - \overline{ESG_{i,t}^{dis}}}{\sigma_{dis}} \right) - \left( \frac{ESG_{i,t}^{rate} - \overline{ESG_{i,t}^{rate}}}{\sigma_{per}} \right),$$

where,  $ESG_{i,t}^{dis}$  and  $ESG_{i,t}^{rate}$  denote the firm's ESG disclosure score and real ESG performance score, respectively;  $\overline{ESG_{i,t}^{dis}}$ 、 $\overline{ESG_{i,t}^{rate}}$  and  $\sigma_{dis}$ 、 $\sigma_{per}$  represent the mean value and the standard deviation, respectively. The former represents the firm's standardized self-assessed ESG score, while the latter represents the standardized ESG score assessed by others.

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