Regional environmental supervision and corporate environmental investment: from the perspective of ecological damage compensation

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Received: 6 July 2021 / Accepted: 29 December 2021 / Published online: 6 January 2022
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Abstract
On the basis of the “Pilot System of the Ecological Damage Compensation” launched in 2015 and a research sample of listed companies in China’s heavy pollution industry from 2014 to 2017, this paper uses a difference-in-differences model to empirically evaluate the impact of the damage compensation system on corporate environmental investment, as well as the moderating effect of market degree and firm ownership. The result shows that the implementation of the damage compensation system significantly promotes corporate environmental investment and that the market degree exerts a moderating effect. The effect of supervision remains the same because of firm ownership. This research uses a pilot policy to form a natural experimental group to accurately identify the impact of environmental supervision on corporate environmental investment. The aforementioned conclusions recognize the need for the construction of the ecological damage compensation system, provide a reference for the national government to formulate specific effective environmental policies, stimulate the environmental governance motivation of regional governments, and encourage enterprises to assume environmental responsibilities and thereby achieve green sustainable development.

Keywords Ecological damage compensation system · Corporate environmental investment · Regional environmental supervision · Market degree · Firm ownership

Introduction
The global ecological environment has been severely damaged in recent years. Environmental problems continually emerge, including poor air quality; heavy metal contents in soil, which exceed the standard; and water quality deterioration. The increasingly serious ecological damage problem and public awareness of environmental protection have prompted governments to pay increased attention to environmental protection. The current focus of environmental pollution control is increasing investments in environmental protection and reducing excessive emission of pollutants from the source.

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Owing to its ability to create a large amount of material wealth for society through production and operation activities, the enterprise is a vital part of the economic structure of the country. However, enterprises inevitably adversely affect the environment, for instance, by discharging sewage and excessively consuming and using natural resources (Fabian 2015; Jin et al. 2019; Zhang et al. 2020a, b). In accordance with the “who pollutes, who controls” principle in “Environmental Protection Law,” enterprises should assume the main responsibility of environmental protection and increase environmental investment.

In the short term, the main beneficiary of corporate environmental investment is society rather than enterprises. Rational managers have difficulty using limited resources for environmental investment with low economic benefits and high uncertainty for the future (Walker et al. 2019). The apparent “altruist non-self-interest” characteristic of corporate environmental investment inevitably promotes externally solving environmental problems at the institutional constraint level.

Governments have gradually strengthened the construction of environmental laws and regulations, attached importance to the assessment of the environmental performance of local governments, needed to strictly supervise and manage environmental pollution and promoted corporate green development (Han 2020; Ge and Li 2020). However, corporate profit-based activities are conducive to promoting local economic growth and achieving the goals set by the government and the individual utility of local officials. Consequently, local governments may have insufficient incentives to regulate the environment and thus refuse to implement environmental policies that may indirectly lead to reduced fiscal revenues and relax regulations on corporate environmental pollution (Jiang et al. 2014).

The construction of the “Pilot System of the Ecological Damage Compensation” is a vital environmental protection measure and fully considers the regulatory effectiveness of local governments. This system has changed the traditional problem of “corporate pollution, government pay” and adheres to the “polluter pays” principle (Wang 2018). Under the strict supervision of the relevant departments of the state, local governments strengthen environmental supervision, and the pollution fees paid by enterprises become their fiscal revenues. Undoubtedly, this has significantly stimulated local governments to implement environmental regulations. In recent years, global environmental problems have become prominent, governments have implemented measures to protect the environment, and verifying the role of the ecological damage compensation system in environmental protection has been given importance. Developed countries such as the USA, France, and Japan typically represent countries that restore ecological environments through damage compensation. However, China, the second-largest economy worldwide, has received increased attention for its environmental behavior. Moreover, China is the largest developing country globally; thus, the effect of the damage compensation system in China may provide a reference for other developing countries.

The study of environmental governance in economics and management mainly focuses on two aspects: (i) the impact of environmental regulation on regional or industrial productivity and economic development at the macro level (e.g., Song et al. 2020a, b; Yu and Shen 2020; Zou et al. 2020; Turken et al. 2019; Knellera and Manderson 2012) and (ii) the impact of environmental regulation on corporate innovation and environmental behavior at the microlevel. (e.g., Saltari and Travaglini 2011; Gao and Zheng 2017; Jiang and Akbar 2018; Song et al. 2019). These studies have yielded fruitful research results.

However, few studies discuss macro-governance policies, local government behavior, and microenterprise-level factors in one scenario. Notably, strengthening corporate environmental investment is an important measure to prevent and control environmental pollution. Although external environmental regulation is also important, it may occur because environmental regulation is not an authoritative unified measurement method, and the results of relevant literature research vary.

Thus, in this paper, we use the implementation of central environmental policy as an external biochemical tool to measure regional environmental supervision. The first research question is as follows: Does implementing the damage compensation system encourage companies to increase their investment in environmental protection? China is in a critical period of comprehensively deepening its market-oriented reform. The degree of marketization mainly reflects the institutional environment in different regions and refers to the extent to which markets play a role in resource allocation. Significant differences in market degree have been determined in different regions. These differences can affect organizational and individual behavior to a certain extent. As an investment behavior, corporate social responsibility behavior and environmental investment are also affected. Moreover, the characteristics of Chinese enterprises, such as firm ownership, cannot be ignored (Luo and Tang 2009). Thus, the second research question is as follows: Will the effect of the damage compensation system on corporate behavior vary by market degree and firm ownership?

This paper starts with the ecological damage compensation system in evaluating the effect of regional environmental supervision on corporate behavior. Referring to the practice most reported in the literature, we use the difference-in-differences model to test the impact. The three main results are as follows: (1) The implementation of the damage compensation system can effectively promote environmental investment. (2) The effect of the system is limited by
the degree of regional marketization. The scale of corporate environmental investment in high-marketization areas is significantly larger than that in low-marketization areas. (3) The “special status” of state-owned enterprises cannot be the “umbrella” of environmental damage, and firm ownership shows no significant moderating effect.

This study has several notable contributions to the literature. First, with regard to the research method, the literature has not presented an authoritative, unified measurement of environmental regulation. The formation of a natural experimental group by using the pilot policy can largely alleviate the endogenous problems. It cannot only identify the effect of environmental regulations on environmental investment but also accurately evaluate the governance effect of policy implementation and expand the existing research. Second, from the perspective of research, the literature mainly examines the impact of environmental regulation on industrial structure and technological innovation. This paper considers the perspective of the main body of policy implementation and local government and evaluates the effectiveness of environmental protection policy at the microlevel, providing evidence for existing environmental regulation research. Third, the literature does not consider the impact of the external institutional environment on the effectiveness of policy governance. This paper considers market degree, regional environmental supervision, and corporate environmental investment in one scenario. This paper also provides a basis for the central government to formulate targeted environmental policies, encourage local governments to strengthen environmental supervision, and motivate enterprises to strengthen their environmental protection behavior.

The remainder of the paper is organized as follows. The following section introduces the research hypothesis, theoretical analysis, and literature review. The third section explains the methodology, namely, the variable settings, sample selection, data source, and model design. The fourth section presents the empirical results and analysis and discusses the conduct of an additional robustness test and an endogenous test. The fifth section presents the mechanism analysis. The last section concludes the paper.

**Theoretical background and hypothesis development**

**Institutional background**

2015 was a year when China was confronted with numerous environmental problems. In the same year, major events such as “the Tianjin bombing” and “the launch of two rounds of red alerts for heavy pollution in Beijing” aroused high social concern about environmental issues. On December 3, 2015, the General Office of the CPC Central Committee and the State Council issued the “Pilot System of the Ecological Damage Compensation,” which was implemented in seven provinces and cities: Jiangsu, Shandong, Hunan, Chongqing, Jilin, Yunnan, and Guizhou.

The implementation of the damage compensation system significantly affects environmental supervision in pilot areas mainly because of the following characteristics:

(1) Local governments have the motivation to fully implement a damage compensation system and effectively strengthen environmental supervision. With the authorization of the State Council, the pilot local government shall become the claimant person of ecological environment damage compensation within the administrative area and consult with the compensation obliger on specific issues such as damage repair and liability, and the compensation expenses shall become the fiscal revenue of the local government.

(2) Strict external governance promotes local governments to take measures for environmental supervision. The system requires that information such as ecological environment damage assessment, compensation, and repair effect report should be disclosed to the public to protect the public’s right to know. At the same time, local governments should implement their responsibilities and report to the State Council at the end of August annually on the progress of the pilot work. The Ministry of Environmental Protection, in cooperation with the relevant departments, is expected to a comprehensive assessment of their work.

In general, the characteristics of the “compensation income + external governance” system have encouraged local governments to strengthen regional environmental supervision.

To further implement the ecological environment management plan, the 38th meeting of the Central Leading Group for Comprehensive Deepening Reform held on August 29, 2017, adopted the “Programme for the Reform of the Compensation System for Ecological and Environmental Damage” and began to implement the ecological environment damage compensation system nationwide. This widely pursued initiative verifies the effectiveness of the damage compensation system to a certain extent.

**Regional environmental supervision and corporate environmental investment**

Porter’s hypothesis argues that reasonable environmental regulation not only enhances technological innovation and increases the productivity and competitiveness of enterprises but also reduces the cost of compliance with environmental regulations, enhances the efficient use of
resources, and achieves a “win–win” for environmental protection and economic growth (Porter and DerLinde 1995; Berman and Bui 1998). However, enterprises are economic subjects in pursuit of maximizing benefits, and environmental investment is an external noneconomic project. Although environmental investment can help enterprises build a long-term competitive advantage, this endeavor requires a large amount of money for a long time, and achieving economic benefits in the short term is difficult (Bansal and Roth 2000; Lu et al. 2019). According to factor endowment theory, rational managers will strengthen their investments only if the investment income from environmental protection (the cost of environmental pollution) is higher than the corresponding cost of environmental investment (Gray and Deily 1996; Arouri et al. 2012). Under the condition that local governments relax environmental supervision, the cost of environmental pollution is low, and the endowment income obtained through environmental protection cannot cover the corresponding cost; thus, enterprises have insufficient enthusiasm for environmental investment.

Based on enterprises’ behavior, strong external regulation is necessary to solve the problem related to the externality of the environment. However, local governments show a pattern of competing for economic growth, and the prospects of officials are linked to local economic growth (Zhou 2007; Yao and Zhang 2013). Driven by economic and political forces, local governments have sufficient incentives to relax environmental regulation to obtain maximum growth of the gross regional product, and the effectiveness of environmental governance is difficult to guarantee. To improve the implementation and effectiveness of environmental policies, the central government of China implemented the requirement of “incentive and restraint” in the ecological civilization system, and the ecological damage compensation system fully reflects this requirement. Therefore, this paper tests whether the damage compensation system can improve regional environmental supervision and enhance corporate environmental investment.

The ecological transfer payment system provides this paper a reference and inspiration, which aims to reduce the loss caused by ecological protection through financial compensation. Liu (2015) and Qi et al. (2019) have studied sample data from 2005 to 2010 and 2003 to 2014, respectively, and found that the ecological transfer payment system can improve environmental governance. Miao and Zhao (2019) reached the same conclusion in their research on water pollution control, and the transfer payment of ecological functional areas has generally improved the ecological environment quality of the areas represented by water quality. Therefore, this paper holds that the implementation of the ecological damage compensation system can effectively increase the enthusiasm of local governments in environmental governance and strengthen regional environmental supervision.

Few studies have used environmental policy to measure environmental supervision and study the direct effect of environmental supervision on corporate environmental investment, but the study of environmental pollution penalties and corporate environmental investment provides a reference for this paper. The conclusion that there has been a significant increase in environmental investment is widely accepted when environmental penalties are sufficiently strong, but the “threshold effect” remains controversial. Leiter et al. (2010) used European manufacturing data from 1998 to 2007 and found that pollution penalties showed a significant positive correlation with environmental investment. Liao and Shi (2018) used Chinese companies as a sample and reached the same conclusion. Eyraud et al. (2013) further confirmed this correlation in 35 countries. However, Tang et al. (2013) found a “U-shaped” relationship between pollution penalties and corporate environmental investment, that is, a “threshold effect.” In summary, the positive correlation between environmental regulation and environmental investment in the literature has been extensively confirmed.

Thus, we assume that hypothesis 1 (H1) is true:

H1: The ecological damage compensation system effectively promotes corporate environmental investment.

The moderating effect of market degree

Modern enterprises implement a system of entrustment and agency, and managers have the power to make business decisions. Managerial activity is largely influenced by the external environment of the country or region (Baumol 1990; Wang and You 2012). China has accomplished remarkable achievements in its transition from a planned economy to a market economy, but reform remains a work in progress. The development of various regions still varies, as does the market degree from region to region (Cull et al. 2013).

High marketization means that the region has a high level of economic development: “market failure” has a low likelihood, the competition between enterprises is relatively fierce, the entire society is close to ideal, and the environmental awareness of the public is rising. Therefore, enterprises need to take the initiative to assume environmental responsibility and increase environmental investment under external pressure (Lu and Zhu 2018). At the same time, in high-marketization areas, products, elements, and intermediary markets are developed, and enterprises are more cautious than usual about inducing negative market reactions (Lei and Maskus 2008). To achieve long-term development, enterprises expand the environmental responsibility assumed and increase environmental investment to enhance...
their corporate image. In some low-marketization areas, narrow local protectionism heavily interferes with normal environmental governance (Li et al. 2008). Some regional governments only pay considerable attention to short-term economic interests and still cooperate with polluting enterprises. Governments do not enforce the law when environmental regulations are violated by enterprises (Zhou 2009), which then avoid environmental responsibility and ignore environmental investment.

The improvement of the market degree means a reduction in government intervention. High marketization is suggestive of a good institutional environment and a competitive market environment, which can transform resources from low efficiency to high efficiency. Resource allocation efficiency maximizes in accordance with market rules (Sun et al. 2014). Companies that negatively respond to environmental responsibility tend to receive fewer resources and are thus burdened with greater costs. After implementing the ecological damage compensation system, local governments are entitled to a compensatory payment. They become willing to strengthen environmental supervision for ecological protection and economic development. At this time, local governments assist with flexible market tools, such as pollution fees and environmental taxes, in addition to common methods of administrative punishment; consequently, enterprises are compelled to increase environmental investment. In accordance with the deterrence theory, Wang et al. (2020) concluded that extending environmental supervision or imposing punishment for target enterprises can promote the environmental investment of peer enterprises. In high-marketization areas, peer companies respond more quickly. The target enterprises—while bearing rising production, costs, and reputation costs—are punished by the government. The optimal response of peer enterprises is to increase environmental investment and transfer part of the production and operation investment to expand environmental investment.

Therefore, this paper presents the following hypothesis:

H2a: Compared with enterprises in low-marketization areas, enterprises in high-marketization areas have a higher level of environmental investment.

H2b: After the implementation of the ecological damage compensation system, the increase in corporate environmental investment is significantly higher in high-marketization areas than low-marketization areas.

The moderating effect of firm ownership

The influence of the macrosystem environment on the behavior of enterprises is often influenced by the nature of the enterprises, and firm ownership characterizes the institutional basis of Chinese enterprises. Studies have found significant differences in investment behavior between state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs) (Li et al. 2015; Zhang 2016). A lack of consistency in social responsibility is also observed (Wei et al. 2017). Environmental investment is an integral part of corporate investment decisions and significantly reflects environmental responsibility (Chang and Hu 2011).

In China, SOEs dominate the national economy. Often, the government extensively intervenes in SOEs to maximize protection for the entire society (Lin and Li 2004). Financial institutions are also more willing to provide policy-based credit to SOEs, easing financing constraints on SOEs in contrast to non-SOEs, which are confronted with serious credit discrimination. Accordingly, SOEs under government intervention inevitably broaden the environmental responsibilities they assume and increase their environmental investment (Tang et al. 2013).

In the context of increasingly serious environmental problems, the central government vigorously promotes green development at present. After the implementation of the ecological damage compensation system, local governments are entitled to a full incentive to strengthen environmental supervision. Enterprise behavior is influenced by external institutional pressures. When enterprise environmental behavior fails to meet societal expectations or policy and regulation standards, its legitimacy is challenged (Suchman 1995; Zeng et al. 2020). Although China has greatly reduced the proportion of the state-owned system in the national economy, the role of the government in resource allocation cannot be ignored. All organizations need to acquire resources from the external environment (Mahoney and Pandian 1992; Lo et al. 2012). The government controls SOEs; SOEs often reflect the will of the government and act as the “image spokesman” for the government; thus, they need to bear more of the policy and social burden (Jin et al. 2019). Under the context of strengthening environmental supervision, SOEs respond to environmental problems more actively and rapidly and seriously consider the environment in decision-making. This paper presents the following hypothesis:

H3a: Compared with non-SOEs, SOEs have a higher level of environmental investment.

H3b: After the implementation of the ecological damage compensation system, the increase in corporate environmental investment of SOEs is significantly higher than that of non-SOEs.

Methodology

Variables

Regional environmental supervision No unified measurement method for regional environmental supervision
is available. Some scholars have measured it by sewage charges, investment in regional industrial pollution control, and implementation of environmental policies (Li et al. 2014; Ren et al. 2019). This paper uses the compensation system as an exogenous measure of regional environmental supervision. Enterprises in pilot areas and after the implementation of the system take 1 and the rest take 0.

Market degree Referring to the research of Chen and Liu (2014) and Zhang and Zou (2021), this paper measures market degree by the “Total Marketization Index Score” of each province from the “China Sub-Province Marketization Index Report (2018).”

Firm Ownership Referring to the research of Wang and Hu Jun (2016) and Feng et al. (2021), if the actual controller of an enterprise is the government, the enterprise is a state-owned enterprise, and the remaining enterprises are non-SOEs. State-owned listed companies are assigned the value of 1; otherwise, the value of 0 is assigned.

Corporate environmental investment There have been studies that use environmental investment data disclosed in “corporate social responsibility reports,” “environmental responsibility reports,” and “sustainable development reports,” but the above measurement has a certain degree of subjectivity, and after an independent audit by a third party, the objectivity and reliability of the financial data can be ensured. Therefore, referring to the research of Deng et al. (2019), Xu et al. (2019), Ma and Tang (2018), using data directly related to environmental protection in the breakdown of construction projects in the annual report of listed companies, such as desulfurization projects, out-of-stock projects, sewage treatment, exhaust gases, dust removal, energy conservation, and other project and added them up to obtain the environmental investment for the current year. In order to control the impact of the difference in the size of the company, we use the total assets to standardize the corporate environmental investment.

Control variables We follow the research of Wei et al. (2017) and Jiang and Akbar (2018) to select the control variables in this paper. The specific variables selected are as follows: the size of the business (size), taking the natural logarithm of the average total assets; corporate performance (ROA), the net return on total assets; financial leverage (leverage), taking asset-liability ratio; investment opportunity (Tobin’s Q), the ratio of the market value of the enterprise to the replacement cost; operating cash flow (flow), taking the ratio of net operating cash flow to average total assets; the age of business (age), the number of years the company has been listed; the ability of enterprises to grow (growth), taking the ratio of operating income in the current year to operating income in the previous year; regional economic conditions (GDP); government subsidies (subsidy); and regional environmental pollution (waste), including regional wastewater, sulfur dioxide, and soot emissions.

In addition, Table 1 summarizes the definitions and measurement methods of all variables.

Sample and data

The compensation system was introduced on December 3, 2015, and implemented nationwide on January 1, 2018. Due to the availability of environmental data, this paper considers as the research sample the listed companies in the heavy polluting industry for 2 years before and after the implementation of the pilot program. The enterprises in the pilot area are experimental groups, and the enterprises in the non-pilot areas are the control group. The pilot areas are Jiangsu, Shandong, Hunan, Jilin, Yunnan, Guizhou, and Chongqing.

Based on the 2008 “Directory of Environmental Protection Verification Industry of Listed Companies by the Ministry of Environmental Protection of China” and the 2010 “Guidelines for Environmental Information Disclosure of Listed Companies,” this paper identifies 16 categories of industries: thermal power, steel, cement, electrolytic aluminum, coal, metallurgy, chemicals, petrochemicals, building materials, papermaking, brewing, pharmaceutical, fermentation, textile, tanning, and mining, which are heavy pollution industries. The sample is screened as follows: first, special treatment (ST) and *ST enterprises are excluded; second, enterprises with missing data are excluded, including samples that entered the market after 2014 and enterprises for which the in-building engineering accounts did not provide details. After the aforementioned screening process, 412 enterprises and 1648 observation samples were obtained, of which the experimental group contained 552 observation samples, and the control group contained 1096 observation samples. To eliminate the influence of extreme values, we performed Winsorize processing on all continuous variables at the levels of 1% and 99%.

The environmental investment data are collected by hand from the annual reports of enterprises; the marketization data are derived from the “China Sub-Province Marketization Index Report (2018);” the data on regional environmental pollution stakes are from the “China Environmental Statistics Yearbook,” and the data on the other research variables are from the “iFind database” (http://www.51ifind.com/). This paper uses Excel 2019 and Stata 14.0 for data processing.
Model

To examine the impact of regional environmental supervision on corporate environmental investment, this paper uses a difference-in-differences model. Since the parallel trend hypothesis is an important prerequisite for the use of the model (Lu and Ling 2017; Hsueh 2019), this paper compares corporate environmental investment in pilot areas (experimental groups) and non-pilot areas (control groups) before and after the compensation system (2015). As shown in Fig. 1, the trends of environmental investment in the two groups were basically the same before 2015. However, the trends began to show a significant difference after 2015. Therefore, this paper successfully addresses the parallel trend hypothesis, and the setting of the difference-in-differences model is reasonable. Figure 2 shows the impact of

| Table 1 Variable definitions and measurements |
|-----------------------------------------------|
| Variable type | Variable symbol | Variable name | Variable measurement |
| Explained variables | Invest | Investment in environmental protection | Total investment/average total assets of enterprises |
| Explaining variables | Treatment | Policy virtual variables | The number of enterprises in the pilot area is 1 |
| | Time | Time virtual variable | After the implementation of the CSEED is 1, before the implementation of 0 |
| | Treatment × time | Interactive item 1 | Interaction of policy virtual variables and time virtual variable |
| | MD | Market degree | The score of the regional market index |
| | MD × time | Interactive item 2 | Interaction of MD and time virtual variable |
| | FO | Firm ownership | SOEs take the value of 1, and non-SOEs take the value of 0 |
| | FO × time | Interactive item 3 | Interaction of FO and time virtual variable |
| Control variables | Company characteristics | Size | Size of the enterprise | Ln (total assets) |
| | ROA | Return on assets | Net profit/total assets |
| | Lev | Financial leverage | Total liabilities/total assets |
| | Tobin’s Q | Investment opportunities | Enterprise market value/asset replacement cost |
| | Flow | Operating cash flow | Net operating cash flow/average total assets |
| | Age | Age of business | Number of years the firm has been listed |
| | Growth | Ability to grow | Operating income for the year/operating income of the previous year |
| Regional characteristics | GDP | Economic situation in the province | Ln (regional GDP) |
| | Subsidy | Regional financial subsidies | Ln (regional financial subsidy) |
| | Waste 1 | Industrial wastewater emissions | Ln (regional industrial wastewater emissions in the current year) |
| | Waste 2 | Industrial sulfur dioxide emissions | Ln (regional industrial sulfur dioxide emissions in the current year) |
| | Waste 3 | Industrial soot emissions | Ln (regional industrial soot emissions in the current year) |

Fig. 1 Average CEI in the pilot and non-pilot areas
market degree on corporate environmental investment before and after the compensation system. It can be found that the level of environmental investment of both groups in the pilot areas has been improved, but the increase in the environmental investment of enterprises in the high-marketization areas was higher. The results of the examination on the impact of firm ownership on environmental investment are shown in Fig. 3. The environmental investment of SOEs also saw a greater degree of growth. The preliminary examination of the moderating effect of market degree and firm ownership cannot be rejected.

This paper employs the following difference-in-differences model:

\[
\text{Invest} = \alpha + \beta_1 \text{Treated} + \beta_2 \text{Time} + \beta_3 \text{Treated} \times \text{Time} + \beta_4 \text{Controls} + \epsilon
\]  

(1)

Invest is corporate environmental investment, which is standardized by the total assets. Treated indicates enterprises in pilot areas with the value “1” and non-pilot areas with the value “0.” Time is the implementation of the compensation system; after 2015, this variable takes the value of “1,” and before 2015, this variable takes the value of “0.” Controls represents the control variables. \(\alpha\) is the intercept term, and \(\epsilon\) is the error term.

Our primary focus is \(\beta_3\), the coefficient estimate of the interaction between Treated and Time. A positive significant \(\beta_3\) in formula (1) would be evidence supporting H1.
To explore the moderating effect of market degree and firm ownership further, the following test model is set up for the experimental group:

\[ \text{Invest} = \alpha + \beta_1 MD + \beta_2 \text{Controls} + \varepsilon \]  
\[ (2) \]

\[ \text{Invest} = \alpha + \beta_1 MD + \beta_2 \text{Time} + \beta_3 MD \times \text{Time} + \beta_4 \text{Controls} + \varepsilon \]  
\[ (3) \]

\[ \text{Invest} = \alpha + \beta_1 \text{FO} + \beta_2 \text{Controls} + \varepsilon \]  
\[ (4) \]

\[ \text{Invest} = \alpha + \beta_1 \text{FO} + \beta_2 \text{Time} + \beta_3 \text{FO} \times \text{Time} + \beta_4 \text{Controls} + \varepsilon \]  
\[ (5) \]

In formulas (2) and (3), MD is the market degree in the pilot areas. In formulas (4) and (5), FO is firm ownership, SOEs take the value of “1,” and non-SOEs take the value of “0.”

**Empirical results and analysis**

**Descriptive statistics**

Table 2 reports the descriptive statistics of the main variables. The average value of the standardized value for corporate environmental investment is 0.0021, the maximum value is 0.1567, the minimum value is as low as 0, and the level of environmental protection investment between enterprises varies greatly. The average value of Treated is 0.3350, indicating that 33.50% of the enterprises are affected by the compensation system, and enterprises in pilot areas accounted for approximately one-third of the total sample.

Table 3 provides the results of the analysis of the differences before and after the compensation system. As seen from panel A, after the implementation of the compensation system, there was no significant change in corporate environmental investment in the non-pilot areas, while investment in the pilot areas rose from 0.0005 to 0.0013. That is, the implementation of the compensation system has a significant effect on corporate environmental investment. According to panel B, the added value of the corporate environmental investment in the high-marketization areas is higher than that in the low-marketization areas by 0.0020, which means the compensation system has a larger effect on corporate environmental investment in high-marketization areas. The results of panel C also show that the increase in the environmental investment of SOEs is higher than that of non-SOEs. The above statistical analysis results support the original hypothesis.

**Hypothesis test**

**Main effect test**

Table 4 reports the basic test results of the implementation of the compensation system and environmental investment. Column (1) does not include control variables and year fixed effect, industry fixed effects, and region fixed effects; the results are not significant. After adding the control variable, the coefficient of Treated × Time in column (2) is 0.0018 and significantly positive at the 5% level. After considering the fixed effect in column (3), the significance is further improved. After the implementation of the compensation system, compared with unaffected enterprises (non-pilot
area enterprises), the level of environmental investment of enterprises in the pilot areas has been significantly improved.

The results show that regional environmental supervision has significantly increased corporate environmental investment, which is consistent with the findings of Liao and Shi (2018), Eyraud et al. (2013), and H1 has been supported. This paper holds that the implementation of the compensation system has made the pilot regional government become the right holder for the compensations for ecological damages, and the relevant information on ecological damage needs to be disclosed and reported to the State Council regularly in accordance with the law. Thus, the compensation system has a significant impact on regional environmental supervision in pilot provinces and cities. Local governments cannot only claim compensation from parties responsible for ecological damage as local governments' fiscal revenue but also fulfill the environmental regulatory requirements of the central government, which require polluting enterprises in their jurisdictions to prevent and control environmental pollution and improve the ecological environment. This paper tests the effect of the implementation of the central policy from the local government level and proves the effectiveness of the environmental policy from the main body of the environmental pollution-enterprise level.

### Moderating effect test

This paper examines the moderating effect of market degree, and the results are listed in Table 5. Column (1) shows that compared with enterprises in low-marketization areas, those in high-marketization areas have a higher level of corporate environmental investment. Under column (2), the interaction coefficient of 0.0008 is significant at 5%. That is, after the damage compensation system, market degree exerts a moderating effect on corporate environmental investment, and the increase in environmental investment is higher in high-marketization areas than low-marketization areas. Both H2a and H2b are thus verified.

When environmental supervision is strengthened, the increase of corporate environmental investment is significantly higher in high-marketization areas than low-marketization areas. This result can be explained as follows: the damage compensation system clearly stipulates that local governments can obtain compensation for environmental damage and should protect the public’s right to know about the infraction and subsequent compensation. Environmental protection departments also conduct evaluations; local officials practicing favoritism in their claims work are severely punished. Thus, the damage compensation system greatly encourages the regional government to introduce stringent regulations and interventions for enterprises. In high-marketization areas, the government can fully utilize administrative means and market tools to force enterprises to increase their investment in environmental protection. The system also more heavily affects enterprise behavior in high-marketization areas than low-marketization areas.

The results of the moderating effect of firm ownership are listed in Table 6; non-SOEs are shown to have a higher level of environmental investment. The coefficient \( FO \times Time \) was not significant, indicating that when environmental supervision was strengthened, firm ownership exerted no significant effect on corporate environmental investment; the environmental investment of SOEs was not significantly higher than that of non-SOEs. H3a and H3b are thus rejected.

The results indicate that non-SOEs have a higher level of environmental protection investment. Non-SOEs have no “innate advantages” associated with local governments. They want to achieve satisfactory performance in environmental protection to earn government support. Non-SOEs may also have a greater environmental investment to establish a positive image before creditors, customers, suppliers, and other stakeholders. Meanwhile, firm ownership has not exerted a significant moderating effect on corporate investment.

### Table 3: Difference statistics before and after the compensation system

| Panel | N | Before the policy | After the policy | Difference |
|-------|---|------------------|-----------------|------------|
| Panel A: all samples | | | | |
| Experimental group (pilot areas) | 552 | 0.0005 | 0.0018 | 0.0013 |
| Control group (non-pilot areas) | 1096 | 0.0027 | 0.0026 | −0.0001 |
| Difference-in-differences | | | | 0.0014 |
| Panel B: CEI in enterprises in pilot areas (experimental group) | | | | |
| Enterprises in High-marketization Areas | 240 | 0.0004 | 0.0029 | 0.0025 |
| Enterprises in Low-marketization Areas | 312 | 0.0005 | 0.0010 | 0.0005 |
| Difference-in-differences | | | | 0.0020 |
| Panel C: CEI in enterprises in pilot areas (experimental group) | | | | |
| SOEs | 164 | 0.0002 | 0.0020 | 0.0018 |
| Non-SOEs | 388 | 0.0006 | 0.0014 | 0.0008 |
| Difference-in-differences | | | | 0.0010 |
environmental investment for the following reasons: Both SOEs and non-SOEs need to assume the main responsibility for sustainable development. The central government of China is vigorously developing the green economy. The implementation of the damage compensation system has prompted local governments to strengthen environmental supervision and restrain enterprise environmental behavior with different types of ownership. Although SOEs are the pacesetters in the construction of national ecological civilization, they should bear greater environmental responsibility and pressure than non-SOEs. However, SOEs have also

Table 4 Main effect test

| Variable       | Invest | Invest | Invest |
|----------------|--------|--------|--------|
|                | (1)    | (2)    | (3)    |
| Treated        | −0.0022*** | −0.0027*** | −0.0026*** |
|                | (−2.84) | (−3.23) | (−3.12) |
| Time           | −0.0002  | 0.0007  | −0.0001 |
|                | (−0.79) | (0.88)  | (−0.08) |
| Treated×time   | 0.0015  | 0.0018** | 0.0018*** |
|                | (1.35)  | (2.18)  | (3.14)  |
| Size           | 0.0013*** | 0.0008**  |        |
|                | (4.36)  | (2.37)  |        |
| ROA            | −0.0031  | −0.0006 |
|                | (−1.17) | (−0.23) |
| Lev            | 0.0053*** | 0.0030 |
|                | (2.78)  | (1.54)  |
| Tobin’s Q      | −0.0003  | 0.0014 |
|                | (−0.12) | (−0.65) |
| Flow           | 0.0071*  | 0.0022 |
|                | (1.69)  | (0.51)  |
| Age            | −0.0000  | 0.0000 |
|                | (−0.14) | (0.06)  |
| Growth         | −0.0002  | −0.0001 |
|                | (−1.33) | (−0.07) |
| GDP            | −0.0027** | −0.0021* |
|                | (−2.19) | (−1.65) |
| Subsidy        | 0.0012  | 0.0012 |
|                | (1.15)  | (1.14)  |
| Wasted 1       | 0.0000  | −0.0006 |
|                | (0.03)  | (−0.65) |
| Wasted 2       | −0.0008  | −0.0006 |
|                | (−1.23) | (−0.80) |
| Wasted 3       | 0.0022*** | 0.0020*** |
|                | (−2.68) | (2.72)  |
| Intercept      | 0.0027  | −0.0243* | −0.0283* |
|                | (5.98)  | (−2.68) | (−1.75) |
| Year           | No      | No      | Yes    |
| Industry       | No      | No      | Yes    |
| Region         | No      | No      | Yes    |
| Sample size    | 412     | 412     | 412    |
| Observations   | 1648    | 1648    | 1648   |
| $R^2$          | 5.70%   | 7.07%   | 11.24% |

Note: $T$ statistics are shown in brackets.

*Statistical significance at the 10% level; **statistical significance at the 5% level; ***statistical significance at the 1% level.

Table 5 Moderating the effect of market degree

| Variable | Invest | Invest |
|----------|--------|--------|
|          | (1)    | (2)    |
| MD       | 0.0008** | −0.0001 |
|          | (2.23)  | (−1.19) |
| Time     | −0.0061 |
|          | (−0.91) |
| MD×time  | 0.0008** |
|          | (2.19)  |
| Intercept| 0.0030  | −0.0093 |
|          | (0.44)  | (−0.43) |
| Controls | Yes     | Yes    |
| Year     | Yes     | Yes    |
| Industry | Yes     | Yes    |
| Region   | Yes     | Yes    |
| Sample size | 412   | 138    |
| Observations | 1648 | 552    |
| $R^2$    | 6.13%   | 5.26%  |

$T$ statistics are shown in brackets.

*Statistical significance at the 10% level; **statistical significance at the 5% level; ***statistical significance at the 1% level.

Table 6 Moderating the effect of firm ownership

| Variable | Invest | Invest |
|----------|--------|--------|
|          | (1)    | (2)    |
| FO       | −0.0015** | −0.0012 |
|          | (−2.23) | (−0.09) |
| Time     | 0.0019  |
|          | (0.82)  |
| FO×time  | −0.0010 |
|          | (−1.01) |
| Intercept| 0.0062  | 0.0048 |
|          | (0.87)  | (0.25)  |
| Controls | Yes     | Yes    |
| Year     | Yes     | Yes    |
| Industry | Yes     | Yes    |
| Region   | Yes     | Yes    |
| Sample size | 412   | 138    |
| Observations | 1648 | 552    |
| $R^2$    | 11.10%  | 5.30%  |

$T$ statistics are shown in brackets.

*Statistical significance at the 10% level; **statistical significance at the 5% level; ***statistical significance at the 1% level.
significantly contributed to the performance of local governments simultaneously. They are more favored by local governments to a certain extent, which can protect SOEs from the negative impact of environmental regulations. The dual effect of firm ownership explains its nonsignificant moderating effect on environmental investment.

Robustness test

PSM-DID

To eliminate the prior differences between the experimental group and the control group and eliminate the noise of other variables, this paper follows Xu and Yan (2019) and Zang et al. (2020) and uses the propensity score matching method (PSM) to match the new control group and the experimental group. The matching standard includes corporate size, financial leverage, investment opportunities, growth ability, regional economic level, and regional subsidies. The score matching method is a 1:1 match, and the result is shown in Table 7 below. The coefficient of Treated $\times$ Time is significantly positive, indicating that the conclusion of the main effect test is still valid. That is, after the compensation system, corporate environmental investment has been significantly improved.

Placebo test

Taking the impact of other major environmental policies into account, this paper refers to the study of Chen et al. (2015) and Sun (2019) and conducts a placebo test. As the compensation system is a pilot policy, the natural experimental group and control group are defined, and the results of the main effect test have been relatively stable. The improvement in corporate environmental investment is significantly affected by the compensation system rather than other policies and regulations during the same period. In the moderating effect test, the effect of market degree on environmental investment may be a “false fact” due to the fact that exogenous events are not unique. To exclude the abovementioned alternate interpretation, this paper takes the listed companies in the non-pilot areas as a placebo sample. If market degree no longer has an obvious impact on corporate environmental investment in the placebo sample, it means that it is the compensation system that induces the regional government to strengthen environmental supervision, and the level of government intervention suddenly increases in high-marketization areas, resulting in increased corporate environmental investment. The specific test results are shown in Table 8 below. The coefficient of MD $\times$ Time is nonsignificant, largely excluding noise from other policies and regulations during the same period.

Selection deviation of pilot areas

Self-selection bias means that the explanatory variable is not random, but the result of individual selection and this selection process will lead to bias in the estimation of the main effect. As can be seen from Fig. 1 above, before the implementation of the policy, the environmental protection investment level of enterprises in the experimental group, that is, the pilot area, was significantly lower than that of the control group; after the implementation of the policy, the environmental protection investment level of the experimental group and the control group tends to the same level, so the compensation system improves corporate environmental investment. However, it can be considered that the significance of the results may be due to the low level of environmental investment of the experimental group. To solve this problem, this paper refers to the paper of Ye (2018) and selects the enterprises with a low level of environmental protection investment (lower than the average) in the control group as the new control group for the test. If the coefficient is still significantly positive, it shows that the

### Table 7: Double differential test after the PSM

| Variable      | PSM-DID Coefficients | t-value |
|---------------|----------------------|---------|
| Treated       | −0.0026***           | −3.12   |
| Time          | −0.0001              | −0.08   |
| Treated $\times$ time | 0.0018*         | 1.66    |
| Intercept     | −0.014               | −1.48   |
| Controls      | Yes                  |         |
| Year          | Yes                  |         |
| Industry      | Yes                  |         |
| Region        | Yes                  |         |
| $R^2$         | 11.24%               |         |

*statistical significance at the 10% level; **statistical significance at the 5% level; ***statistical significance at the 1% level

### Table 8: Placebo tests that exclude interference from other policies and regulations

| Variable | Coefficients | Standard error | t-value | P-value |
|----------|--------------|----------------|---------|---------|
| MD       | 0.0037***    | 0.14%          | 2.59    | 0.98%   |
| Time     | 0.0013       | 0.12%          | 1.11    | 26.68%  |
| MD $\times$ time | 0.0006 | 0.15% | 0.45 | 65.57% |
| Intercept| −0.0020      | 0.90%          | −0.22   | 82.69%  |
| Controls | Yes          | Yes            |         |         |
| Observations | 1096 | 1096 | 1096 | 1096 |
| $R^2$    | 9.67%        | 9.67%          | 9.67%   | 9.67%   |

*statistical significance at the 10% level; **statistical significance at the 5% level; ***statistical significance at the 1% level
implementation of the pilot policy has indeed improved the environmental protection investment level of enterprises in the pilot area. As shown in Table 9 below, the interaction coefficient is significantly positive at the 1% level.

**Mechanism analysis**

This paper analyzes the impact of ecological damage compensation system on enterprise environmental protection investment and puts forward an impact mechanism of the policy on enterprise investment, that is, the policy improves the local government’s enthusiasm for environmental governance, strengthens the implementation of environmental protection policy and regional environmental supervision, so as to improve the level of corporate environmental protection investment. In order to verify the above impact mechanism, this paper refers to Li (2013) and Zhang (2016), taking the regional sewage charges as the environmental regulation strength. If the implementation of the pilot policy can improve the regional environmental regulation strength, the impact mechanism has been basically verified. The test results are shown in Table 10 below. After adding control variables and fixed effects, the interaction coefficient in column (3) is significantly positive at the level of 1%, which indicates that the implementation of eco-environmental damage compensation system improves the level of regional environmental supervision.

**Discussion and conclusion**

Due to increasingly serious ecological problems, the intensity of environmental regulation in various countries is increasing, and the effectiveness of environmental policies depends on the decision-making of the “supervisor”—local government—and the “implementer”—enterprises. This paper regards China’s compensation system as an exogenous policy shock and the heavy pollution industry enterprises as the research object and uses a difference-in-differences model for empirical research, answering two questions: (a) whether the implementation of the compensation system can strengthen regional environmental supervision and promote corporate environmental investment? (b) Do market degree and firm ownership have a moderating effect? The findings are summarized as follows. First, the compensation system can effectively improve corporate environmental investment. Second, the effectiveness is restricted to a market degree. For enterprises in high-marketization areas, the strengthening of local governments’ environmental supervision has greatly limited their freedom, and the sudden increase in government regulation has also affected them to a greater extent. Third, compared to non-SOEs, for SOEs, the “special status” cannot be used as an “umbrella” to protect them when they cause environmental damage, and both will be treated equally.

**Theoretical contributions**

This paper makes the following theoretical contributions. First, according to our review of the literature, this paper examines the impact of external environmental regulation on corporate environmental investment and considers the impact of local governments that implement ecological damage compensation policy for the first time, which enriches environmental regulation research. Many studies have explored the role of environmental regulation in
promoting corporate technological innovation and measured the intensity of regional environmental supervision with variables such as the pollution removal rate, pollution penalty amount, and government environmental expenditures. These studies have not developed a consensus regarding an authoritative, unified method of measurement for the concept (Jiang 2015; Song et al. 2020a, b). This paper combines theoretical analysis with empirical testing, employs the implementation of a specific policy to represent a change in regional environmental supervision, regards the pilot regional enterprises as a natural experimental group, and accurately identifies the role of regional environmental supervision in promoting environmental investment.

Second, the relevant literature has studied the impact of environmental regulation on environmental problems at the national, regional, and industry levels without considering environmental regulations at the corporate level, and the results may be influenced by aggregated data (Ren et al. 2018; Swain et al. 2020; Levinson and Taylor 2004). This paper considers macroenvironmental policy, regional environmental supervision, and micro-enterprise environmental investment in the same scenario, not only to test the implementation effect of the central government policy from local governments but also to prove the effectiveness of environmental protection policy in terms of its effect on enterprises. This paper analyzes and verifies the impact of national environmental policy and regional environmental supervision on enterprises, expands the research boundary of environmental regulation theory, and provides a reference and research direction for follow-up research.

Third, this paper further analyzes the moderating effects of market degree and firm ownership, expands the research on the effect of environmental regulation on the organizational behavior of enterprises, and enriches legitimacy theory to a certain extent. The results support the hypothesis that the increase in the environmental investment of enterprises in high-marketization areas is higher because a sudden high government intervention put legal pressure on the enterprises, which caused enterprises to increase their environmental investment to fulfill external requirements. Notably, firm ownership did not play the expected moderating role, which contrasts with the results of Zhang et al. (2019) and Peng et al. (2020). This paper holds that the dual role of SOEs is the main reason for this difference. Although SOEs are the leading force in the construction of national ecological civilization, the outstanding contribution made by SOEs to local economic development and their innate legal umbrella has helped them avoid the negative impact of environmental regulation on their economic interests. In the process of constructing an ecological civilization, SOEs and non-SOEs should assume the main responsibility of sustainable development, and the nature of state ownership should not be a tool for enterprises to circumvent environmental regulation.

Policy implications

This research has the following three policy implications. First, reasonable environmental regulation can guarantee the effectiveness of local government policy implementation, thus driving enterprises to strengthen environmental protection. However, the externality of corporate environmental investment, coupled with the local government’s pursuit of governing objectives and economic utility, makes it necessary to solve environmental governance problems due to policy constraints at the central government level. The central government needs to formulate scientific and effective policies, apply the “incentive and restraint” method in the compensation system to policy formulation for local governments and various industries, and ensure the supervision and implementation of environmental policies. Second, in the process of constructing an ecological civilization, the central government has gradually increased environmental regulation and paid attention to both incentives and punitive environmental policies. For political, economic, and ecological reasons, local governments should implement the central policy strictly and make every effort to change the negative situation of “policies not step forward the South China Sea” Local governments can strengthen environmental supervision by increasing regional pollution penalties and supervising the timeliness and transparency of corporate information regarding environmental impacts. Third, the results of this paper show that the market degree strengthens the role of environmental regulation in promoting environmental investment. It is necessary to clarify the advantages and disadvantages of government intervention in enterprises, accelerate marketization reform, give full play to the role of the market in the allocation of resources, and work to optimize the environmental regulation effect.

Management implications

This research also has several management implications. First, in the context of a series of environmental governance policies and an increase in local government environmental supervision, enterprises need to face more severe penalties for environmental damage. If enterprises want to protect their own economic interests, they must realize legitimacy and put an end to environmental pollution and environmental violations. Second, according to the principle of “who pollutes who governs, who develops who protects,” enterprises, as the main users of resources and the main producers of environmental pollution, should make every effort to prevent and control environmental pollution, increase investment in environmental protection
projects, disclose environmental information, publicize their environmental protection efforts, and take the initiative to assume primary responsibility for the construction of an ecological civilization.

Limitations and research prospects

This paper is subject to a few limitations. First, this paper combines theoretical analysis with empirical testing, innovatively considers the perspective of the policy implementing subject “local government,” and uses the behavior of the main environmental body “enterprise” to test the effect of the policy; therefore, there are few directly relevant studies. Second, this paper studies the compensation system and comes to the conclusion that the ecological damage compensation policy is effective, which may be subject to certain limitations. Follow-up studies should consider testing other ecological damage compensation policies to ensure the generalizability of the results of this paper. Third, due to the availability of data, this paper limits the sample to listed companies in China’s heavy pollution industry and does not cover other industries or unlisted companies. Follow-up studies can expand the empirical sample and reverify the conclusion.

Author contribution

HZ contributed to the conception of the study; CC contributed to the data curation, software, writing—original draft preparation; YJ contributed significantly to analysis and manuscript preparation; and QZ helped perform the analysis with constructive discussions.

Funding

This research was supported by the Youth Project for the National Nature Science Foundation of China (Grant No.71904208), the Major Project for National Natural Science Foundation of China (Grant No. 71991483), the Project of Social Science Achievement Evaluation Committee of Hunan Province (XSP21YBZ168), and the Youth Project for Nature Science Foundation of Hunan Province (2021JJ40796).

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication All authors read and approved the final manuscript. Therefore, all are happy to consent to publish this work in the journal Environmental Science and Pollution Research (ESPR), subject to peer review as per ESPR policy.

Competing interests The authors declare no competing interests.

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