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Biodiversity conservation and corporate environmental information disclosure: Evidence from a quasi-natural experiment in China

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ABSTRACT

This study examines the causal relationship between biodiversity conservation and corporate environmental information disclosure (EID) by leveraging the exogenous shock to neighboring urban firms in China brought about by the National Park Pilot (NPP) policy. Using a staggered difference-in-differences model, our findings demonstrate a significant causal increase in the EID levels of firms affected by the NPP policy. Further analysis reveals that the positive impact of this policy on corporate EID level is more pronounced among firms without green investors, having lower levels of retail investor interaction, and operating in non-heavily polluting industries. Overall, our study suggests that the implementation of the NPP policy enhances the market value of affected firms substantially.

1. Introduction

Biodiversity refers to the diversity within species, between species, and of the ecosystem. Human survival and development are tied closely to biodiversity. According to the "New Natural Economy Report" by the World Economic Forum (2020), approximately $44 trillion—more than half of the world's gross domestic product—moderately or heavily depends on natural ecosystems. However, biodiversity is declining at an unprecedented rate in human history. Approximately 75 % of the Earth's terrestrial environment and 66 % of its marine environment have been affected by human activities, with nearly a million species facing extinction worldwide (IPBES, 2019). Over the next decade, biodiversity loss is projected to be the third most significant global risk, following extreme weather events and critical changes to Earth's systems (McLennan, 2022). Thus, biodiversity conservation is of paramount importance. Given the risks associated with biodiversity loss, many countries are implementing active biodiversity conservation measures. As the world's second-largest economy and one of the earliest signatories to the Convention on Biological Diversity, China has taken a strong stance in supporting and promoting biodiversity conservation. Establishing national parks to protect biodiversity is among the country's most significant initiatives.

It is widely recognized that environmental issues profoundly influence firm behavior and decision-making (Lang, Ma, Mirza, & Umar, 2023). For example, prior studies indicate that air pollution increases regulatory costs for firms, prompting them to hold more cash while reducing investment and innovation to mitigate potential risks (Farooq, Ashfaq, Rustamovna, & Al-Naimi, 2023; Li, He, Gao, & Zeng, 2021). Research also shows that market pressures and policy uncertainties related to climate change can shape firms' strategies (Cadez, Czerny, & Letmathe, 2019). However, the relationship between biodiversity and corporate decision-making remains relatively unexplored and warrants further research.

Findings from other environmental issues cannot be directly applied to biodiversity due to differences in spatial scope, impact, and risk primarily because biodiversity is more susceptible to specific environmental conditions (Buckley & Jetz, 2008; Tamme, Hiiesalu, Laanisto, Szava-Kovats, & Pärtel, 2010; Tilman et al., 2017). Additionally, assessing biodiversity-related financial risks requires a localized approach as the impacts and dependencies are inherently regional, in

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contrast to the global risks associated with climate finance (Nedopil, 2023).[1] The actions of regional firms affecting biodiversity have drawn increasing attention of all sectors of society.[2] Therefore, biodiversity from various stakeholders and conservation initiatives places greater demands on the behavior and decisions of local firms, compared with other environmental issues.

Disclosure, a critical aspect of corporate behavior and decisions, is essential for firms' long-term sustainability. Notably, information about a firm's environmental risk exposure can influence investor decisions and risk pricing (Cohen, Kadach, & Ormazabal, 2023). Prior research on environmental disclosure has primarily focused on climate governance (Ilhan, Krueger, Sautner, & Starks, 2023) and air pollution (Dong, Fisman, Wang, & Xu, 2021). However, as biodiversity loss gains global priority, scholars are paying increased attention to its implications. To date, limited research has explored the link between biodiversity conservation and corporate environmental information disclosure (EID).

As ecological degradation accelerates, firms face mounting biodiversity risks resulting from both biodiversity loss and biodiversity conservation actions. Firms must gain the trust of governments, the public, and investors through various strategies, and a notable approach is EID, which enables firms to demonstrate their environmental protection efforts and mitigate information asymmetry. However, firms must carefully weigh the costs and benefits of disclosing environmental information. Therefore, whether biodiversity conservation influences firms' EID levels remains an empirical question.

The scarcity of research on the relationship between biodiversity conservation and EID levels is largely due to challenges in objectively quantifying such information. Previous studies have often relied on textual data from newspaper articles, corporate announcements, and other sources to construct biodiversity risk indices (Giglio, Kuchler, Stroebel, & Zeng, 2023; Ma, Wu, & Zeng, 2024). However, these approaches have inherent limitations, as the identification and quantification of relevant terms are susceptible to subjective judgment. Furthermore, because firms' EID levels are derived from textual information, using text analysis to assess the impact of biodiversity conservation on EID inevitably introduces subjectivity. To circumvent this issue, we employ China's "National Park Pilot" (NPP) policy as a quasi-natural experiment to examine the impact of biodiversity conservation on firms' EID levels.

To enhance the protection of critical ecosystems and conserve biodiversity, the Chinese government has implemented the NPP policy. The national park pilots are authorized by the central government and managed by government-led initiatives, enforcing stricter protections and higher regulatory oversight. This biodiversity conservation policy increases the biodiversity-related risks for firms operating near national park pilot areas. We argue that the adoption of the NPP policy has introduced exogenous variations in the biodiversity risks faced by firms.

Unlike most studies in the existing literature, our empirical strategy helps mitigate concerns about the subjective judgment issues inherent in textual analysis. Moreover, because firms have no influence over government decisions, our approach avoids potential endogeneity problems. Thus, the NPP policy serves as an ideal exogenous policy shock for examining the impact of biodiversity conservation on firms' EID levels.

We manually collected data on the NPP policy and used Chinese listed firms from 2013 to 2022 as our sample. We then estimated the impact of the NPP policy on corporate EID using a staggered difference-in-differences (DID) approach. Our findings reveal that the EID levels of treated firms significantly increased relative to those of control firms after the implementation of the NPP policy. This result remains robust across alternative measures of key variables, propensity score matching (PSM) samples, and the exclusion of observations from large cities that serve as regional centers. Additionally, our staggered DID regression results pass the parallel trend test and remain valid when accounting for potential heterogeneous treatment effects using the methods of Goodman–Bacon (2021) and Callaway and Sant'Anna (2021). Finally, placebo test results confirm that unobservable random factors do not account for the observed relationship between the NPP policy and firms' EID levels.

Further analyses indicate that the impact of the NPP policy on corporate EID varies depending on firms' green investors, retail investors, and industry classification. Specifically, firms without green investors experience less environmental pressure and have lower EID levels. The same trend is observed for firms with lower levels of retail investor interaction and those in non-heavily polluting industries. The implementation of the NPP policy has increased public attention, investor pressure, and government regulation. As a result, these "low-pressure" firms are more significantly affected by the NPP policy.

Finally, we examined the economic consequences of the NPP policy for firms by using Tobin's Q as a measure of market value. Our results show that the implementation of the NPP policy significantly increases firms' market value.

Our study makes several key contributions. First, previous biodiversity research focuses mainly on biodiversity finance (Rubino, 2000). There are fewer studies on the impact of biodiversity on firm-level decisions and behavior. In particular, there has been little academic research has examined whether biodiversity conservation influences corporate EID levels. Given that firms face increasing biodiversity risks, the relationship between biodiversity conservation and EID is highly relevant and warrants investigation. Our study provides novel empirical evidence on how biodiversity conservation influences corporate decision-making.

Second, we contribute to the research on corporate EID. Numerous studies have analyzed the determinants of EID from various perspectives, including air pollution (Yang et al., 2024), legitimacy (Cho & Patten, 2007), administrative penalties (Ding, Qu, & Shahzad, 2019), and investor pressure (Zeng, Xu, Yin, & Tam, 2012). However, to date, no research has specifically examined the impact of biodiversity conservation on corporate EID. By leveraging China's NPP policy as a quasi-natural experiment, our study systematically investigates whether and how biodiversity conservation influences corporate EID, offering a new perspective on the determinants of environmental disclosure.

Third, although previous biodiversity studies have primarily relied on textual analysis, we use the NPP policy as an exogenous policy shock and apply a staggered DID model to address the endogeneity problems associated with textual analysis methods. This approach advances the methodological framework for biodiversity-related research.

Finally, our findings have important implications for policymakers seeking to enhance biodiversity conservation and corporate environmental sustainability through regulatory measures such as the NPP policy. Our results demonstrate that the NPP policy can significantly enhance firms' market value, providing empirical evidence for the economic significance of biodiversity conservation and informing future policy development.

The remainder of our paper is structured as follows: Section 2 introduces the institutional background and outlines hypothesis development, and Section 3 presents the research design. Section 4 reports the empirical results of the baseline regression, and Section 5 provides additional tests. Section 6 examines the economic consequences of the

[1] For example, emissions from a new coal-fired power plant in Europe can affect climate change around the world and affect real estate assets in coastal areas of Australia. In contrast, biodiversity-related risks and impacts are more (though not exclusively) locally constrained: e.g., overuse of fertilizers affects local agriculture and biodiversity (e.g., in Germany), while the corresponding risks of biodiversity loss are similarly locally constrained, and spatial risks tend to diminish (e.g., there is no direct impact on domestic assets in Australia).

[2] The Wildlife Conservation Society has pointed out that Sinopec's oil extraction practices have opened up large industrial parks, resulting in soil and water pollution, which has led to the destruction of large areas of natural habitat and loss of biodiversity. This incident has sparked a lot of public discussion.

findings and Section 7 discusses the conclusions.

2. Institutional background and hypothesis development

2.1. Institutional background

The Convention on Biological Diversity defines biodiversity as "the variability in living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and in ecosystems."

During[3] the United Nations Biodiversity Conference of 2022, Chinese President Xi Jinping emphasized that biodiversity enriches the Earth with vitality and provides the foundation for human existence and progress. He underscored that preserving biodiversity is essential for safeguarding our shared home and plays a crucial role in sustainable development.

To enhance biodiversity protection, China is accelerating the development of a protected area system. In 2015, the National Development and Reform Commission, along with other government departments, initiated the pilot phase of a national park system in 12 provinces. The national park pilots include 77 species classified under National First Class Protected Animal and National Level Protected Plant categories, as well as hundreds of other protected plant and animal species. Detailed information on the pilot national park systems is provided in Panel A of Appendix A.

The primary objective of the NPP policy is to protect ecosystems and biodiversity. Specifically, key natural ecological areas are designated for protection to ensure biodiversity conservation. Concurrently, a range of industrial transformation, green ecology, and public participation policies have been introduced in the areas surrounding the national parks.

Since the establishment of the national park pilots, ecological protection within these areas has been significantly strengthened, oversight of human activities has improved, and the policy's social impact has gradually expanded. Consequently, the NPP policy has had a positive effect on biodiversity conservation both within the protected areas and in adjacent municipalities. The specific policies and ecological outcomes for each national park pilot are detailed in Panels B and C of Appendix A.

Beyond enhancing environmental protection, the NPP policy has also had a profound impact on local firms. With stricter regulations, some firms have faced penalties for non-compliance.[4] Conversely, many firms have chosen to seize opportunities presented by the NPP policy and actively assume responsibility for biodiversity conservation.[5] These proactive measures not only help firms mitigate potential risks but also significantly enhance their social reputation and influence. In summary, the NPP policy presents both opportunities and challenges for firms.

On one hand, biodiversity conservation helps ensure a stable supply of raw materials while reducing production costs and risks. By engaging in biodiversity conservation efforts, firms can enhance their brand image, attract more customers, and increase investment. On the other hand, stricter environmental regulations heighten the risk of future litigation and challenge firms' legitimacy. Investors require more environmental information to assess corporate risks. In recent years, investor interest in biodiversity-related policies has grown significantly, with investors beginning to demand a risk premium due to the uncertainty surrounding future regulations or litigation related to biodiversity protection (Garel, Romec, Sautner, & Wagner, 2024).

These opportunities and challenges inevitably influence firms' strategic decisions and sustainability-related actions, such as cash holdings (Li et al., 2021); environmental, social, and governance reporting (Kopnina, Zhang, Anthony, Hassan, & Maroun, 2024); and overall sustainability initiatives (Karolyi & Tobin-de la Puente, 2023). However, the extent to which biodiversity conservation affects firms' EID levels remains unclear and requires further research.

2.2. Hypothesis development

According to the theory of environmental legitimacy (Bansal & Clelland, 2004), a firm's environmental performance should align with societal expectations. Environmental legitimacy is crucial for firms as it enhances executives' awareness (Zhou, Govindan, Xie, & Yan, 2021), mitigates unsystematic risk (Bansal & Clelland, 2004), and influences firms' green innovation initiatives (Li, Huang, Ren, Chen, & Ning, 2018). Consequently, firms engage in eco-friendly practices to establish environmental legitimacy and meet public expectations (Berrone, Fosfuri, & Gelabert, 2017). This dynamic suggests that public expectations and firms' green actions can mutually reinforce one another.

Unlike public expectations, government environmental regulations impose mandatory requirements on firms' environmental actions. These regulations drive green product and process innovation (Porter & Van der Linde, 1995; Zhang, Liang, Feng, Yuan, & Jiang, 2020), promote industrial structure upgrades (Song, Zhang, & Zhang, 2021), and support environmental sustainability (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013). Additionally, environmental regulations influence how investors assess firms and make investment decisions.

A significant information asymmetry exists between investors and firms, as investors primarily rely on firm reports to obtain relevant information (Li et al., 2018). Furthermore, investor attention is constrained by time and cognitive capacity (Hirshleifer & Teoh, 2003). As a result, discrepancies often arise between firms and investors regarding the availability and interpretation of firms' green initiatives. To reduce information asymmetry, investors closely monitor firms' disclosure practices.

Corporate disclosure is a complex process that requires careful attention and long-term planning, like other major corporate activities (Lev, 1992). Firms disclose different types of information selectively (Boot & Thakor, 2001), with environmental information being one such category. Previous research on environmental disclosure falls into two primary areas. The first examines the factors influencing environmental disclosure, such as legitimacy (Cho & Patten, 2007), administrative penalties (Ding et al., 2019), and investor pressure (Zeng et al., 2012). The second explores the economic consequences of environmental disclosure, including its impact on stock market crash risk (Zhang, Su, Wang, & Zhang, 2022), financial performance (Wang, Wang, Wang, & Yang, 2020), green innovation (Liao, 2018), and financing efficiency (Zhou & Ding, 2023). However, little research has examined the relationship between EID and biodiversity conservation.

In recent years, biodiversity conservation has emerged as not only an environmental priority but also an economic concern. The government has introduced stricter regulations to protect biodiversity, which can indirectly enhance firms' environmental disclosure (Zheng, Ge, Li, Duan, & Yu, 2020). Additionally, firms operating near national park

[3] The 15th session of the United Nations Biodiversity Conference (COP15) focuses on global biodiversity conservation. The conference aims to reach a global agreement to address biodiversity loss. Chaired by China and hosted by Canada, COP 15 resulted in the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF). The GBF aims to address biodiversity loss, restore ecosystems, and protect indigenous rights.

[4] Since the establishment of the national park pilots, listed companies located in prefecture-level cities around national parks have received 1068 environmental penalties (as of April 2024). Among them, the New Hope Group has been penalized 144 times for environmental pollution, water pollution, and other environmental problems. These punishment cases were reported by Sina Finance, NetEase Finance, Thepaper.cn and other media, causing widespread social concern.

[5] Under the guidance of the NPP policy, the Nio launches Clean Parks Global ecological co-construction plan. This is the world's first open platform sponsored by an automobile company to support the construction of national parks and nature reserves. In 2022, the Three Gorges Corporation released its first biodiversity conservation report, which highlights its remarkable achievements and expresses its firm commitment to the continuous protection of biodiversity.

Table 1
Sample selection.

Initial observations	36,236
excluding financial and real estate sector firms	(2087)
excluding samples under special treatment, such as ST, PT, and *ST	(969)
excluding samples listed for less than one year and those with debt-to-asset ratio of more than 1	(4521)
excluding samples with missing data for key variables	(831)
Available firm–year observations	27,828
Unique firms	4224

Note: This table reports the criteria and steps used to screen the sample. As shown, we began with a sample of 36,236 firm–year observations listed on the Shanghai and Shenzhen Stock Exchanges from 2013 to 2022. From this, we obtained sample of 27,828 firm–year observations, covering 4224 different firms.

pilot areas face increased biodiversity-related risks. To build investor confidence, these firms must engage in environmental disclosure to reduce information asymmetry (Zeng et al., 2012). Furthermore, firms must address environmental legitimacy challenges. Public expectations create an "invisible social contract" that compels firms to enhance their EID levels to maintain a strong reputation and expand their market share (Delmas & Toffel, 2008).

Based on these discussions, we expect that the adoption of the NPP policy will enhance the EID levels of affected firms. Therefore, we propose our main hypothesis as follows:

H1. Firms affected by the NPP policy increase their level of EID.

3. Research design

3.1. Sample and data

The initial sample of this study comprises China's A-share listed firms from 2013 to 2022. This timeframe was chosen to ensure that the data includes at least three years before and after the implementation of the national park pilots. Financial and environmental information for the firms was sourced from the China Stock Market and Accounting Research (CSMAR) and China Center for Economic Research databases. As outlined in Table 1, we began with a sample of 36,236 firm–year observations. The sample selection was then refined by excluding financial and real estate sector firms, those under special treatment by the stock market (i.e., ST, PT, and *ST), those listed for less than one year and those with a debt-to-asset ratio greater than 1, and those missing data for key variables. Ultimately, a total of 27,828 firm–year observations for 4224 firms were retained. The treatment group affected by the NPP policy includes 275 listed firms. To minimize the impact of outliers on the empirical results, all continuous variables were winsorized at the 1st and 99th percentile levels.

3.2. Variable definitions

3.2.1. Dependent variable

The dependent variable in this study is the level of corporate EID (*Envidq* and *ascore*), measured by assessing the content and depth of their environmental disclosures. Following prior studies (Meng, Zeng, Tam, & Xu, 2013; Xing, Zhang, & Tripe, 2021; Zeng et al., 2012), we constructed two proxies for corporate EID levels. The first is a scoring framework based on Global Reporting Initiative guidelines (Xing et al., 2021), which includes both hard and soft disclosure categories and is divided into five subsections comprising a total of 25 items. Hard disclosure refers to information supported by concrete evidence or data, whereas soft disclosure involves information presented through the firm's own narratives or explanations (Verrecchia, 1983). Each item is scored according to the level of disclosure, with scores ranging from 0 to 2. For the hard information category, a score of 2 is assigned when quantitative information is available, 1 for qualitative information, and 0 if no information is provided. In the soft information category, where there is no quantitative data, a score of 2 is assigned if the firm discloses information, and 0 if it does not. The EID level (*Envidq*) is then calculated as the natural logarithm of 1 plus the sum of all the items. The detailed scoring criteria for this proxy are provided in Panel A of Appendix B.

Given that environmental disclosure regulations differ across countries, we developed a second proxy (*ascore*) specifically to better assess the EID levels of Chinese firms. In China, the Environmental Disclosure Rules were issued by the China State Environmental Protection Administration (SEPA) in 2007 to standardize and guide EID for both the government and firms. According to SEPA guidelines, we built the second scoring framework, which is divided into nine items. Scores for this proxy range from 0 to 3: a score of 3 is given for the availability of monetary information, 2 for specific non-monetary information, 1 for general non-monetary information, and 0 for the absence of information (Wiseman, 1982). The EID level (*ascore*) is computed by summing all items. This measure is well-suited and commonly used in studies focusing on China (Meng et al., 2013; Zeng et al., 2012). Detailed descriptions of this variable are presented in Panel B of Appendix B.

3.2.2. Independent variable

The staggered DID model is applicable when a policy is implemented incrementally across different affected groups. Because the NPP policy was rolled out in three phases—2016, 2017, and 2019—we employed a staggered DID model to compare changes in EID levels between firms affected by the NPP policy and those that were not.

The impact of the NPP policy is extensive. The pilot national park system encompasses 12 provinces in China, including Fujian, Gansu, Hainan, Heilongjiang, Hunan, Hubei, Jilin, Qinghai, Shaanxi, Sichuan, Yunnan, and Zhejiang. The total area of the national park pilots exceeds 220,000 km^2, representing approximately 2.3 % of China's land area. The national parks are managed under a state-led system, jointly administered by central and local governments. As a result, biodiversity conservation efforts associated with the national park pilots extend beyond the designated pilot areas.

For instance, Yichang, a prefecture-level city bordering Shennongjia National Park, has leveraged the opportunities presented by the NPP policy by enhancing industrial emission monitoring, implementing stricter water source protections, and enforcing penalties for pollution violations. Similarly, the Nanshan National Park pilot spans multiple county-level cities within Shaoyang City. Following the implementation of the NPP policy, water conservation and biodiversity protection measures have been expanded across Shaoyang City. These cases illustrate that the NPP policy influences not only the prefecture-level cities where pilot areas are located but also neighboring cities.

We defined the affected cities as those hosting national park pilots as well as adjacent prefecture-level cities. The distribution of affected cities is illustrated in Fig. 1. In the figure, the green areas represent the pilot national park boundaries, whereas the gray areas denote the affected cities. Accordingly, we construct a dummy variable, Policy, which is set to 1 if a firm is located in one of the affected cities and 0 otherwise.

3.2.3. Control variables

Following prior research (Meng et al., 2013; Xing et al., 2021; Zeng et al., 2012), we controlled for several additional factors that may influence firms' EID levels. First, to account for firms' operational performance and fundamental characteristics, we include the following variables: firm size (*Size*), asset tangibility (*PPE*), financial leverage (*Lev*), cash holdings (*Cash*), profitability (*ROA*), firm age (*Age*), and investment (*Expend*). Second, to control for corporate governance factors, we included board size (*Boardsize*), management shareholding (*ManagerHold*), percentage of independent directors (*Indp*), and CEO duality (*Dual*). Detailed variable definitions are provided in Appendix C.

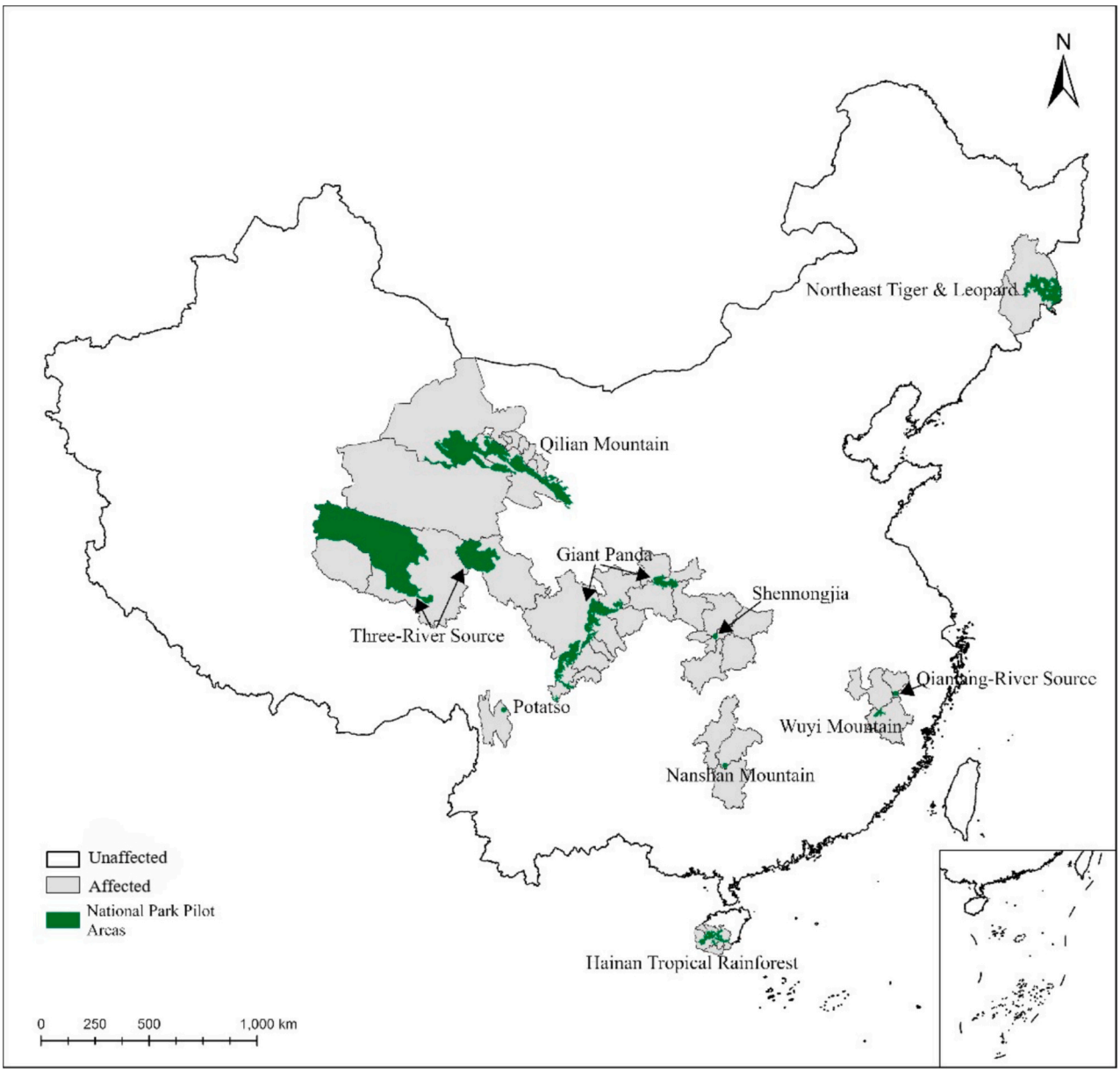


Fig. 1. Distribution of cities affected by the NPP policy.

3.3. Empirical model

To examine the effect of the NPP policy on firms' EID levels, we employed the following generalized DID model:

$$EIDlevel = \alpha_0 + \alpha_1 Policy + \alpha_2 Controls + Firm + Year + \varepsilon_{i,t} \quad (1)$$

where *EIDlevel* represents the proxies for firms' EID levels, namely, the scoring frameworks *Envidq* or *ascore* discussed previously. *Policy* is a dummy variable indicating whether a firm is affected by the NPP policy. By definition, higher values of *Envidq* or *ascore* indicate a greater level of EID.

Consistent with prior literature (Meng et al., 2013; Xing et al., 2021; Zeng et al., 2012), we include a set of control variables (*Controls*) to account for other factors that may influence firms' EID levels (see Appendix C for detailed definitions).

According to H1, α_1 is expected to be significantly positive, indicating that the NPP policy leads to a significant increase in the EID levels of treated firms relative to control firms. To account for potential confounding factors, we incorporated firm and year fixed effects into the baseline model to control for time-specific shocks and unobservable firm characteristics. Additionally, we clustered standard errors at the firm level to address potential residual correlations. Finally, $\varepsilon_{i,t}$ represents the random disturbance term in the model.

4. Empirical results

4.1. Descriptive statistics and correlation matrix

Table 2 presents the descriptive statistics for the full sample of 27,828 firm–year observations from 2013 to 2022. The average values of *Envidq* and *ascore*, which measure firms' EID levels, are 2.083 and 5.071, respectively, with maximum values of 3.689 and 17.000. These statistics indicate substantial variation in EID levels among Chinese listed firms. The descriptive statistics for all control variables are generally consistent with prior research.

Table 3 reports the Pearson correlation matrix for the main variables. Consistent with H1, the NPP policy indicator (*Policy*) is positively correlated with *Envidq* and *ascore*, the two proxies for firms' EID levels.

Table 2
Descriptive statistics.

Variable	N	Mean	p50	SD	Min	Max
Envidq	27,828	2.083	2.197	0.929	0.000	3.689
ascore	27,828	5.071	4.000	4.077	0.000	17.000
Policy	27,828	0.046	0.000	0.209	0.000	1.000
ROA	27,828	0.039	0.040	0.062	−0.239	0.197
Manager Hold	27,828	0.155	0.029	0.201	0.000	0.688
BTM	27,828	0.603	0.597	0.244	0.118	1.181
PPE	27,828	0.333	0.323	0.164	0.019	0.744
Expend	27,828	0.050	0.037	0.045	0.001	0.222
Size	27,828	22.170	21.990	1.240	19.960	26.060
Lev	27,828	0.402	0.391	0.196	0.055	0.868
Dual	27,828	0.317	0.000	0.465	0.000	1.000
Boardsize	27,828	8.412	9.000	1.593	5.000	14.000
Indp	27,828	0.376	0.364	0.052	0.333	0.571
age	27,828	9.578	7.000	7.742	0.000	28.000

Note: This table reports the summary statistics of the full sample of 27,828 firm–year observations during 2013–2022. All variables are defined in Appendix C, and all continuous variables are winsorized at the 1st and 99th percentiles.

As shown in Table 3, significant correlations exist between the dependent variables (*Envidq* and *ascore*) and all control variables. These results underscore the necessity of including control variables when examining the impact of the NPP policy on firms' EID levels.

4.2. Baseline results

Table 4 presents the main regression results on the relationship between the NPP policy and firms' EID levels. Columns (1) and (3) show the regression results of the two EID proxies on the NPP policy indicator, incorporating firm and year fixed effects but excluding all control variables. In contrast, Columns (2) and (4) report the regression results with the inclusion of all control variables under the two measures of EID. The coefficients on Policy are significantly positive at the 5 % level or higher across all columns, regardless of whether *Envidq* or *ascore* is used as the dependent variable. Because higher values of *Envidq* and *ascore* indicate greater EID levels, these results suggest that firms affected by the NPP policy exhibit significantly higher EID levels than unaffected firms.

Specifically, the coefficients on *Policy* in Columns (2) and (4) are 0.122 and 0.619, respectively. This implies that when a firm is affected by the NPP policy, its EID level increases by 0.122 or 0.619 relative to that of control firms. Overall, these findings demonstrate that the NPP policy has a statistically and economically significant impact on the EID levels of treated firms, supporting H1.

4.3. Robustness test

4.3.1. Parallel trend test

The parallel trend test is crucial for validating the effectiveness of staggered DID models. This test examines whether treated and control firms exhibited similar trends in EID levels before the implementation of the NPP policy. Table 5 presents the results of the parallel trend test, which estimates the dynamic differences in EID levels between treatment and control firms while controlling for all covariates and fixed effects in Model (1).

In Table 5, Pre$x$ (x = 1, 2, 3) represents the change in EID level differences between treatment and control firms x years before the implementation of the NPP policy. Conversely, Post$x$ represents the change in EID level differences between treatment and control firms x years after the implementation of the NPP policy. Following Chircop, Fabrizi, Malaspina, and Parbonetti (2023), the year immediately preceding the implementation of the NPP policy is selected as the benchmark year.

Table 5 indicates that the estimated coefficients on Pre$x$ are all statistically insignificant. This finding suggests that no significant difference in EID levels existed between treatment and control firms prior to the implementation of the NPP policy. In contrast, the estimated coefficients on Post$x$ are all significantly positive, indicating that the EID levels of treatment firms improved significantly relative to control firms after the policy was implemented. These results confirm that the NPP policy directly contributed to an increase in firms' EID levels, reinforcing the robustness of the baseline findings.

4.3.2. Heterogeneity-robust estimates in staggered DID regressions

Existing research raises concerns regarding the potential biases associated with the two-way fixed effects (TWFE) estimator in staggered DID regressions. When treatment timing varies across firms, earlier-treated firms may serve as controls for later-treated firms, creating a "bad control group." If these earlier-treated samples receive excessive weight in the estimation, it can introduce significant bias or even reverse causal effects.

To address these concerns, we employed the Bacon decomposition method proposed by Goodman–Bacon (2021) to evaluate the impact of negative weights (i.e., the influence of bad control groups) on our TWFE estimates. As shown in the first row of Table 6, our analysis reveals that less than one-sixth of the weights are negative, with the sum of these negative weights amounting to only 0.0007. This suggests that our baseline results are not substantially affected by heterogeneity in treatment timing.

To further mitigate concerns about estimation bias arising from temporal heterogeneity effects in staggered DID regressions, we applied

Table 3
Correlation matrix.

	Envidq	*Ascore*	*Policy*	*ROA*	*ManagerHold*	*BTM*	*PPE*	*Expend*	*Size*	*Lev*	*Dual*	*Boardsize*	*Indp*	*Age*
Envidq	1													
Ascore	**0.744**	1												
Policy	**0.056**	**0.048**	1											
ROA	**0.077**	**0.059**	0.008	1										
Manager Hold	**−0.126**	**−0.152**	**−0.015**	**0.167**	1									
BTM	**0.220**	**0.222**	0	**−0.182**	**−0.123**	1								
PPE	**0.201**	**0.215**	0.007	**−0.090**	**−0.179**	**0.153**	1							
Expend	**0.110**	**0.092**	−0.005	**0.143**	**0.130**	**−0.045**	**0.165**	1						
Size	**0.365**	**0.400**	0.009	0.001	**−0.362**	**0.521**	**0.146**	**−0.016**	1					
Lev	**0.106**	**0.168**	0.006	**−0.364**	**−0.295**	**0.350**	**0.243**	**−0.037**	**0.497**	1				
Dual	**−0.069**	**−0.097**	**−0.028**	**0.038**	**0.245**	**−0.122**	**−0.107**	**0.081**	**−0.192**	**−0.134**	1			
Boardsize	**0.121**	**0.144**	**0.038**	−0.002	**−0.220**	**0.161**	**0.122**	**−0.026**	**0.292**	**0.155**	**−0.191**	1		
Indp	**−0.030**	**−0.037**	**−0.021**	−0.012*	**0.081**	**−0.046**	**−0.033**	**0.019**	**−0.029**	**−0.019**	**0.122**	**−0.545**	1	
Age	**0.117**	**0.149**	**0.035**	**−0.183**	**−0.539**	**0.205**	**0.159**	**−0.213**	**0.428**	**0.335**	**−0.256**	**0.197**	**−0.044**	1

Note: This table details the Pearson correlation matrix of the main variables. Figures in bold are significant at least at the 5 % level. Variable definitions are provided in Appendix C.

Table 4
Baseline results.

Variables	*Envidq*		*Ascore*	
	(1)	(2)	(3)	(4)
Policy	0.116**	0.122**	0.607***	0.619***
	(2.170)	(2.330)	(3.121)	(3.313)
ROA		−0.091		0.246
		(−1.011)		(0.635)
ManagerHold		0.085		0.999***
		(1.151)		(3.341)
Cash		0.029		0.312
		(0.484)		(1.239)
PPE		0.219***		1.012***
		(3.250)		(3.610)
Expend		0.292**		1.131*
		(2.300)		(1.949)
Size		0.161***		0.671***
		(9.201)		(9.968)
Dual		−0.005		−0.127*
		(−0.299)		(−1.716)
Lev		−0.039		−0.408*
		(−0.621)		(−1.649)
Boardsize		−0.009		−0.052*
		(−1.276)		(−1.820)
Indp		−0.074		0.224
		(−0.437)		(0.315)
Age		0.017		−0.203
		(0.377)		(−0.949)
_cons	2.077***	−1.627***	5.043***	−7.942***
	(850.653)	(−2.872)	(568.977)	(−3.149)
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	27,828	27,828	27,828	27,828
Adj-R^2	0.685	0.689	0.618	0.621

Note: This table presents the results of the staggered difference-in-differences tests that examine the impact of the NPP policy on the corporate environmental information disclosure (EID) level. A firm's EID level is measured by *Envidq* in Columns (1) and (2) and *ascore* in Columns (3) and (4). The independent variable is *Policy*, which is a dummy variable indicating whether the firm is affected by the NPP policy. The regression specification follows Model (1). Variable definitions are provided in Appendix C. The firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 5
Parallel trend test.

Variables	*Envidq*	*Ascore*
	(1)	(2)
Pre3	0.238	−0.740
	(0.942)	(−0.605)
Pre2	−0.003	0.001
	(−0.055)	(0.002)
Pre1	0.068	0.206
	(1.166)	(0.724)
current	0.110*	0.550**
	(1.930)	(1.987)
Post1	0.160***	0.742***
	(2.785)	(2.665)
Post2	0.204***	0.539**
	(3.604)	(1.967)
Post3	0.246***	0.559**
	(4.368)	(2.055)
Controls $_{i,t}$	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Observations	27,828	27,828
Adj-R^2	0.689	0.621

Note: This table presents the results of the parallel trend test. We omitted the dummy variable for the year before the event, which serves as the benchmark period.

Table 6
Robustness tests: heterogeneity-robustness estimate.

	Envidq	*Ascore*
	(1)	(2)
Baseline estimators/TWFE method	0.122**	0.619***
	(2.330)	(3.313)
*Alternative estimators/*Callaway and Sant'Anna (2021)*' method*	0.097*	0.396*
	(1.67)	(1.73)
Controls $_{i,t}$	YES	YES
Observations	24,167	24,167

Note: This table presents the regression results obtained from different estimation methods of the staggered DID model, the baseline model shown as Model (1) in the text. Detailed variable definitions are provided in Appendix C. T-statistics based on standard errors are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

the estimator proposed by Callaway and Sant'Anna (2021). The second row of Table 6 reports alternative point estimates using this method. The estimated coefficients on *Policy* remain comparable in magnitude to our baseline estimates and are statistically significant. Even when accounting for variations in treatment timing, the results consistently indicate that the NPP policy leads to an increase in firms' EID levels. This further reinforces the robustness of our baseline findings, confirming that they are not excessively influenced by heterogeneity in treatment timing.

4.3.3. Placebo tests

To further validate our results, we conduct a placebo test by randomly selecting a group of pseudo-treated firms while designating the remaining firms as pseudo-control firms. We then replicate the analysis in Table 4 for 1000 iterations. Fig. 2 illustrates the distribution of the 1000 estimated coefficients on Policy, with results using *Envidq* and *ascore* as proxies for firms' EID levels shown at the top and bottom, respectively. Most *p*-values from these regressions, where treatment was randomly assigned, are not statistically significant. This finding mitigates concerns about self-selection bias and confirms that our conclusions are not driven by random chance. The evidence strongly supports the conclusion that the NPP policy leads to an increase in the EID levels of treated firms.

4.3.4. Replacement of key variables

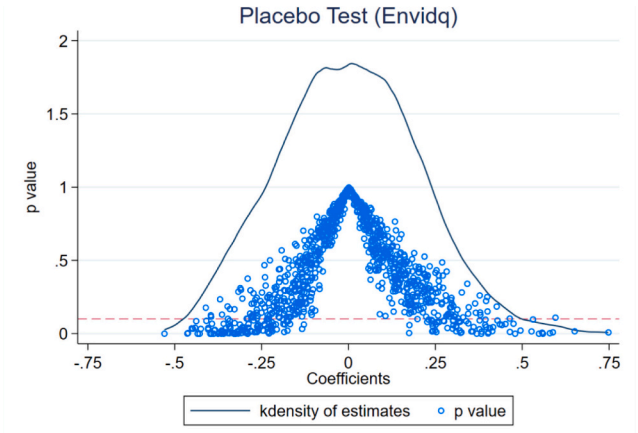
Given the potential lagged impact of the NPP policy, we further examined its effect on firms' EID levels by redefining the explanatory variable Policy. If the NPP policy was enacted in the first half of the year, *Policynew* was set to 1 for the current and subsequent years. If the NPP policy was enacted in the second half of the year, *Policynew* was set to 0 for the current year and 1 for the following and subsequent years.

Panel A of Table 7 presents the regression results of Model (1) using *Policynew* as an alternative explanatory variable. The coefficients on *Policynew* are consistently positive and significant at the 5 % level or higher, regardless of whether *Envidq* or *ascore* was used as the dependent variable. These results reinforce our previous finding that firms affected by the NPP policy exhibit significantly higher EID levels following its implementation.

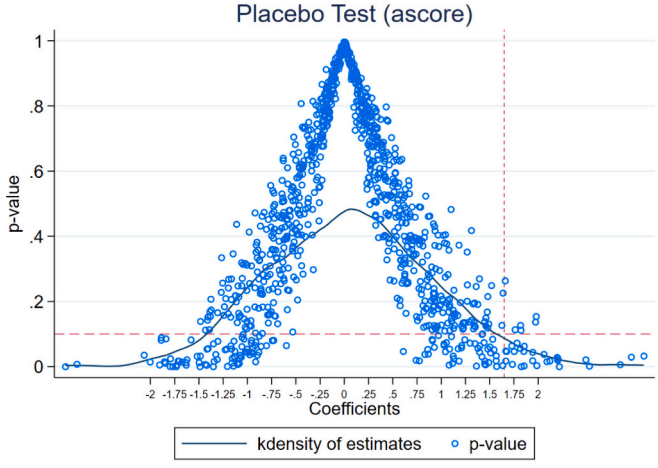
4.3.5. Excluding large cities that are regional centers

Given the differences in population density and industrial development between large cities and small to mid-sized cities, we further tested the robustness of our results by excluding sample data from Chengdu, Chongqing, and Xi'an, which are major regional centers. Additionally, firms located in these large cities constitute a relatively high proportion of the treatment group. Excluding them allowed us to examine whether the NPP policy's effect on EID levels remains robust when focusing on smaller cities.

Panel B of Table 7 reports the regression results after excluding these large cities. The coefficient on *Policy* remains positive and statistically



(a)



(b)

Fig. 2. Placebo test results, including *p*-values and *kdensities* of estimates from the regression 1,000 times by randomly generating the treatment group: (a) *Envidq* EID level measures, (b) *ascore* EID level measures.

significant at the 1 % level, further supporting the robustness of our baseline findings.

4.3.6. PSM

To address potential biases arising from differences in firm characteristics between the treated and control groups, we implemented PSM to re-evaluate the robustness of our baseline results. We used all control variables as covariates and applied 1:10 nearest-neighbor caliper matching and radius matching with a caliper distance of 0.1.

Table 8 presents the regression results using these PSM samples. The coefficient on the NPP policy indicator (*Policy*) remains significantly positive across all specifications, confirming that firms affected by the NPP policy exhibit higher EID levels. These findings align closely with our previous results. In summary, the robustness of the PSM sample results suggests that differences in firm characteristics between the treated and control groups do not drive our baseline findings.

5. Further analysis

We further investigated the impact of the NPP policy on corporate EID levels. In the previous discussion, we argued that increased public expectations, investor attention, and government regulation drive firms to enhance their EID levels to alleviate the "pressure" they face. However, how does the NPP policy affect firms that already experience a higher level of pressure.

For instance, due to mandatory government disclosure requirements for environmental information, heavily polluting firms already maintain relatively high EID levels, leaving them with limited room for further improvement. We anticipated that these firms would be less affected by the NPP policy. To explore this issue further, we examined three distinct sources of pressure on firms: green investor concerns, the level of

Table 7
Robustness tests.

Panel A: Replacement of key variables		
Variables	*Envidq*	*Ascore*
	(1)	(2)
Policynew	0.130**	0.618***
	(2.438)	(3.238)
Controls $_{i,t}$	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Observations	27,828	27,828
Adj-R^2	0.689	0.679

Panel B: Excluding large cities that are regional centers		
Variables	*Envidq*	*Ascore*
	(1)	(2)
Policy	0.235***	0.700***
	(3.543)	(3.065)
Controls $_{i,t}$	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Observations	27,149	27,149
Adj-R^2	0.689	0.622

Note: Panel A replicates the regressions in Table 4 while alternatively identifying firms affected by the NPP policy. If the NPP policy was enacted in the first half of the year, *Policynew* = 1 for the current year and subsequent years, and if the NPP policy is enacted in the second half of the year, the *Policynew* = 0 for the current year and 1 for the following year and subsequent years. Panel B replicates the regressions in Table 4, and observations of sample firms in Chongqing, Xi'an, and Chengdu were excluded because they are large cities in regional centers and are a large proportion of the sample. Detailed variable definitions are provided in Appendix C. The firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 8
Robustness tests: propensity score matching.

Variables	*Envidq*	*Ascore*
	1:10 nearest-neighbor caliper matching	
	(1)	(2)
Policy	0.122**	0.619***
	(2.330)	(3.313)
Controls	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Observations	9898	10,459
Adj-R^2	0.689	0.621

Note: This table presents the results of replicating baseline regressions in Table 4 using the propensity score matched samples. All control variables as covariates were treated for 1:10 nearest-neighbor caliper matching and radius matching with the caliper distance of 0.1. Firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

investor interaction, and whether a firm operates in a heavily polluting industry.

5.1. Green investors

Our previous analyses suggested that investor attention partially influences firms' EID levels. However, institutional investors hold significant financial advantages and possess stronger information access capabilities compared to retail investors (Campbell & Kracaw, 1980). To further analyze this effect, we divided investors into institutional and retail investors to examine their respective impacts on firms' EID levels.

Green investors specifically invest in firms that align with their ethical criteria. As a unique category of institutional investors, green investors exhibit stronger environmental concerns than other institutional investors. Prior research indicates that green investors help steer firms toward environmental governance (Shi, Wang, Jiang, Yang, & Sui, 2024) and encourage green innovation (Tang, Tong, & Chen, 2024). They are also more likely to support firms investing in environmentally friendly projects.

We suspected that firms without green investors would exhibit weaker environmental performance and, in particular, lower EID levels. Therefore, these firms have greater potential for improvement in their EID levels. The implementation of the NPP policy compensates for the lack of investor-driven incentives in firms without green investors, as suggested by our previous analyses. Consequently, we expected that firms without green investors will be more significantly affected by the NPP policy, leading to a greater increase in their EID levels. Following Tang et al. (2024), we identified whether a firm has green investors based on the following steps:

- Obtaining fund information from the CSMAR database.
- Searching for keywords in the fund's Investment Objective and Investment Scope. If the information indicates that the fund invests in environmental protection, ecology, green, or new energy development, the fund is classified as a green investor.
- Identifying firms with green investors.

Based on this classification, we constructed an indicator variable, *instattention*, which is set to 1 if the firm has green investors and 0 otherwise. Table 9 presents the baseline model regression results for these two groups. The coefficient of *Policy* remains positive and statistically significant at the 5 % level or higher for firms without green investors (Columns (2) and (4)). However, in Columns (1) and (3), the coefficient of *Policy* is insignificant for firms with green investors. Additionally, the *p*-values reported in the bottom row demonstrate that the difference in the coefficients on *Policy* between the two groups is statistically significant. These results indicate that listed firms without green investors are more strongly influenced by the NPP policy than those with green investors.

Table 9
Heterogeneity analysis: green investor attention.

Variables	*Envidq*		*Ascore*	
	instattention = 1	*instattention = 0*	*instattention = 1*	*instattention = 0*
	(1)	(2)	(3)	(4)
Policy	0.047	0.135**	0.471	0.626***
	(0.478)	(2.191)	(1.099)	(2.978)
Diff	0.070		0.090	
Controls $_{i,t}$	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	8664	19,164	8664	19,164
Adj-R^2	0.724	0.682	0.623	0.615

Note: This table presents the results of heterogeneity analysis for institutional investor attention. We measured institutional investor attention by whether a firm has green investors. The whole sample was partitioned into two subgroups based on *instattention*. *Diff* denotes the empirical *p*-values from Fisher's permutation test. Detailed variable definitions are provided in Appendix C. The firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

5.2. Retail investor

In addition to green investors, other investors also closely monitor corporate disclosure. For retail investors, information visibility is a key factor in making investment decisions. However, retail investors face challenges in accessing comprehensive stock information due to the costs associated with searching for and processing information (Wen, Xu, Ouyang, & Kou, 2019). As a result, retail investors actively focus on firm disclosure to mitigate information asymmetry.

To measure retail investor attention, prior studies often used metrics, such as the number of news releases on listed firms' *Twitter* feeds and the number of discussion posts on investment platforms like Yahoo Finance. In China, official interactive investor platforms have been established by the Shenzhen Stock Exchange and the Shanghai Stock Exchange. These platforms allow any investor to submit questions to firms' managers, who may choose to respond. The interactions are publicly visible, and the primary users of these platforms are retail investors. These platforms provide a direct and transparent way for retail investors to interact with firms' management.

Investor–firm interactions can enhance market information efficiency and influence capital market behavior. Specifically, such interactions have been shown to improve the accuracy of firm earnings forecasts (Bartov, Faurel, & Mohanram, 2018), enhance equity liquidity (Blankespoor, Miller, & White, 2014), and increase firms' disclosure levels (Wong, Yu, Zhang, & Zhang, 2024).

Given the effects of investor interaction, we expected that firms with lower levels of interaction would generally exhibit lower EID levels. Consequently, these firms may be more significantly affected by the NPP policy, as the policy would serve as an external driver to enhance their EID levels.

To empirically test this hypothesis, we obtained data on the number of questions asked by investors (*asked number*) and the number of firm responses (*responded number*) from investor interaction platforms. Both variables were winsorized at the 1st and 99th percentiles to control for outliers, and we separately examine their effects on firms' EID levels.

First, we divided the sample into two groups based on the mean value of *asked number*. A firm with an above-average number of investor questions was classified as having a higher interaction level. We constructed a new indicator variable, *retailattentionQ*, which equals 1 if the firm has a higher interaction level and 0 otherwise. Panel A of Table 10 presents the baseline model regression results for the two groups. Columns (1) and (3) show that the impact of the NPP policy on firms' EID levels is not significant for firms with a higher interaction level. In contrast, Columns (2) and (4) reveal that the NPP policy has a significant and positive impact on the EID levels of firms with a lower interaction level.

Second, we divided the sample into two groups based on the mean value of *responded number*. Using the same methodology as with *asked number*, we constructed another indicator variable, *retailattentionR*, to classify firms with higher or lower interaction levels. Panel B of Table 10 presents the corresponding baseline model regression results, which align with the findings from *asked number*.

Furthermore, the *p*-values reported in the bottom row of both Panels A and B confirm that the difference in the coefficients on Policy between the two groups is statistically significant. These results indicate that the impact of the NPP policy on corporate EID levels is more pronounced

Table 10
Heterogeneity analysis: retail investor attention.

Panel A: Dividing subsamples based on retailattentionQ index				
Variables	*Envidq*		*Ascore*	
	retaliattentionQ = 1	*retaliattentionQ* = 0	*retaliattentionQ* = 1	*retaliattentionQ* = 0
	(1)	(2)	(3)	(4)
Policy	0.048	0.184**	0.270	0.600**
	(0.619)	(2.333)	(0.963)	(2.115)
Diff	0.010		0.089	
Controls$_{i,t}$	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	13,927	13,901	13,927	13,901
Adj-R^2	0.696	0.702	0.635	0.630

Panel B: Dividing subsamples based on retailattentionR index				
Variables	*Envidq*		*Ascore*	
	retailattentionR = 1	*retailattentionR* = 0	*retailattentionR* = 1	*retailattentionR* = 0
	(1)	(2)	(3)	(4)
Policy	0.072	0.179**	0.400	0.610**
	(0.933)	(2.365)	(1.398)	(2.187)
Diff	0.070		0.060	
Controls$_{i,t}$	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	13,968	13,860	13,968	13,860
Adj-R^2	0.724	0.702	0.623	0.633

Note: This table presents the results of heterogeneity analysis for retail investor attention. The whole sample was partitioned into two subgroups based on the *retailattentionQ* and *retailattentionR* indices. *Diff* denotes the empirical *p*-values from Fisher's permutation test. Detailed variable definitions are provided in Appendix C. The firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

among listed firms with lower interaction levels, regardless of whether *Envidq* or *ascore* was used as the dependent variable.

5.3. Heavily polluting industries

Firms with different levels of pollution are subject to varying degrees of regulation, leading to differences in their exposure to the NPP policy. Prior to the implementation of the NPP policy, China had already enacted several laws and regulations governing EID requirements for heavily polluting industries. For example, the "Guidelines on EID for Listed Firms (Draft for Public Comments)" were introduced in 2010, and the Law of the People's Republic of China on Environmental Protection was implemented in 2015. As a result, firms in heavily polluting industries were already subject to greater scrutiny and regulatory oversight concerning EID, whereas firms in non-heavily polluting industries received relatively less attention and regulation regarding disclosure practices.

We inferred that, prior to the implementation of the NPP policy, firms in non-heavily polluting industries likely had lower EID levels compared with their heavily polluting counterparts. However, after the introduction of the NPP policy, firms in non-heavily polluting industries became subject to increased regulatory attention and public scrutiny. Consequently, these firms may have been more motivated to improve their EID levels to enhance their reputation and demonstrate compliance. Therefore, we expected that firms in non-heavily polluting industries would be more significantly affected by the NPP policy than those in heavily polluting industries.

To test this hypothesis, we classified heavily polluting industries based on the Environmental Disclosure Rules issued by SEPA. These industries include 16 categories, such as coal, metallurgy, and chemicals. We then divided the sample into two groups: firms in heavily polluting industries (*Pollute* = 1) and firms in non-heavily polluting industries (*Pollute* = 0).

Table 11 presents the regression results for the baseline model across these two groups. For firms in heavily polluting industries, the coefficient of *Policy* is statistically insignificant, regardless of whether *Envidq* or *ascore* was used as the dependent variable. In contrast, for firms in non-heavily polluting industries, the coefficient of *Policy* is consistently positive and statistically significant at the 5 % level or higher. Moreover, the *p*-values in the bottom row confirm a statistically significant

Table 11
Heterogeneity analysis: heavily polluting industries.

Variables	*Envidq*		*Ascore*	
	Pollute = 1	*Pollute* = 0	*Pollute* = 1	*Pollute* = 0
	(1)	(2)	(3)	(4)
Policy	0.072	0.149**	0.425	0.697***
	(0.818)	(2.310)	(1.216)	(3.203)
Diff	0.091		0.091	
Controls $_{i,t}$	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	8080	19,748	8080	19,748
Adj-R^2	0.648	0.678	0.576	0.611

Note: This table presents the results of heterogeneity analysis based on heavily polluting industries. The whole sample was partitioned into two subgroups based on whether the firm is in a heavily polluting industry. *Diff* denotes the empirical *p*-values from Fisher's permutation test. Detailed variable definitions are provided in Appendix C. The firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 12
Economic effects.

Variables	*TQA*	*TQB*
	(1)	(2)
Policy	0.123**	0.132**
	(2.153)	(2.092)
Controls $_{i,t}$	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Observations	27,828	27,828
Adj-R^2	0.658	0.034

Note: This table presents the impact of the NPP policy on the market value of firms as measured by Tobin's Q. Detailed variable definitions are provided in Appendix C. The firm and year fixed effects are included in all columns. T-statistics based on standard errors clustered by firm are presented in parentheses. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

difference in the coefficients on Policy between the two groups.

These findings indicate that firms in non-heavily polluting industries are more significantly impacted by the NPP policy than firms in heavily polluting industries.

Overall, the effect of the NPP policy on corporate EID levels is more pronounced for firms without green investors, with lower levels of retail investor interaction, and in non-heavily polluting industries. These findings suggest that a firm's EID level is strongly influenced by the level of external pressure it faces. This further reinforces the causal interpretation of our main results.

6. Economic consequences

The NPP policy plays a crucial role in biodiversity protection, ecosystem sustainability, and the promotion of synergistic economic and ecological development. At the same time, it influences firms' green governance and environmental actions. Based on our previous analyses, we find that the NPP policy significantly enhances firms' EID levels. EID is essential for investors and the public to access accurate environmental information about firms. Numerous studies have demonstrated that disclosure can positively impact firms' market value from multiple perspectives (Andrikopoulos & Kriklani, 2013; Pedron, Macagnan, Simon, & Vancin, 2021; Plumlee, Brown, Hayes, & Marshall, 2015).

In this section, we examine the effect of the NPP policy on firms' market value. Because the policy has led to a significant increase in EID levels, firms that disclose environmental information can reduce information asymmetry between themselves and investors. A high level of EID enhances a firm's environmental reputation, strengthens competitiveness, and ultimately increases market value. Therefore, we expect that the NPP policy positively affects firms' market value.

We measured firms' market value using Tobin's Q and employed two distinct proxies for robustness:

- TQA, calculated as the market value of equity divided by total assets.
- TQB, calculated as the market value of equity divided by total assets, excluding net intangible assets and net goodwill.

To test our hypothesis, we specified the following model:

$$Marketvalue = \alpha_0 + \alpha_1 Policy + \alpha_2 Controls + Firm + Year + \varepsilon_{i,t} \quad (2)$$

where *Marketvalue* represents the proxies for firms' market value (*TQA* and *TQB*). The definitions of all other variables align with those in Model (1). We incorporated firm and year fixed effects to account for time-specific shocks and unobservable firm characteristics that might influence the results. Additionally, we clustered standard errors at the firm level to address potential residual correlations. Finally, $\varepsilon_{i,t}$ represents the random disturbance term in the model.

Table 12 presents the regression results. The coefficients on *Policy* are positive and statistically significant at the 5 % level in all columns, regardless of whether *TQA* or *TQB* is used as the dependent variable. These findings confirm our expectations and indicate that the NPP policy significantly enhances firms' market value, leading to positive economic consequences.

7. Conclusion

We utilized the NPP policy in China as an exogenous shock to biodiversity conservation and investigate the causal relationship between biodiversity conservation and firms' EID levels. Employing a staggered DID model, we identified a causally significant improvement in the EID levels of firms affected by the NPP policy compared with unaffected firms. This finding is robust across multiple validation methods, including robustness tests, placebo tests, and parallel trend tests. Additionally, we implemented alternative DID estimators to address potential concerns related to heterogeneous treatment effects.

Further analysis revealed that the impact of the NPP policy on corporate EID levels is more pronounced in firms without green investors, with lower levels of retail investor interaction, and in non-heavily polluting industries. These firms initially exhibited lower EID levels due to reduced regulatory oversight, lower public pressure, and weaker investor attention prior to the implementation of the NPP policy. As a result, they experienced a more substantial impact following the policy's implementation. These findings are consistent with our baseline regression results.

Finally, we examined the economic consequences of the NPP policy and found that it significantly enhances firms' market value. Our study provides valuable insights for corporate decision-making and government regulation in the face of ecological challenges, offering a systematic analysis of how biodiversity conservation influences corporate environmental disclosure.

Authors' statement

We hereby declare that no generative AI or AI-assisted technologies were utilized in the research or writing process of this manuscript. The research design, data analysis, interpretation of results, and manuscript preparation were conducted entirely by the authors without the use of any AI tools.

Declaration of competing interest

None.

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Appendix A. Information about the NPP policy

Panel A: Basic information about the national park pilots

No.	Name	Startup time	Representative species	Area/km^2
1	Three River Source	2016.3	*Snow leopard; Tibetan Antelope*	123,100
2	Shennongjia	2016.5	*Snub-nosed monkey*	1170
3	Qiantang River Source	2016.6	*Black fronted Muntjac;Abies beshanzuensis M. H. Wu*	252
4	Wuyi Mountain	2016.6	*Cabot's Tragopan*	1001
5	Potatso	2016.6	*Black-necked Crane*	602
6	Nanshan	2016.7	*Fea's Muntjac;Abies ziyuanensis* L. *K. Fu & S.* L. *Mo*	636
7	Giant Panda	2017.1	*Giant Panda*	27,134
8	Northeast Tiger & Leopard	2017.1	*Amur Tige; Amur Leopard*	14,612
9	Qilianshan	2017.9	*Snow leopard*	50,237
10	Hainan Tropical Rainforest	2019.7	*Hainan Gibbon*	4403

Panel B: Characteristic initiatives of national parks for biodiversity conservation

Pilot area	Main practices
Three River Source	Integrate management and law enforcement agencies and develop green eco-industries in neighboring cities
Shennongjia	Regional cooperation ; Transform ecologically harmful industries
Qiantang River Source	Promote inter-provincial protection policies
Wuyi Mountain	Build eco-tea industry, eco-tourism and other public wealthy industry; Collaborative governance between the national park authorities and local governments
Potatso	First to explore the franchise system
Nanshan	Ecological compensation mechanism
Giant Panda	Wide participation of residents; Strict implementation of ecological compensation policies such as returning farmland to forests and public welfare forests
Northeast Tiger & Leopard	Guide residents to transform their way of production and life
Qilianshan	Closure of the mining industry
Hainan Tropical Rainforest	Development of green industries in national parks and surrounding areas in accordance with local conditions

Panel C: Representative ecological achievements of the national park pilots

Achievements	National park	Specific reflection
Ecosystem services remain stable or have been improved	Qilianshan	Aboveground vegetation in grassland ecosystems increased
	Three River Source	Wetland ecosystems and the amount of water conservation in them increase by more than 6 % per year on average
	Qiantang River Source	The air quality index exceeds 98.2 %, and the water quality index is 100 %
Illegal acts and damages have been effectively curbed	Northeast Tiger & Leopard	The degree of human interference significantly reduced, including illegal activities such as logging and poaching
	Qilianshan	Illegal and criminal activities have been severely limited, and the number of vandalism cases has dropped significantly
	Wuyi Mountain	Rectification of illegal tea plantation 3.11 km^2
Species' populations have increased or their habitats have been restored	Northeast Tiger & Leopard	There are 10 newly bred tiger cubs and seven leopard cubs, and the distribution range is gradually expanding
	Qilianshan	Snow leopards have been observed to expand their range and move down into coniferous forests
	Giant Panda	The area of suitable habitat for giant pandas increased by 1.6 %, nine giant panda corridors and seven wildlife corridors were completed, and 128.5 km^2 of vegetation was restored
	Three River Source	The disturbance of human activities has decreased significantly, the Tibetan antelope population has recovered, and the traces of rare and endangered wild animals have increased
	Shennongjia	According to the migration ability of different types of species, 25 wildlife passages in three categories have been built, effectively alleviating the isolation impact of highways on wild animals such as golden monkeys
New species are discovered, and new distributions are recorded	Hainan Tropical Rainforest	19 new species were discovered
	Potatso	The range of black-necked cranes expanded from Bita Sea to Shendu Lake and Miritang, and the stable population increased from 28 to 38 (2016–2019). The distribution of Buxbaumiapunctata, a rare and endangered moss, was detected for the first time
	Nanshan	Two new species of plants and four new species of animals were found; 447 species of vascular plants and 68 species of vertebrates were recorded

Appendix B. Contents of EID level

Panel A: Measure of Envidq

Item
Soft Disclosure Items (max score is 22)
S1 Environmental Management Disclosure (max score is 16)
1. Environmental protection concept (0–2)

(*continued on next page*)

(*continued*)

Panel A: Measure of Envidq
Item
2. Environmental goals (0–2)
3. Environmental protection management system (0–2)
4. Environmental protection education and training (0–2)
5. Special action on environmental protection (0–2)
6. Environmental event emergency response mechanism (0–2)
7. Environmental protection honor or award (0–2)
8. "three simultaneities" system (0–2)
S2 Environmental Information Disclosure Media (max score is 6)
1. Annual Report of Listed Firm (0–2)
2. Social Responsibility Report (0–2)
3. Environmental Report (0–2)
Hard Disclosure Items (max score is 28)
H1 Environmental Certification Disclosure (max score is 4)
1. ISO 14001 Certification Status (0–2)
2. ISO 9001 Certification Status (0–2)
H2 Environmental Liability Disclosure (max score is 12)
1. Wastewater Discharge Volume (0–2)
2. Chemical Oxygen Demand Emission (0–2)
3. Sulfur Dioxide (SO2) Emission (0–2)
4. Carbon Dioxide Emission (0–2)
5. Emission of Flue Dust and Dust (0–2)
6. Industrial Solid Waste Emission (0–2)
H3 Environmental Performance and Governance Disclosure (max score is 12)
1. Air Pollution Control and Reduction (0–2)
2. Wastewater Pollution Control and Reduction (0–2)
3. Dust and Flue Dust Control (0–2)
4. Utilization and Disposal of Solid Waste (0–2)
5. Noise, Light Pollution, and Radiation Control (0–2)
6. Implementation of Cleaner Production (0–2)

Panel B: Measure of ascore
Item
1. Information related to ISO environmental system authentication
2. Lawsuit, atonement, penalty, and bounty related to environmental protection
3. Influence of government environmental protection policy
4. Firm's environmental protection policies, strategies, and goals
5. Firm's environmental investment expenditure for technologies development
6. Government appropriated funds allowance and tax abatement related to the environment
7. Disposal and treatment of generated waste, recycling, and integrated utilization of waste products
8. Construction and operation of environmental improvement
9. Other environmental-related information, such as environmental education, tree planting, biodiversity conservation, and other environmental projects to promote the public welfare

Note: Panel A presents the measure of *Envidq*. This index includes hard and soft disclosure categories and can be divided into five subsections and 25 items. Hard disclosure refers to information based on concrete evidence or data, and soft disclosure is disclosed by firms' own narration or explanation, according to Verrecchia (1983). All terms are based on the Global Reporting Initiative guidelines. Panel B presents the measure of *ascore*. This index includes nine items based on the Environmental Disclosure Rules issued by the China SEPA in 2007.

Appendix C

Table C1
Variable definitions.

Dependent variables	
Envidq	Environmental information disclosure level, measured as the natural logarithm of the EID level according to Appendix B Panel A after adding 1.
ascore	Environmental information disclosure level, measured as the EID level according to Appendix B Panel B.
Independent variables	
Policy	A dummy variable, used to distinguish whether the firm is affected by the NPP policy. If a firm's location is in a neighboring city of the national park pilot in year *t*, the *Policy* of this firm is taken as 1 in year *t* and thereafter, 0 otherwise.
Control variables	
Size	Firm size, measured as the natural logarithm of total assets of the firm
Lev	Financial leverage, measured as total debt divided by total assets of the firm
ROA	Return on assets, measured as net profits divided by the total assets of the firm

(*continued on next page*)

Table C1 (*continued*)

Dependent variables	
PPE	Asset tangibility, measured as net value of fixed assets and inventory divided by total assets of the firm
Cash	Cash, measured as cash and cash equivalents divided by total assets of the firm
Boardsize	Board size, measured as the natural logarithm of number of board members of the firm
ManagerHold	Management shareholding, measured as the percentage of shares held by all board members and the executive
Expend	Investment, measured as the cash paid for the acquisition of long-term assets divided by total assets
Indp	Percentage of independent directors, measured as the number of independent directors divided by number of board of directors
age	Firm age, measured as the natural logarithm of firm age in the current year
Dual	An indicator variable, equals 1 if the firm's board chair is also the CEO and 0 otherwise
Other variables	
Policynew	Indicator variable: equals 1 if the NPP policy is enacted in the first half of the year for the current year and subsequent years, and if the NPP policy is enacted in the second half of the year, the *Policynew* equals 0 for the current year and 1 for the following year and subsequent years
instattention	Indicator variable: equals 1 if the firm has green investors and 0 otherwise
retailattentionQ	Indicator variable: equals 1 if the retail investors ask more questions on the investor interactive platforms in China than the median and 0 otherwise
retailattentionR	Indicator variable: equals 1 if the firm responds to more questions on the investor interactive platforms in China than the median and 0 otherwise
Pollute	Indicator variable: equals 1 if the firm is in a heavily polluting industry and 0 otherwise. Heavily polluting industries are mainly defined in accordance with the Management List of Industry Classification for Environmental Verification of Listed Firms formulated by the Ministry of Environmental Protection in 2008 and the Guidelines for Disclosure of Environmental Information of Listed Firms, and include mainly coal, metallurgy, chemical and other 16 types of industries
TQA	Market value of equity/total assets of the firm
TQB	Market value of equity/(total assets − net intangible assets – net goodwill)

Table C2
Glossary.

Term	Definition
Biodiversity Conservation	The protection of the variety of life on Earth, including the diversity within species, between species, and of ecosystems. It aims to preserve the complex interrelationships among living organisms and their environments.
Corporate Environmental Information Disclosure (EID)	The practice of companies voluntarily or mandatorily disclosing information related to their environmental performance, risks, and management strategies. In this study, EID levels are measured using two proxies: *Envidq* and *ascore*.
The National Park Pilot (NPP) Policy	A policy initiative in China aimed at establishing national parks to protect critical ecosystems and biodiversity. The policy is implemented in phases across different regions and serves as an exogenous shock to examine its impact on corporate behavior.
Environmental Legitimacy	The alignment of a company's environmental performance with societal expectations. It is crucial for companies to maintain a positive image and reputation in the face of environmental challenges.
State Environmental Protection Administration (SEPA)	The Chinese government agency responsible for formulating and implementing environmental policies and regulations.
Global Reporting Initiative (GRI)	An international organization that provides guidelines for sustainability reporting, including environmental disclosures. It is used as a basis for constructing the *Envidq* measure in this study.

Data availability

Data will be made available on request.

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