Pacific-Basin Finance Journal 92 (2025) 102787

Contents lists available at ScienceDirect

Pacific-Basin Finance Journal

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

Beyond greenwashing: How does firm-level biodiversity disclosure affect corporate sustainability strategy?☆

Feng He [a], Chunyang Wei [a], Brian Lucey [d,e], Jing Hao [b,c,*]

[a] School of Finance, Capital University of Economics and Business, 100070 Beijing, China
[b] School of Accounting, Capital University of Economics and Business, 100070 Beijing, China
[c] Faculty of Finance, City University of Macau, Macau, China
[d] Trinity Business School, Trinity College Dublin, Dublin, Ireland
[e] Paris School of Business, Paris, France

ARTICLE INFO

Keywords:
Firm-level biodiversity disclosure
Corporate sustainability
Green washing

ABSTRACT

This paper examines the impact of firm-level biodiversity disclosure on corporate sustainability strategy. Using a sample of Chinese A-share listed companies from 2009 to 2022, we find that a higher level of firm-level biodiversity disclosure is associated with a reduction in corporate green washing tendency, which is measured by the ESG report textual similarity. This effect is mainly achieved through reduction in information asymmetry and the promotion of green transition. Cross-sectional heterogeneity test reveals that the impact is more pronounced in firms with lower media coverage, firms in non-heavy-polluting industries, firms with weaker environmental regulations pressure, and firms with lower managerial myopia. Further analysis shows that increased firm-level biodiversity disclosure also enhances the tone of ESG reports and alleviate corporate financing constraints. This paper contributes to a better understanding of the economic impacts of environmental disclosure and expands the literature on the determinants of corporate sustainability strategy.

1. Introduction

In recent years, the Earth has been grappling with a severe biodiversity crisis, posing significant risks and challenges to human society. As integral components of the global economy, firms are not immune to the impacts of biodiversity-related risks. On one hand, firms are exposed to physical risks stemming from biodiversity loss. For example, resource-dependent firms may encounter substantial cost increases or even supply chain disruptions due to the depletion of natural resources or the destroy of critical ecosystems. On the other hand, firms also face transition risks arising from regulatory changes prompted by biodiversity degradation (Giglio et al., 2023; Flammer et al., 2025). Biodiversity risk has emerged as a critical concern for investors and other stakeholders, who closely monitor how firms address these risks and evaluate their long-term sustainability and growth prospects, thereby influencing investment decisions and firm valuations (Chen et al., 2021; Ma et al., 2024; Garel et al., 2024; Ali et al., 2024).

With the global proliferation and growing emphasis on sustainable development, corporate ESG disclosure and practices have emerged as a prevailing trend, attracting significant attention from investors, policymakers, and academia (Pedersen et al., 2021; Hao

☆ This article is part of a Special issue entitled: 'ICMResponsibleScience25' published in Pacific-Basin Finance Journal.

* Corresponding author: School of Accounting, Capital University of Economics and Business, 100070 Beijing, China.
E-mail address: krystalh_hj@163.com (J. Hao).

https://doi.org/10.1016/j.pacfin.2025.102787
Received 5 March 2025; Received in revised form 13 April 2025; Accepted 22 April 2025
Available online 25 April 2025

et al., 2025). Effective ESG disclosure and practices not only enhancing a firm's external financing capacity and reduce capital costs (Cheng et al., 2014; Asimakopoulos et al., 2023), but also improving its market competitiveness (Tong and Yang, 2025), increasing stock liquidity (Li et al., 2025), and boosting financial performance (Liu et al., 2024). In recent years, the disclosure of ESG reports has become a widespread practice among firms. According to a KPMG sustainability report survey, approximately 80 % of large and middle-sized listed firms worldwide published ESG or CSR (Corporate Social Responsibility) reports in 2024.[1] However, due to the absence of standardized regulatory frameworks or disclosure guidelines, significant variations exist in the content, format, and style of these reports. Furthermore, the greenwashing concern in corporate ESG disclosure has become increasingly prevalent. Greenwashing refers to the practice of companies employing symbolic or misleading ESG disclosures to gain market and public recognition, thereby crafting a green image that often diverges from their actual practices (Bromley and Powell, 2012). While greenwashing may temporarily enhance corporate performance and financing capabilities, its long-term consequences are detrimental to both firms and society (Yu et al., 2020; Lee and Raschke, 2023). Consequently, the extent to which corporate ESG reports authentically and effectively communicate information to external stakeholders has become a pressing research question.

The activities related to biodiversity conservation are increasingly compromised by greenwashing behavior. For example, The European Commission earmarked EUR 66 billion through the Common Agricultural Policy (CAP) to fund biodiversity conservation initiatives from 2014 to 2020. Nevertheless, the European Court of Auditors' 2020 special report found that the Commission had omitted or concealed critical information on genetic diversity metrics in their past announcements, thereby obscuring the limitations of these investments.[2] Moreover, corporate investments in biodiversity credit markets—emerging financial mechanisms framed as biodiversity compensation tools—primarily function to signal purported environmental commitments. However, whether such biodiversity credit instruments can truly enhance biodiversity protection remains debatable. These greenwashing behavior makes it difficult for investors and the public to discern actual environment performance. While corporate ESG reports serve as a vital communication tool for firms to convey information to external stakeholders and address investor concerns, the textual similarity of ESG reports is a potential signal of corporate green washing. Against the backdrop of escalating global biodiversity risks, it is increasingly imperative to explore how corporate biodiversity risk management practices influence the quality and strategic approach of ESG report disclosures.

Previous research on corporate ESG disclosure has primarily focused on whether firms issue standalone ESG reports (Thorne et al., 2014; Chantziaras et al., 2020). However, research solely from the perspective of whether a report is issued fails to address the core concerns of the authenticity and effectiveness of ESG disclosure. Consequently, some scholars have begun to explore the factors that drive firms to manipulate the disclosure quality of ESG reports to engage in greenwashing. From an external perspective, existing research finds that the implementation of regulatory policies does not reduce corporate greenwashing; instead, it incentivizes firms to engage in greenwashing as a response to regulatory pressure (Tan et al., 2024; Zhang, 2023; Liao et al., 2023). Some studies have also identified the positive effects of policy reforms in curbing corporate greenwashing (Li et al., 2024). From an internal perspective, corporate governance plays a crucial role in mitigating greenwashing. Factors such as independent directors and institutional investor ownership could reduce greenwashing (Yu et al., 2020), promote technological innovation (Hao et al., 2024; Bai et al., 2025) and green innovation (He et al, 2024a). Conversely, investment, financing demands and high debt levels may increase firms' incentives for greenwashing in pursuit of economic benefits (Xia et al., 2023). Additionally, managerial attributes, including executive gender diversity (Nepal et al., 2025), educational background, have been found to influence corporate greenwashing behavior. Furthermore, disagreement in third-party ESG ratings can exacerbate greenwashing tendencies (Hu et al., 2023b). However, few studies have examined the impact of corporate risk management practices on greenwashing from biodiversity risk practices.

As one of the key approaches to biodiversity risk management, firm-level biodiversity disclosure refers to the disclosure of biodiversity-related content and information in annual reports. Since biodiversity-related content is closely related to ESG reporting, firms' biodiversity disclosure practices may influence their ESG reporting disclosure strategies. Specifically, firm-level biodiversity disclosure may have both positive and negative impacts on greenwashing tendency. On the one hand, biodiversity disclosure provides firms with a platform to demonstrate their biodiversity risk management practices. Prior research suggests that firm-level biodiversity disclosure is often aimed at sending positive signals to external stakeholders and obtaining reputational or financial rewards (Ali et al., 2024). However, if the disclosed biodiversity information is vague, it is difficult to play a signaling role and meet the information needs of investors. In this case, firms are more inclined to adopt proactive disclosure strategies to risk prevention and management (Yao et al., 2024), disclosing more specific biodiversity information (Adler et al., 2018). Thus, an increase in voluntary firm-level biodiversity disclosure can reduce information asymmetry. As information asymmetry diminishes, corporate opportunistic behavior becomes more detectable and financing costs decrease, leading to a decline in greenwashing tendency. Additionally, biodiversity disclosure encourages firms and managers to systematically assess and address biodiversity risks, thereby fostering green transitions, enhancing environmental performance and market competitiveness. When firms have good environmental performance, they are more inclined to disclose more specific and detailed information (Koh et al., 2023). Thus, increasing voluntary biodiversity disclosure can reduce information asymmetry, promote green transitions, and ultimately curb corporate greenwashing tendency. On the other hand, firm-level biodiversity disclosure also may be driven by passive legitimacy pressures. Given the high costs associated with implementing biodiversity practice, firms may focus on short-term economic benefits and use biodiversity disclosure as an impression management tool (Boiral, 2016; Adler et al., 2017) without undertaking substantive biodiversity actions (Wagner, 2023). In such cases, firms may engage in symbolic disclosure to mask their true performance. Furthermore, firm-level biodiversity disclosure could

[1] Data source: https://kpmg.com/dk/en/home/insights/2024/11/survey-of-sustainability-reporting-2024.html

[2] The full report is available at https://www.eca.europa.eu.

lead firms to imitate the biodiversity practices and disclosures of other benchmark companies. Thus, firm-level biodiversity disclosure may also increase greenwashing tendency. In summary, the impact of firm-level biodiversity disclosure on corporate greenwashing tendency remains to be tested.

Therefore, this paper empirically examines the relationship between firm-level biodiversity disclosure and corporate greenwashing tendency using a sample of A-share listed companies in China from 2009 to 2022. Consistent with existing research, this study applies text analysis by employing two natural language processing techniques, including the TF-IDF model and the Word Embedding neural network language model. These methods measure the ESG report textual similarity between firms and their industry peers, as well as between current and previous reports, serving as a proxy for corporate greenwashing tendency. Meanwhile, following He et al. (2024b), we conduct text mining on the annual reports disclosed by Chinese listed companies based on the biodiversity dictionary constructed by Giglio et al. (2023) to calculate the frequency of biodiversity-related keywords, which serves as a proxy for the level of firm-level biodiversity disclosure. Our baseline analysis shows that firm-level biodiversity disclosure significantly reduces ESG report textual similarity, indicating that increased firm-level biodiversity disclosure curbs greenwashing tendency and enhances the quality of ESG report disclosure. Subsequently, we conduct robustness tests using several methods, including applying instrumental variable, using propensity score matching, adding additional fixed effects, and substituting both dependent and independent variable measurement methods. The results confirm that the baseline regression findings remain robust.

We then investigate the mechanisms through which firm-level biodiversity disclosure curbs greenwashing tendency. Our analysis reveals that information asymmetry and green transition are two key mechanisms. On the one hand, firm-level biodiversity disclosure prompts firms to reduce information asymmetry, leading to higher financial and reputational costs associated with misrepresentation and fraud and lower financing cost, thus curbing the greenwashing tendency. On the other hand, firm-level biodiversity disclosure promotes green transition, enhances environment performance and market competitiveness, enabling management to disclose more firm-specific information, which further reduces the greenwashing tendency. Furthermore, we analyze the heterogeneous effects of external information environment, external regulatory pressures, and internal corporate motivations on the relationship between firm-level biodiversity disclosure and corporate greenwashing tendency. The results illustrate that the negative effects of firm-level biodiversity disclosure on corporate greenwashing tendency are more pronounced in firms with lower media attention, firms in non-polluting industries, firms with weaker environmental regulation presure, and firms with weaker managerial myopia. This suggests that improving the corporate information environment and fostering managerial attention to sustainable development play a crucial role in mitigating greenwashing, while external regulatory pressure diminishes this negative effect. Further analysis shows that increased firm-level biodiversity disclosure also enhances the optimism of ESG reports, which ultimately alleviates corporate financing constraints.

This paper contributes to the literature in the following two ways. First, this study expands the understanding of the economic consequences of biodiversity risk management practices. Existing literature has mainly focused on the economic consequences of corporate biodiversity risk exposure, including exacerbating corporate operational conditions (Kedward et al., 2023; Bach et al., 2025) and heightening corporate risks (Adamolekun, 2024; Liang et al., 2024a; Ma et al., 2024; Garel et al., 2024; Ali et al., 2024; Li et al., 2025). Subsequently, some studies have examined the economic consequences of biodiversity risk management practices (Tian and Chen, 2025; Shen and Zhou, 2024; Ahmad and Karpuz, 2024; Bassen et al., 2024). As one of the key approaches to biodiversity risk management, existing literature has also examined corporate biodiversity information disclosure. Firms may tend to disclose more biodiversity information to signal their performance in risk prevention and management (Adler et al., 2018). In contrast, firms may also use biodiversity disclosure as a means of impression management, engaging only in symbolic disclosure without taking substantive actions (Adler et al., 2017; Wagner, 2023). However, no studies have empirically examined the direct economic consequences of firm-level biodiversity disclosure. Applying the indexed proposed by He et al. (2024b), this paper analyzes the impact of firm-level biodiversity disclosure on corporate greenwashing tendency.

Secondly, this paper further enriches the literature on the determinants of corporate sustainability disclosure strategy. Existing research on ESG disclosure primarily focuses on whether firms issue independent ESG reports (Thorne et al., 2014; Alkhawaja et al., 2023; Chantziaras et al., 2020), while overlooking the authenticity of ESG reports. As stakeholder attention to corporate ESG disclosures continues to grow, the phenomenon of greenwashing in ESG reports has become more prominent. Thus, some literatures are increasingly examining the determinants of corporate greenwashing behavior. While the implementation of regulatory policies often incentivizes firms to adopt greenwashing strategies to mitigate regulatory pressure (Zhang, 2023; Tan et al., 2024; Liao et al., 2023), corporate governance also plays a crucial role in corporate greenwashing, such as the role of independent directors and institutional investor ownership (Yu et al., 2020), technological innovation (Bai et al., 2025), green innovation (He et al., 2024a), financing demands and high debt levels (Xia et al., 2023), managerial attributes (Nepal et al., 2025) and ESG disagreement (Hu et al., 2023b). However, few existing studies have examined the impact of corporate risk management practices on greenwashing tendency. Li et al. (2024) find that enhanced corporate environmental disclosure plays a critical role in curbing greenwashing. Therefore, this paper explores whether firm-level biodiversity disclosure, in the face of growing biodiversity risks, leads to lower greenwashing tendency and enhance the quality of corporate enviromental information disclosure.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature on biodiversity risk exposure, risk management practices, ESG information disclosure and greenwashing, and further proposes our hypothesis based on the relevant theories. Section 3 provides the empirical design, including the data, sampling process and research methods. Section 4 provides the empirical results, including the description, baseline regressions and robustness checks. Section 5 explores the potential mechanisms. Section 6 provides cross-sectional heterogeneity analysis and further examines the economic consequences. We finally conclude in Section 7.

2. Literature review

2.1. Corporate biodiversity risk

2.1.1. Impacts of corporate biodiversity risk exposure

Existing literature on corporate biodiversity risk has primarily focused on its impact from the perspective of corporate biodiversity risk exposure. Specifically, the literature can be divided into two main categories: the impact of biodiversity risk exposure on corporate operations and risks. Regarding corporate operations, as ecosystem destruction and the biodiversity crisis intensify, firms may face significant shortages of raw materials, leading to higher raw material costs, which in turn disrupt supply chains and result in supply chain interruptions (Kedward et al., 2023). In addition, biodiversity risks can increase the cost of selling goods, reduce profitability, and consequently lead to a significant decline in corporate performance (Bach et al., 2025). Regarding corporate risks, firms with higher exposure to biodiversity risks are more likely to experience higher risks of bankruptcy (Adamolekun, 2024) and stock price crashes (Liang et al., 2024a). As corporate risk increases, the market and investors demand higher risk premiums on stocks (Ma et al., 2024; Garel et al., 2024; Ali et al., 2024), which leads to financing constraints. The rise in financing costs further reduces corporate efficiency.

2.1.2. Impacts of biodiversity risk management practices

In the context of the rising global biodiversity risks, how firms respond to and manage biodiversity risks has gradually become a major focus. According to Carvalho et al. (2023), firms had already begun to strategically manage biodiversity risks before 2018, with approximately 29 % of firms implementing biodiversity-related management policies and practices. Existing literature has explored the moderating impact of biodiversity risk management practices on firms. For example, Tian and Chen (2025) find that exposure to biodiversity risks fosters corporate ecological innovation. Shen and Zhou (2024) discovere that biodiversity risk exposure has driven energy transitions across the markets. Additionally, corporate biodiversity risk exposure has been found to increase corporate cash holdings driven by preventive and risk management motivations (Ahmad and Karpuz, 2024). Furthermore, Bassen et al. (2024) observe that sustained biodiversity risk management efforts and practices help mitigate the impact of negative information, thus reducing corporate stock price crash risk.

As one of the key approaches to biodiversity risk management, existing literature has also examined corporate biodiversity information disclosure. Adler et al. (2018) study the information disclosure regarding biodiversity and endangered species among the world's top 150 wealthiest firms, finding that most firms provide limited disclosures on biodiversity and endangered species. Interestingly, firms with lower environmental impacts tend to disclose more biodiversity information, possibly because they are more inclined to adopt proactive disclosure strategies to signal their commitment to risk prevention and management. However, due to the high complexity of biodiversity-related actions, the rise in biodiversity risks may also lead firms to adopt passive risk management practices (Schaltegger et al., 2023). Existing studies indicate that there are no standardized metrics or requirements in place across countries to regulate corporate biodiversity risk management practices (Kennedy et al., 2023), and a comprehensive biodiversity risk management framework is lacking. As a result, firms may prioritize short-term economic gains while neglecting long-term ecological impacts, using biodiversity disclosure as an impression management tool (Boiral, 2016; Adler et al., 2017) rather than taking substantive biodiversity actions (Wagner, 2023). Currently, no studies have empirically examined the direct economic consequences of firm-level biodiversity disclosure on greenwashing tendency. Therefore, this paper employs the firm-level biodiversity disclosure data to analyze the impact of firm-level biodiversity disclosure on authenticity and effectiveness of ESG report.

2.2. ESG information disclosure and greenwashing

2.2.1. The theory of ESG information disclosure

Existing research on the motivations for corporate ESG disclosures is primarily based on four theoretical frameworks: stakeholder theory, legitimacy theory, signaling theory, and institutional theory. According to stakeholder theory, ESG disclosures are a key demand from stakeholders. To respond to the informational needs of investors and other stakeholders regarding non-financial information, firms are motivated to disclose their ESG practices (Michelon et al., 2020). In addition, signaling theory suggests that firms are motivated to convey their good ESG practices as a positive signal to external stakeholders. Since ESG practices are internal to the corporate, they are often difficult for external parties to directly observe or may pay high information acquisition costs. To reduce information asymmetry and convey positive signals, firms need to engage in proactive ESG disclosures (Zerbini, 2017; DesJardine et al., 2021). Thus, signaling theory provides another important motivation for corporate ESG disclosure. Furthermore, legitimacy requirements also represent a key motivation. Legitimacy is defined as a widely held perception or assumption that an entity's actions are desirable, proper, and appropriate within a given social system. To meet legitimacy demands, firms are compelled to disclose ESG information (Reber et al., 2022). Institutional theory posits that, when facing institutional legitimacy pressures, rational actors tend to imitate the behaviors of industry leaders in order to mitigate risk. Therefore, based on institutional theory, firms are motivated to imitate the ESG disclosures and practices of industry benchmarks (Xue and Hu, 2023).

2.2.2. Determinants of ESG information disclosure: Issuing standalone ESG reports

Existing literature on the determinants of ESG disclosure has primarily focused on whether firms issue independent ESG reports. Research indicates that ESG disclosure is mainly influenced by three categories of factors: corporate characteristics, board characteristics, and external environment. Regarding corporate characteristics, Thorne et al. (2014) discover a significant positive

relationship between corporate size and ESG disclosure, suggesting that larger firms are more likely to publish standalone social responsibility reports. Regarding board characteristics, independent directors with political backgrounds or diverse educational backgrounds and boards with gender diversity (Alkhawaja et al., 2023) have a positive impact on ESG reporting. Regarding external environment, religious beliefs significantly increase the likelihood of issuing standalone social responsibility reports, while regional corruption weaken this effect (Chantziaras et al., 2020).

2.2.3. Determinants of ESG information disclosure: Corporate greenwashing tendency

As stakeholder attention to corporate ESG disclosures continues to grow, the phenomenon of "greenwashing" in ESG reporting has become more prominent. Greenwashing refers to the practice of firms using symbolic or misleading ESG disclosures to gain market and public recognition, thereby creating a green image, while disconnecting ESG claims from actual practices (Bromley and Powell, 2012). In the short term, greenwashing can enhance corporate performance and financing capacity. However, the positive impact will gradually diminish in the long run (Lee and Raschke, 2023), while it simultaneously erodes corporate trust and investor appeal (Yu et al., 2020).

Some scholars examine the determinants that drive firms to manipulate ESG disclosure, thereby engaging in greenwashing. From an external perspective, existing research suggests that regulatory policies often fail to effectively curb greenwashing; instead, they may induce greenwashing as firms attempt to navigate regulatory pressures. Specifically, Zhang (2023) finds that in low-carbon pilot cities, mandatory carbon emission policies lead firms to adopt symbolic and selective disclosures without substantive efforts. Moreover, as carbon trading systems intensify financial constraints, they heighten greenwashing incentives (Tan et al., 2024). Similarly, due to financial constraints, the regulatory pressures from green finance regulations and subsidy shocks intensify firms' financial risks and liquidity constraints, thereby increasing their incentives for greenwashing. Hu et al. (2023a) find that environmental tax reforms do not significantly enhance corporate green innovation or environmental investment, suggesting that highly polluting firms tend to resort to greenwashing in the short term as a means of responding to environmental regulations. Liao et al. (2023) report that firms engage in more greenwashing after receiving financial report comment letters, and improvements in internal and external governance structures help mitigate such behaviors. However, some studies highlight policy reforms' effectiveness in mitigating greenwashing. For example, Li et al. (2024) find that the social responsibility reforms implemented by the State-owned Assets Supervision and Administration Commission (SASAC) significantly reduce greenwashing by improving firms' environmental disclosure and alleviating external regulatory pressure.

From an internal perspective, corporate governance factors play a crucial role in mitigating greenwashing. Yu et al. (2020) find that a higher proportion of independent directors and institutional investor ownership significantly reduce corporate greenwashing behavior. Additionally, corporate technological innovation also can curb greenwashing. The adoption of artificial intelligence technology contributes to lower cost, increased profits, enhanced productivity, and reduced information asymmetry, which significantly suppresses greenwashing (Bai et al., 2025). However, firms often prioritize economic interests over business ethics. Xia et al. (2023) reveal that investment and financing needs drive firms toward greenwashing, with higher debt levels further exacerbating such tendencies. Apart from firm-level characteristics, executive attributes also shape greenwashing behavior. Nepal et al. (2025) find that gender diversity in management teams can reduce greenwashing, as female executives enhance environmental awareness within leadership teams and foster green innovation. Moreover, disagreement in third-party ESG ratings introduce agency costs and exacerbate information asymmetry, thereby heightening the likelihood of greenwashing (Hu et al., 2023b). Despite these insights, limited research has examined the role of corporate biodiversity risk management practices in addressing greenwashing.

2.3. Hypothesis development

In recent years, the Earth has been facing a severe biodiversity crisis, which poses significant risks and challenges to human society (Giglio et al., 2023; Flammer et al., 2025). According to environmental scanning theory, firms typically monitor the external economic, social, legal, and political environments to adjust their strategic decisions in response to changes in these external conditions (Daft et al., 1988). Therefore, firms will conduct biodiversity risk management in order to adapt to the continuously changing external environment and address the challenges posed by biodiversity risks. As an essential approach of biodiversity risk management, firms engage in voluntary biodiversity disclosure, which reduces information asymmetry, drives green transition, and ultimately curbs greenwashing.

First, firm-level biodiversity disclosure can curb greenwashing behavior by reducing information asymmetry. Firm-level voluntary biodiversity disclosure can serve as a platform for firms to communicate their biodiversity risk management practices. On one hand, existing research indicates that corporate practices in environmental and social responsibility can enhance its reputation (Zhang et al., 2021), alleviate financing constraints (Asimakopoulos et al., 2023), and increase market value. As a result, firms actively engage in biodiversity risk management practices to send positive signals and obtain reputational or financial rewards (Adler et al., 2018; Ali et al., 2024). According to signaling theory, firms are motivated to signal their performance to external stakeholders, reducing information asymmetry and distinguishing themselves from other firms. However, if the relevant information disclosed by firms is mainly concentrated at the industry and market level, similar to peers or other firms in the market, the information asymmetry will be intensified, diminishing the effectiveness of signaling (Wu et al., 2024). To gain a competitive advantage and convey effective signals, firms tend to disclose proprietary or firm-specific information (Zerbini, 2017; DesJardine et al., 2021), thereby reducing information asymmetry. On the other hand, according to stakeholder theory, the disclosure of non-financial information is a key requirement from stakeholders (He et al., 2023), including detailed information on biodiversity risk management practices. Currently, biodiversity risk has become a key concern for investors and other stakeholders, who closely monitor firms' biodiversity risk management strategies to

assess the sustainability and growth potential, and make investment decisions (Ma et al., 2024; Garel et al., 2024). To respond to the informational needs of investors and other stakeholders, firms are motivated to disclose non-financial information in their ESG reports (Michelon et al., 2020). Hope et al. (2016) find that when firms provide more detailed disclosures on risk factors, market reactions tend to be more favorable. Therefore, firms tend to provide more specific biodiversity risk management practices in their disclosures, thereby mitigating information asymmetry.

It is proved that reducing information asymmetry helps curb corporate greenwashing. On the one hand, greater corporate transparency raises the financial and reputational costs associated with misrepresentation and fraud while increasing the likelihood of opportunistic behavior being exposed, thereby deterring greenwashing behavior (Bai et al., 2025). On the other hand, lower information asymmetry enhances investor confidence and reinforces market trust, which reduces financing costs and diminishes corporate incentives to engage in greenwashing (Xia et al., 2023). Hence, firm-level biodiversity disclosure will curb greenwashing behavior.

Second, firm-level biodiversity disclosure promotes green transition, which further curbing greenwashing. Voluntary biodiversity disclosure makes firms to develop a deeper understanding of their ecological impact, which in turn pressures management to systematically assess and concern biodiversity risk. Existing literature has found that both corporate and managerial environmental concern can promote green economic behaviors and positively impacts corporate green innovation strategy. In the context of rising global biodiversity risk, firms with higher levels of biodiversity concern will actively engage in green technological innovations to demonstrate their commitment and practices to risk management and sustainable development to investors and other stakeholders, thereby acquiring external strategic resources and maintaining a competitive edge. Thus, voluntary biodiversity disclosure drives corporate green transition, improving environmental performance and market competitiveness. When firms describe their positive performance, they tend to focus on firm-specific information, providing more effective incremental information (Kimbrough and Wang, 2014; Koh et al., 2023). Additionally, this allows firms to gain consumer and investor trust through authentic environmental initiatives rather than resorting to deceptive green marketing tactics, thereby diminishing their reliance on greenwashing for impression management (Nepal et al., 2025). Therefore, firm-level biodiversity disclosure can curb greenwashing motivation, leading firms to disclose more specific and verifiable ESG reports.

On the basis of the above analysis, we propose the following hypothesis:

H1a. Firm-level biodiversity disclosure will reduce corporate greenwashing behavior.

However, firm-level biodiversity disclosure may also increase greenwashing behavior. Existing studies indicate that activities related to biodiversity conservation are increasingly compromised by greenwashing behavior. According to legitimacy theory, Hassan et al. (2020) argue that firms predominantly employ greenwashing strategies to shape an environmentally friendly image rather than implementing substantive measures for biodiversity preservation. Therefore, the higher firm-level biodiversity disclosure may lead to more corporate greenwashing tendency.

Specifically, on one hand, due to the high compliance costs associated with implementing biodiversity risk management practices, management may focus more on short-term economic benefits, using biodiversity disclosure as a tool for impression management (Boiral, 2016; Adler et al., 2017) rather than implementing substantive biodiversity actions (Wagner, 2023). In such cases, to conceal their true performance and satisfy legitimacy requirements, firms may resort to greenwashing by engaging in symbolic

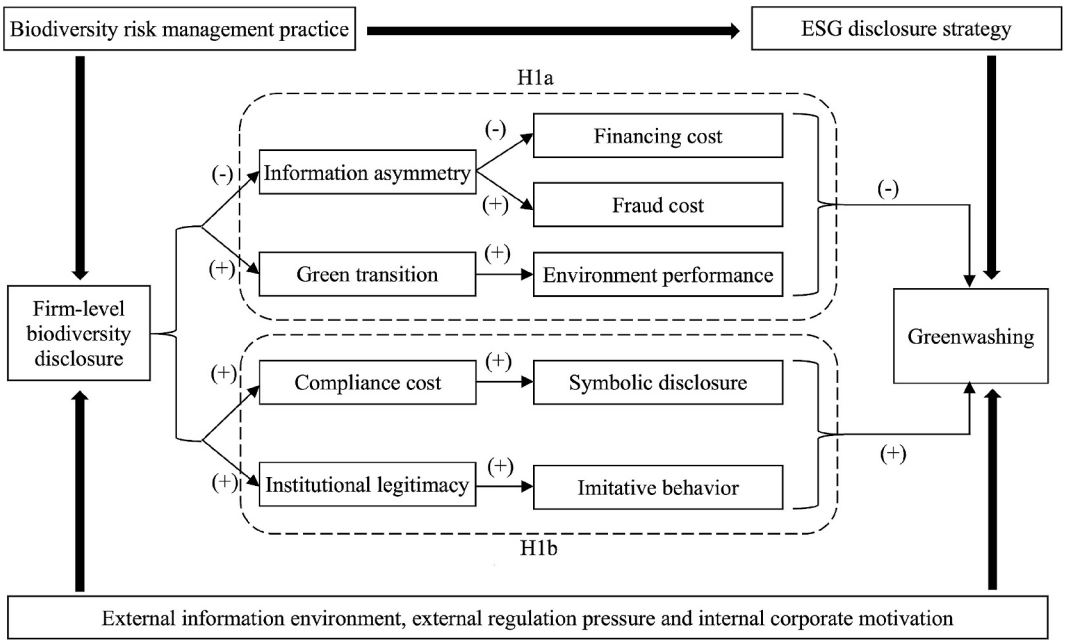

Fig. 1. Hypothesis development framework.

disclosure—presenting vague and uninformative ESG reports with little substantive action (Marquis et al., 2016; Zhang, 2023).

On the other hand, even without cost considerations, firm-level biodiversity disclosure may still drive an increase in greenwashing. Institutional theory suggests that when facing institutional legitimacy pressures, rational participants tend to imitate the behaviors of industry leaders to reduce risk. According to the studies by Xue and Hu (2023) and Liang et al. (2024b), firms are motivated to imitate the ESG disclosure content and sustainability practices of industry benchmarks. As a result, firm-level biodiversity disclosure may contribute to increased greenwashing, leading to firms imitate peer biodiversity engagement and ESG disclosure practices to exaggerate their own sustainability performance.

On the basis of the above analysis, we propose the following hypothesis:

H1b. Firm-level biodiversity disclosure will increase corporate greenwashing behavior.

The logic of the hypothesis is summarized in Fig. 1 as below:

3. Research design

3.1. Data

This study utilizes a sample of A-share listed companies in China from 2009 to 2022, and we exclude the following firms from the original sample: (1) special treatment firms, including ST, *ST and PT firms; (2) financial and insurance firms; (3) observations with missing values. All continuous variables are winsorized at the 1 % and 99 % level. Consequently, we obtained 8417 firm-year observations. Data on firm-level biodiversity disclosure is derived from the Biodiversity Disclosure Index for Chinese Listed Companies, calculated by He et al. (2024b). Greenwashing index is obtained from the WINGO financial text data platform, measured by ESG report textual similarity, while additional firm-level data is primarily sourced from the CSMAR and CNRDS databases.

3.2. Model specification

To investigate the impact of firm-level biodiversity disclosure on corporate green washing tendency, this paper constructs the following two-way fixed effects model:

$$Greenwashing_{i,t} = \beta_0 + \beta_1 Biodislosure_{i,t} + \beta_2 Controls_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

where the subscripts i and t represent firms and years, respectively. The dependent variable, $Greenwashing_{i,t}$, represents the probability of corporate greenwashing. It is measured by the median textual similarity between the firm's report for the given year and the reports of all other firms in the same industry, calculated using the TF-IDF and Word Embedding neural network language models. A higher value indicates higher textual similarity in the corporate ESG report, suggesting a higher level of greenwashing. The independent variable, $Biodislosure_{i,t}$, represents the level of corporate disclosure to biodiversity. $Controls_{i,t}$ is a set of control variables. μ_i and γ_t represent firm and time fixed effects, respectively. $\varepsilon_{i,t}$ is the error term in the baseline model.

3.3. Main variables

3.3.1. Firm-level biodiversity disclosure

This study follows the methodology of He et al., 2024b and employs text analysis techniques. Using the biodiversity dictionary developed by Giglio et al. (2023), we perform text mining on the annual reports disclosed by Chinese listed companies to calculate the frequency of biodiversity-related keywords, assessing the level of firm-level biodiversity disclosure. Specifically: (1) Construction of the biodiversity index. The words includes terms related to biodiversity, such as biodiversity, ecosystem, ecology, habitat, species, (rain)forest, deforestation, fauna, flora, marine, tropical, freshwater, wetlands, wildlife, coral, aquatic, desertification, carbon sink, ecological sphere, and biosphere; (2) Text mining of the annual reports disclosed by Chinese listed companies to calculate the frequency of biodiversity-related keywords; (3) Calculation of the biodiversity disclosure index. Firm-level biodiversity disclosure is measured by dividing the frequency of biodiversity-related keywords in the corporate annual report by 100.

3.3.2. Greenwashing tendency

According to Brown and Tucker (2011), and Xue et al. (2024), this paper uses the textual similarity of ESG reports as a proxy variable for corporate greenwashing tendency. For firms with no substantial ESG practice, they tend to use vague and symbolic disclosures in their reports, leading to higher textual similarity. In contrast, firms with authenticity ESG practice are more willing to disclose quantitative data on their ESG performance, demonstrating more substantive disclosures and resulting in lower textual similarity. Therefore, the higher the textual similarity of ESG reports suggests a greater reliance on symbolic disclosures, fewer substantive disclosures, and a higher likelihood of corporate greenwashing tendency, leading to a lower quality of ESG disclosure.

Specifically, this study uses data from the WINGO Financial Text Data Platform to construct ESG similarity textual similarity through the TF-IDF and Word Embedding methods as the proxy variable for corporate greenwashing tendency. TF-IDF is a statistical approach used to evaluate the importance of words or terms within a document set or corpus. Word Embedding is a neural network-based language model that represents words as multi-dimensional vectors, capturing contextual and semantic information. By training Word Embedding to generate word vectors, it enables quantitative analysis of relationships between texts, while also accounting for

how individual words impact the overall meaning of the text. The specific steps as follows: (1) Tokenize the text into words or terms. (2) Clean the tokenized results to remove noise. (3) Calculate the TF-IDF values for the words in the text. (4) Use Word Embedding to train the word vectors. (5) Weight the word vectors using the TF-IDF scores to generate text vectors. (6) Measure the similarity between texts using the cosine similarity function. A higher cosine value indicates a greater degree of similarity between the texts. Using this approach, three variables are constructed to measure the textual similarity of corporate ESG reports: First, calculate the median similarity between the report text for the current period and other companies in the same industry. Second, measure the similarity between the current report and the report from the previous period. Third, use the TF-IDF method to directly compute the similarity between the current and previous reports. The latter two methods are used for robustness checks in the subsequent analysis.

3.3.3. Control variables

Based on previous research (Xue et al., 2024; He et al., 2025), this paper controls for a series of firm-level characteristics, including firm age (*Age*), firm size (*Size*), leverage ratio (*Lev*), ownership structure (*ROA*), whether the firm audited by one of the Big Four audit firms (*Big*4), ownership concentration (*Top*1), board size (*Board*), revenue growth rate (*Growth*), proportion of independent directors (*IndDirect*). In addition, considering the significant regional differences, this paper further controls for regional-level variables such as GDP (*GDP_P*), and GDP per capita (*GDP_C*). Specific variable definitions are provided in Table 1.

4. Empirical results

4.1. Descriptive statistics

Table 2 shows the summary statistics of the main variables in this paper. The mean value of corporate greenwashing ($Greenwashing_{i,t}$) is 0.475, indicating that corporate greenwashing tendency among Chinese listed companies is generally high and the quality of ESG report disclosure is relatively poor. The mean value of firm-level biodiversity disclosure ($Biodislosure_{i,t}$) is 0.082, with a standard deviation of 0.167, reflecting a generally low level of biodiversity disclosure among firms and substantial variation across firms. The distributions of other variables are within reasonable ranges.

4.2. Baseline results

Table 3 reports the baseline regression results of the impact of firm-level biodiversity disclosure on corporate greenwashing tendency. We control for both firm-specific and time-specific fixed effects. To ensure the robustness of the estimation results, we sequentially add control variables in the regression. The standard errors are clustered at the firm level all the time. Column (1) presents the univariate regression results controlling for firm and time fixed effects. As shown in the table, the regression coefficient for $Biodislosure_{i,t}$ is −0.106, which is statistically significant at the 1 % level. Next, in columns (2) and (3), control variables are added sequentially, and the regression coefficient for remains statistically significant at the 1 % level. These findings suggest that the greater the firm-level biodiversity disclosure, the lower greenwashing tendency, indicating higher ESG disclosure quality. For example, in column (3), with a one standard deviation increase in firm-level biodiversity disclosure, the corporate greenwashing tendency decreases by 3.34 % of the sample mean (=0.095* 0.167/0.475). These results confirm H1a.

4.3. Robustness checks

4.3.1. Instrumental variable

To address potential endogeneity issues, this study introduces regional forest cover rate as an instrumental variable and performs a two-stage least squares (2SLS) regression. On the one hand, regional forest cover rate influences the level of firm-level biodiversity disclosure in the local area; on the other hand, forest cover rate does not directly affect the textual similarity of corporate ESG reports.

Table 1
Variable definitions.

Variables	Definition
Greenwashing	Median similarity between the firm's report and industry peers
Biodisclosure	Frequency of biodiversity-related keywords divided by 100
Age	Natural logarithm of the firm's fiscal year minus the listing year plus one
Size	Natural logarithm of total assets in a given year (in RMB)
Lev	Financial leverage, measured by total liabilities over total assets
ROA	Net profit over total assets
SOE	Takes the value of 1 for SOE and 0 for non-SOE
Big4	Takes the value of 1 if the auditing firm is 1 of the Big Four, and 2 otherwise
Top1	Shareholding proportion of the largest shareholder
Board	Natural logarithm of the number of directors on a board
Growth	(Current period revenue - prior year revenue) / prior year revenue
IndDirect	Number of independent directors scaled by the total number of directors on a board
GDP_P	Natural logarithm of the GDP of the firm's headquarters location
GDP_C	Natural logarithm of per capita GDP for each province

Table 2
Summary statistics.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	N	Mean	Sd	P50	Max	Min
Greenwashing	8417	0.475	0.217	0.435	0.861	0.077
Biodisclosure	8417	0.082	0.167	0.030	1.130	0.000
Age	8417	2.394	0.772	2.639	3.367	0.000
Size	8417	23.101	1.429	22.960	26.350	19.590
Lev	8417	0.478	0.203	0.486	0.960	0.050
ROA	8417	0.042	0.060	0.038	0.209	−0.319
SOE	8417	0.552	0.497	1.000	1.000	0.000
Big4	8417	1.863	0.344	2.000	2.000	1.000
Top1	8417	0.372	0.160	0.356	0.900	0.034
Board	8417	2.286	0.186	2.303	2.773	1.792
Growth	8417	0.348	0.956	0.122	7.382	−0.747
IndDirect	8417	3.643	0.139	3.621	4.394	2.727
GDP_P	8417	10.411	0.750	10.474	11.768	6.408
GDP_C	8417	11.193	0.506	11.218	12.156	9.482

This table reports the descriptive statistics for the variables included in Eq. (1). All the variable definitions are presented in Table 1.

Table 3
Baseline results.

Variables	(1)	(2)	(3)
	Greenwashing	Greenwashing	Greenwashing
Biodisclosure	−0.106***	−0.094***	−0.095***
	(0.032)	(0.033)	(0.033)
Age		0.004	0.003
		(0.009)	(0.009)
Size		−0.019***	−0.019***
		(0.006)	(0.006)
Lev		0.006	0.005
		(0.026)	(0.026)
ROA		0.111***	0.110***
		(0.039)	(0.039)
SOE		−0.028*	−0.029*
		(0.016)	(0.016)
Big4		−0.000	0.000
		(0.027)	(0.026)
Top1		−0.041	−0.040
		(0.043)	(0.042)
Board		0.000	−0.000
		(0.022)	(0.022)
Growth		−0.001	−0.001
		(0.002)	(0.002)
IndDirect		−0.007	−0.008
		(0.021)	(0.021)
GDP_P			0.062
			(0.071)
GDP_C			−0.039
			(0.068)
Constant	0.392***	0.843***	0.666**
	(0.010)	(0.179)	(0.339)
Observations	8417	8417	8417
R-squared	0.640	0.642	0.642
Firm FE	YES	YES	YES
Year FE	YES	YES	YES

*** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$, respectively. The Standard errors clustered by firm level are in parentheses. All the variable definitions are presented in Table 1.

Thus, this instrument variable satisfies both relevance and exogeneity conditions. Additionally, the weak instrument test for the chosen instrument shows that the Wald F-statistic is well above 10, confirming that there is no issue with weak instruments. As shown in columns (1) and (2) of Table 4, after considering the issue of endogeneity, firm-level biodiversity disclosure ($Biodislosure_{i,t}$) remains significantly negatively correlated with greenwashing tendency at the 5 % level, further validating the robustness of the previous results.

Table 4
Robustness tests.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	IV-2SLS		PSM		Additional fixed effect		Alternative dependent variable		Alternative independent variable	
	Biodisclosure	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing
Biodisclosure		−2.541**	−0.075**	−0.061**	−0.091***	−0.091***	−0.097***	−0.045*	−0.042**	−0.082**
		(−2.188)	(0.032)	(0.028)	(0.031)	(0.032)	(0.027)	(0.026)	(0.018)	(0.036)
Coverage	0.003**									
	(2.290)									
Constant	−0.804***		0.726	0.793*	0.750**	0.750**	1.189***	1.121***	0.619*	0.621*
	(−2.931)		(0.465)	(0.458)	(0.361)	(0.373)	(0.318)	(0.353)	(0.342)	(0.342)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	8174	8174	4009	3819	8157	8157	6732	6732	8287	8287
R-squared			0.600	0.611	0.795	0.795	0.305	0.520	0.641	0.641
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	NO	NO	NO	NO	YES	YES	NO	NO	NO	NO
Industry*Province	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO
Wald F statistic	23.818									

***, **, * indicate significance at 1 %, 5 %, and 10 %, respectively. The Standard errors clustered by firm level are in parentheses. All the variable definitions are presented in Table 1.

4.3.2. Propensity score matching

Subsequently, this study employs propensity score matching (PSM) to address the endogeneity issues resulting from sample selection bias. Given that mixed matching may lead to "time mismatch" problems and that yearly matching may cause instability in the control group, this study uses both mixed matching and yearly matching to cross-validate the results. The selection of the control group follows these steps: First, the sample is divided into two groups— "high biodiversity disclosure" and "low biodiversity disclosure"—based on the top and bottom one-third of firm-level biodiversity disclosure level, assigning values of 1 and 0, respectively. Then, a logit model is estimated to calculate the propensity score for each sample. Finally, 1:1 nearest neighbor matching is performed based on the calculated propensity scores. After selecting appropriate matched samples, the regression is re-estimated. As shown in columns (3) and (4) of Table 4, regardless of whether mixed or yearly matching is applied, the estimated results remain consistent with the main findings of this study.

4.3.3. Other robustness checks

Additionally, this study conducts further robustness tests to address potential issues of omitted variable bias and sample selection bias. First, we controlled for fixed effects at the province and province-industry levels. As shown in Table 4, columns (5) and (6), the results remain robust, confirming the initial findings. Next, the study replaces the definitions of both the dependent and independent variables. In the baseline regression, corporate greenwashing tendency is measured using the combined TF-IDF and Word Embedding methods, calculating the median similarity between the firm's current report and all other firms in the same industry for the given year. Since ESG report textual similarity also includes a longitudinal comparison between the current report and previous years' reports, we constructed two alternative indicators: (1) the similarity between the current report and the previous year's report is calculated using the same methodology as in the baseline regression; (2) similarity is measured only using the TF-IDF method between the current report and the previous year's report. The results are shown in Table 4. As seen in columns (7) and (8), firm-level biodiversity disclosure ($Biodislosure_{i,t}$) remains significantly negatively correlated with corporate greenwashing tendency. Subsequently, the study substitutes the measurement of the independent variable by using the proportion of words related to biodiversity in the annual report's total word count and the proportion of characters related to biodiversity in the annual report's total character count. As shown in Table 4, columns (9) and (10), the conclusions remain unchanged, further validating the robustness of the findings.

5. Exploring the channels

The above findings indicate that firm-level biodiversity disclosure significantly reduces corporate greenwashing tendency, thereby improving the quality of ESG disclosures. Based on the previous analysis, two main mechanisms contribute to this effect, one is the reduction of information asymmetry, and the other is the promotion of corporate green transition.

5.1. Reducing information asymmetry

To test the information asymmetry mechanism, this study constructs two variables to measure the degree of corporate information asymmetry. First, following the approach of Hutton et al. (2009), we use the sum of the absolute values of discretionary accruals over the past three years as a measure of information asymmetry. A higher value of this variable indicates a higher level of information asymmetry. Second, we use the transparency rating of listed companies disclosed by the Shenzhen and Shanghai Stock Exchanges. The rating ranges from 1 to 4, where 4 indicates excellent transparency and 1 indicates non-compliance. As shown in Table 5, the estimated coefficient for firm-level biodiversity disclosure is significantly negative in column (1), indicating that firm-level biodiversity disclosure significantly reduces information asymmetry. In column (2), the estimated coefficient for firm-level biodiversity disclosure is significantly positive, suggesting that firm-level biodiversity disclosure improves the transparency rating, thus reducing information asymmetry. In summary, these findings support the validity of the mechanism.

Furthermore, this study examines the information asymmetry mechanism from the signaling perspective. As discussed above, firm-

Table 5
Mechanism analysis.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Reduce information asymmetry				Promote green transition		
	Opaque	Opacity	Pnews_all	Pnews_ori	EnvrPat	EnvrInvPat	EnvrUtyPat
Biodisclosure	−0.036*	0.481**	0.376**	0.304*	1.068***	1.093***	0.691***
	(0.021)	(0.221)	(0.181)	(0.171)	(0.158)	(0.159)	(0.134)
Constant	0.073	2.785	−0.523	0.055	−2.227	−1.074	−1.478
	(0.347)	(2.377)	(2.328)	(2.169)	(2.110)	(1.777)	(1.823)
Controls	YES	YES	YES	YES	YES	YES	YES
Observations	6711	8417	8243	8243	8410	8410	8410
R-squared	0.098	0.477	0.766	0.783	0.232	0.200	0.152
Firm FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

***, **, * indicate significance at 1 %, 5 %, and 10 %, respectively. The Standard errors clustered by firm level are in parentheses. All the variable definitions are presented in Table 1.

level biodiversity disclosure encourages firms to reduce information asymmetry proactively in order to convey positive signals to investors and other external stakeholders, thereby increasing the disclosure of firm-specific information and ultimately reducing corporate greenwashing tendency. Therefore, this paper tests whether firm-level biodiversity disclosure reduces information asymmetry and sends positive signals to investors and other external stakeholders. Specifically, we use two variables: the natural logarithm of one plus the number of positive news articles in financial media and the natural logarithm of one plus the number of original positive reports in financial newspapers media. As shown in Table 5, both columns (3) and (4) report significantly positive coefficients, indicating that firm-level biodiversity disclosure does indeed convey positive signals to investors and other external stakeholders, further validating the proposed mechanism.

5.2. Promoting green transition

As mentioned above, firm-level biodiversity disclosure promotes green transition, encouraging management to disclose more firm-specific information, thereby reducing corporate greenwashing tendency. To validate this mechanism, following the approach of Kong (2025), we use three measures of corporate green transition: the natural logarithm of one plus the number of (1) green patent applications, (2) green invention patent applications, and (3) green utility model patent applications. As shown in columns (5) to (7) of Table 5, regardless of whether the variable is the number of green patents, green invention patents, or green utility model patents, the regression coefficient of $Biodislosure_{i,t}$ is consistently positive at the 1 % significance level, indicating that firm-level biodiversity disclosure promotes the enhancement of corporate green transition level.

6. Further analyses

6.1. Cross-sectional heterogeneity analysis

6.1.1. External information environment

In addition to the information disclosed by the listed companies themselves, external information channels play a crucial role in transmitting information to external stakeholders (Hao, 2023; He et al., 2025). With the continuous evolution of traditional media and new media platforms, media reports have become an important source of information for investors and other stakeholders, significantly reducing information asymmetry between firms and investors (Bushee et al., 2010; Chen et al., 2013). Existing studies have shown that media can influence corporate behavior by improving the efficiency of information transmission (He et al., 2024c). When corporate media attention is low, the channels for transmitting information to external stakeholders are limited, and the efficiency of communication is reduced, leading to higher levels of information asymmetry. Therefore, when the external information environment is poor, managers are more motivated to voluntarily disclose information in order to reduce information asymmetry and convey positive signal. This paper posits that the effect of firm-level biodiversity disclosure in curbing greenwashing tendency is more pronounced in firms with weaker external information environments. Specifically, we divide the sample into stronger- and weaker-external information environment groups based on the median of media attention. We measure firm-level media attention as the natural logarithm of one plus the total number of news reports related to the company in a given year (He et al., 2024c). Lower media attention indicates a weaker external information environment. The subsample regression results are presented in Table 6. As shown in columns (1) and (2), the coefficient for $Biodislosure_{i,t}$ is significantly negative in column (1), indicating that the impact of firm-level biodiversity disclosure on corporate greenwashing tendency is more significant in the group with lower media attention, confirming the previous analysis. This indicates that improving the corporate information environment and transiting positive signal are key motivations in curbing greenwashing.

6.1.2. External pressure: heavy pollution industry and regional environmental regulation

Existing research suggests that external pressure can have a crowding-out effect on voluntary corporate disclosure. When external pressure is high, firms generally tend to have better environmental performance, making the signaling effect less effective (Rajgopal and Tantri, 2023). Therefore, in groups with higher external pressure, the motivation to signal is weaker, and the negative effect of firm-level biodiversity disclosure on corporate greenwashing tendency may be diminished. Following, this paper examines the heterogeneous effects of external pressure from both industry and regional perspectives. In recent years, firms in heavily polluting industries have faced increasingly stringent government regulations. Currently, regulatory authorities in China require heavily polluting listed companies to disclose environmental information under mandatory disclosure principles, while other firms are not subject to such mandatory requirements. As a result, firms in heavily polluting industries typically have higher quality and more comprehensive disclosures compared to other sectors. Similarly, when regional environmental regulations are stricter, firms in those regions generally perform better in terms of ESG disclosures and practices, which also diminishes the negative effect of firm-level biodiversity disclosure on greenwashing tendency. Overall, this study posits that the effect of firm-level biodiversity disclosure on reducing corporate greenwashing tendency will be more significant in non-heavily polluting firms and firms in regions with weaker environmental regulations.

To validate the previous analysis, this study first divides the sample firms into two categories from the industry perspective: heavily polluting industry firms and non-heavily polluting industry firms, and examines the impact of firm-level biodiversity disclosure on corporate greenwashing tendency under different external regulatory environments. Specifically, according to He et al. (2024d), if a firm belongs to one of the 16 major heavily polluting industries listed in the “Guidelines for the Disclosure of Environmental Information by Listed Companies (Draft for Comments)” published by the Ministry of Ecology and Environment in September 2010 in

Table 6
Heterogeneity analysis.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Media Attention		Polluting industry		Environmental regulation		Managerial myopia	
	Low	High	Heavy	Non-heavy	Low	High	Low	High
	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing	Greenwashing
Biodisclosure	−0.105**	−0.061	−0.046	−0.102***	−0.173***	−0.008	−0.140***	−0.075
	(0.042)	(0.038)	(0.075)	(0.032)	(0.044)	(0.049)	(0.052)	(0.053)
Constant	0.653	0.736	0.481	0.864**	1.047*	1.363**	0.378	1.140**
	(0.529)	(0.606)	(0.631)	(0.404)	(0.575)	(0.615)	(0.619)	(0.528)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	4220	4172	2332	6078	3324	2828	2764	2621
R-squared	0.676	0.428	0.692	0.625	0.666	0.662	0.632	0.651
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

***, **, * indicate significance at 1 %, 5 %, and 10 %, respectively. The Standard errors clustered by firm level are in parentheses. All the variable definitions are presented in Table 1.

China, it is classified as a heavily polluting industry firm. Next, from the perspective of regional environmental regulation, following the method of Liu et al. (2024) and Jiang et al. (2025), this study uses the frequency of environmental protection related terms in provincial government work reports to measure the intensity of environmental regulations, which serves as the grouping variable. As shown in Table 6, in columns (4) and (5), the coefficient for firm-level biodiversity disclosure is significantly negative, indicating that the negative impact of firm-level biodiversity disclosure on greenwashing tendency is more pronounced in firms with non-heavily polluting industries and weaker environmental regulation regions. This suggests that external regulatory pressure diminishes this negative effect.

6.1.3. Managerial myopia

According to Zhao et al. (2025), managerial myopia not only affects corporate short-term profitability but also harms corporate long-term value creation ability by lowering biodiversity performance. We argue that managers are more motivated to voluntarily disclose relevant information to enhance corporate value in firms with lower levels of managerial myopia, making the negative effect of firm-level biodiversity disclosure on corporate greenwashing tendency more pronounced. Following the approach of Zhang and Li (2024), we proxy managerial myopia by the ratio of current short-term investments to the corporate total assets at the beginning of the period, which serves as the grouping variable. As shown in Table 6, in columns (7) and (8), the impact of firm-level biodiversity disclosure on curbing greenwashing is more significant in firms with lower levels of managerial myopia, while it is not significant in the high management myopia group. This suggests that managerial myopia weakens the effect of firm-level biodiversity disclosure on greenwashing, and fostering managerial attention to sustainable development is the crucial internal motivation in mitigating greenwashing.

6.2. Firm-level biodiversity disclosure and ESG report quality

In the previous section, this study found that firm-level biodiversity disclosure enhances corporate sustainability strategy from the perspective of greenwashing, reducing the textual similarity of the ESG report. In addition, corporate ESG disclosure strategy also includes other aspects. Corporate ESG reports are textual in nature and predominantly presented in descriptive form, which makes them difficult to analyze quantitatively (Du and Yu, 2021). Therefore, analyzing other textual attributes such as tone is equally crucial for assessing the strategy of ESG disclosure. This study investigates whether firm-level biodiversity disclosure influences the tone of ESG reports. Specifically, the study uses the “LM dictionary positive word count” to measure the textual tone of the ESG report. As shown in Table 7, in column (1), firm-level biodiversity disclosure is found to foster a more optimistic tone, thus improving the quality of ESG disclosures from multiple dimensions.

6.3. Economic consequence

Finally, this paper analyzes the economic consequences of firm-level biodiversity disclosure. As discussed in previous sections, firm-level biodiversity disclosure reduces information asymmetry, promotes green transition, and sends positive signals to investors and other stakeholders. Therefore, this paper posits that after disclosing authentic and effective ESG reports with lower textual similarity, corporate financing constraints can be alleviated. To test the economic consequences, this paper uses three variables to measure corporate financing constraints. In Table 7, column (2) shows the dependent variable of corporate debt financing cost, measured as the proportion of current liability to the total liabilities for the year. Columns (3) and (4) examine corporate commercial credit financing ability. Following Wu et al. (2014), two indicators are constructed by the ratio of accounts payable over one year and the ratio of accounts receivable over one year. As shown in the table, after curbing corporate greenwashing behavior and improving

Table 7
Further test.

Variables	(1)	(2)	(3)	(4)
	Other ESG report textual quality	Economic consequence		
	LM_posword	$Debt_{t+1}$	LAP_{t+1}	LAR_{t+1}
Biodisclosure	0.357***	−0.130***	−0.007	−0.088
	(0.082)	(0.046)	(0.057)	(0.061)
Greenwashing		−0.031	−0.015	−0.041*
		(0.021)	(0.015)	(0.024)
Biodisclosure *Greenwashing		0.179***	0.152*	0.299***
		(0.067)	(0.091)	(0.100)
Constant	4.857***	1.514***	−0.007	0.712
	(1.115)	(0.414)	(0.258)	(0.446)
Controls	YES	YES	YES	YES
Observations	7813	6531	6521	5848
R-squared	0.172	0.028	0.024	0.172
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

***, **, * indicate significance at 1 %, 5 %, and 10 %, respectively. The Standard errors clustered by firm level are in parentheses.

disclosure quality, firm-level biodiversity disclosure ultimately alleviates financing constraints, evidenced by enhanced access to debt financing and commercial credit.

7. Conclusion

Using firm-level data from China's A-share listed companies between 2009 and 2022, this paper empirically examines the impact of corporate biodiversity disclosure on greenwashing tendency. Our findings indicate that firm-level biodiversity disclosure significantly reduces corporate greenwashing tendency. After conducting a series of robustness checks, including applying instrumental variable, using propensity score matching, adding additional fixed effects, and substituting both dependent and independent variable measurement methods, the results remain consistent. This effect is mainly achieved by reducing information asymmetry and promoting the green transition. Furthermore, we analyze the heterogeneous effects of external information environment, external regulatory pressures, and internal corporate motivations on the relationship between firm-level biodiversity disclosure and corporate greenwashing tendency. We find that the impact is more pronounced in firms with lower media attention, firms in non-polluting industries, firms with weaker environmental regulation presure, and firms with lower levels of managerial myopia. Additionally, further analysis shows that increased firm-level biodiversity disclosure also improves the textual tone of ESG reports, which ultimately alleviates corporate financing constraints.

This paper enriches the literature on the economic consequences of firm-level biodiversity disclosure and the determinants of corporate greenwashing tendency. It further expands on the mechanisms through which corporate risk management practices affect ESG information disclosure quality, providing a theoretical foundation for corporate internal governance, external regulation, and the high-quality development of capital markets. For firms, it is essential to recognize the importance of biodiversity risk management in improving ESG report quality and promoting sustainable development For regulators, there is a need to further refine ESG disclosure regulations and strengthen the requirements for biodiversity-related information disclosure, to promote greater transparency and standardization of corporate environmental behavior. For capital market participants, increased attention should be paid to corporate biodiversity practices, considering it as a key indicator to assess corporate non-financial performance, thereby driving the green transformation and high-quality development of capital markets.

CRediT authorship contribution statement

Feng He: Writing – review & editing, Validation, Project administration, Formal analysis, Data curation, Conceptualization. **Chunyang Wei:** Writing – original draft, Visualization, Software, Methodology, Data curation. **Brian Lucey:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Jing Hao:** Writing – review & editing, Supervision, Software, Project administration, Funding acquisition, Data curation.

Declaration of competing interest

None.

Acknowledgements

The authors acknowledge financial support from National Natural Science Foundation of China (NSFC) project (72471157; 72001156); Capital University of Economics and Business Project (XSCXTD202402).

References

Adamolekun, G., 2024. Firm biodiversity risk, climate vulnerabilities, and bankruptcy risk[J]. J. Int. Financ. Mark. Inst. Money 97, 102075.
Adler, R., Mansi, M., Pandey, R., Stringer, C., 2017. United Nations decade on biodiversity: a study of the reporting practices of the Australian mining industry[J]. Acct. Aud. Acc. J. 30 (8), 1711–1745.
Adler, R., Mansi, M., Pandey, R., 2018. Biodiversity and threatened species reporting by the top fortune global companies[J]. Acct. Aud. Acc. J. 31 (3), 787–825.
Ahmad, M.F., Karpuz, A., 2024. Beyond climate change risk: biodiversity and corporate cash holdings[J]. Econ. Lett. 236, 111608.
Ali, R., García-Sánchez, I.M., Aibar-Guzmán, B., Ur Rehman, R., 2024. Is biodiversity disclosure emerging as a key topic on the agenda of institutional investors?[J]. Bus. Strateg. Environ. 33 (3), 2116–2142.
Alkhawaja, A., Hu, F., Johl, S., Nadarajah, S., 2023. Board gender diversity, quotas, and ESG disclosure: global evidence[J]. Int. Rev. Financ. Anal. 90, 102823.
Asimakopoulos, P., Asimakopoulos, S., Li, X., 2023. The role of environmental, social, and governance rating on corporate debt structure[J]. J. Corp. Finan. 83, 102488.
Bach, T.N., Hoang, K., Le, T., 2025. Biodiversity risk and firm performance: Evidence from US firms[J]. Bus. Strateg. Environ. 34 (1), 1113–1132.
Bai, C., Yao, D., Xue, Q., 2025. Does artificial intelligence suppress firms' greenwashing behavior? Evidence from robot adoption in China[J]. Energy Econ. 142, 108168.
Bassen, A., Buchholz, D., Lopatta, K., Rudolf, A.R., 2024. Biodiversity management and stock price crash risk[J]. Bus. Strateg. Environ. 33 (5), 4788–4805.
Boiral, O., 2016. Accounting for the unaccountable: biodiversity reporting and impression management[J]. J. Bus. Ethics 135 (4), 751–768.
Bromley, P., Powell, W.W., 2012. From smoke and mirrors to walking the talk: decoupling in the contemporary world[J]. Acad. Manag. Ann. 6 (1), 483–530.
Brown, S.V., Tucker, J.W., 2011. Large-sample evidence on firms' year-over-year MD&a modifications[J]. J. Account. Res. 49 (2), 309–346.
Bushee, B.J., Core, J.E., Guay, W., Hamm, S.J.W., 2010. The role of the business press as an information intermediary[J]. J. Account. Res. 48 (1), 1–19.
Carvalho, S.H.C., Cojoianu, T., Ascui, F., 2023. From impacts to dependencies: a first global assessment of corporate biodiversity risk exposure and responses[J]. Bus. Strateg. Environ. 32 (5), 2600–2614.
Chantziaras, A., Dedoulis, E., Grougiou, V., Leventis, S., 2020. The impact of religiosity and corruption on CSR reporting: the case of US banks[J]. J. Bus. Res. 109, 362–374.

Chen, C.W., Pantzalis, C., Park, J.C., 2013. Press coverage and stock price deviation from fundamental value[J]. J. Financ. Res. 36 (2), 175–214.
Chen, L., Zhang, L., Huang, J., Xiao, H., Zhou, Z., 2021. Social responsibility portfolio optimization incorporating ESG criteria. J. Manage. Sci. Eng. 6 (1), 75–85.
Cheng, B., Ioannou, I., Serafeim, G., 2014. Corporate social responsibility and access to finance[J]. Strateg. Manag. J. 35 (1), 1–23.
Daft, R.L., Sormunen, J., Parks, D., 1988. Chief executive scanning, environmental characteristics, and company performance: an empirical study[J]. Strateg. Manag. J. 9 (2), 123–139.
DesJardine, M.R., Marti, E., Durand, R., 2021. Why activist hedge funds target socially responsible firms: the reaction costs of signaling corporate social responsibility [J]. Acad. Manag. J. 64 (3), 851–872.
Du, S., Yu, K., 2021. Do corporate social responsibility reports convey value relevant information? Evidence from report readability and tone[J]. J. Bus. Ethics 172 (2), 253–274.
Flammer, C., Giroux, T., Heal, G.M., 2025. Biodiversity finance[J]. J. Financ. Econ. 164, 103987.
Garel, A., Romec, A., Sautner, Z., Wagner, A.F., 2024. Do investors care about biodiversity?[J]. Rev. Financ. Stud. 28 (4), 1151–1186.
Giglio, S., Kuchler, T., Stroebel, J., Zeng, X., 2023. Biodiversity risk[R]. Natl. Bur. Econ. Res. Work. Pap. 31137. Available at https://www.nber.org/papers/w31137.
Hao, J., 2023. Retail investor attention and corporate innovation in the big data era. Int. Rev. Financ. Anal. 86, 102486.
Hao, J., Lu, Y., Zhang, J., Bai, H., Wu, J.G., 2024. Does provincial gambling culture affect corporate innovation? Evidence from China. J. Econ. Behav. Organ 228, 106810.
Hao, J., Sun, R., Gong, X., Zhu, X.R., 2025. ESG and stock price crash risk revisited: Evidence from mandatory ESG disclosure policy in China. Pac.-Basin Financ. J. 91, 102729.
Hassan, A.M., Roberts, L., Atkins, J., 2020. Exploring factors relating to extinction disclosures: what motivates companies to report on biodiversity and species protection?[J]. Bus. Strateg. Environ. 29 (3), 1419–1436.
He, F., Chen, L., Lucey, B.M., 2024b. Chinese corporate biodiversity exposure[J]. Financ. Res. Lett. 70, 106275.
He, F., Duan, L., Wen, S., 2024d. Green credit policy and corporate climate risk exposure. Energy Economics 133, 107509.
He, F., Du, H., Li, Y., Hao, J. 2025. Make it Right: Regulatory Intervention in Managers' Misconduct and Corporate Risk. J. Bus. Ethics. forthcoming. Available at https://doi.org/10.1007/s10551-025-05934-w.
He, F., Chen, L., Wang, Z., Zhang, W., 2025. Financial innovation and corporate climate policy uncertainty exposure: Evidence from China's crude oil futures. Energy Econ. 145, 108426.
He, F., Guo, X., Yue, P., 2024c. Media coverage and corporate ESG performance: Evidence from China. Int. Rev. Finan. Ana. 91, 103003.
He, F., Liu, G., Li, Y., 2023. CSR performance and firm idiosyncratic risk in a data-rich environment: The role of retail investor attention. J. Int. Money Financ. 89, 101877.
He, F., Hao, J. Lucey, B., 2024a. Effects of climate risk on corporate green innovation cycles, Technological Forecasting and Social Change, 173, 113058.
Hope, O.K., Hu, D., Lu, H., 2016. The benefits of specific risk-factor disclosures[J]. Rev. Acc. Stud. 21, 1005–1045.
Hu, S., Wang, A., Du, K., 2023a. Environmental tax reform and greenwashing: evidence from Chinese listed companies[J]. Energy Econ. 124, 106873.
Hu, X., Hua, R., Liu, Q., Wang, C., 2023b. The green fog: environmental rating disagreement and corporate greenwashing[J]. Pac.-Basin Financ. J. 78, 101952.
Hutton, A.P., Marcus, A.J., Tehranian, H., 2009. Opaque financial reports, R2, and crash risk[J]. J. Financ. Econ. 94 (1), 67–86.
Jiang, Y., Wang, X., Wang, W., Yu, X., 2025. Impact of government attention guided by environmental policies on green technology innovation[J]. Int. Rev. Financ. Anal. 101, 104009.
Kedward, K., Ryan-Collins, J., Chenet, H., 2023. Biodiversity loss and climate change interactions: financial stability implications for central banks and financial supervisors[J]. Clim. Pol. 23 (6), 763–781.
Kennedy, S., Fuchs, M., Van Ingen, W., Schoenmaker, D., 2023. A resilience approach to corporate biodiversity impact measurement[J]. Bus. Strateg. Environ. 32 (5), 2567–2582.
Kimbrough, M.D., Wang, I.Y., 2014. Are seemingly self-serving attributions in earnings press releases plausible? Empirical evidence[J]. Account. Rev. 89 (2), 635–667.
Koh, K., Li, H., Tong, Y.H., 2023. Corporate social responsibility (CSR) performance and stakeholder engagement: evidence from the quantity and quality of CSR disclosures[J]. Corp. Soc. Responsib. Environ. Manag. 30 (2), 504–517.
Kong, W., 2025. Does financial risk exacerbate the risk of low-quality green innovation?[J]. Pac.-Basin Financ. J. 90, 102673.
Lee, M.T., Raschke, R.L., 2023. Stakeholder legitimacy in firm greening and financial performance: what about greenwashing temptations?[J]. J. Bus. Res. 155, 113393.
Li, W.A., Du, H., He, F., 2025. Mandatory corporate ESG disclosure and default risk – evidence from China[J]. Pac.-Basin Financ. J. 89, 102578.
Li, Z., Luo, T., Li, J., Tian, Y., 2024. Does social responsibility reform curb corporate greenwashing: evidence from a quasi-natural experiment in China[J]. Int. Rev. Financ. Anal. 96, 103623.
Liang, C., Yang, J., Shen, L., Dong, D., 2024a. The role of biodiversity risk in stock price crashes[J]. Financ. Res. Lett. 67, 105856.
Liang, Q., Li, Q., Lu, M., Shan, Y., Wang, P., 2024b. Peer effects on corporate environmental protection: competition, information cascades or career concerns?[J]. Pac.-Basin Financ. J. 84, 102313.
Liao, F., Sun, Y., Xu, S., 2023. Financial report comment letters and greenwashing in environmental, social and governance disclosures: evidence from China[J]. Energy Econ. 127, 107122.
Liu, J., Uchida, K., Bao, C., 2024b. Environmental regulation, corporate environmental disclosure, and firm performance: evidence from China[J]. Pac.-Basin Financ. J. 85, 102367.
Ma, F., Wu, H., Zeng, Q., 2024. Biodiversity and stock returns[J]. Int. Rev. Financ. Anal. 95, 103386.
Marquis, C., Toffel, M.W., Zhou, Y., 2016. Scrutiny, norms, and selective disclosure: a global study of greenwashing[J]. Organ. Sci. 27 (2), 483–504.
Michelon, G., Rodrigue, M., Trevisan, E., 2020. The marketization of a social movement: activists, shareholders and CSR disclosure[J]. Acc. Organ. Soc. 80, 101074.
Nepal, R., Deng, Y., Dong, K., Goutte, S., 2025. Does executive gender diversity culture inhibit corporate greenwashing behavior? The effect of informal institutions [J]. Int. Rev. Financ. Anal. 97, 103888.
Pedersen, L.H., Fitzgibbons, S., Pomorski, L., 2021. Responsible investing: the ESG-efficient frontier[J]. J. Financ. Econ. 142 (2), 572–597.
Rajgopal, S., Tantri, P., 2023. Does a government mandate crowd out voluntary corporate social responsibility? Evidence from India[J]. J. Account. Res. 61 (1), 415–447.
Reber, B., Gold, A., Gold, S., 2022. ESG disclosure and idiosyncratic risk in initial public offerings[J]. J. Bus. Ethics 179 (3), 867–886.
Schaltegger, S., Gibassier, D., Maas, K., 2023. Managing and accounting for corporate biodiversity contributions. Mapping the field[J]. Bus. Strateg. Environ. 32 (5), 2544–2553.
Shen, L., Zhou, J., 2024. The role of biodiversity and energy transition in shaping the next techno-economic era[J]. Technol. Forecast. Soc. Change 208, 123700.
Tan, R., Cai, Q., Pan, L., 2024. Faking for fortune: emissions trading schemes and corporate greenwashing in China[J]. Energy Econ. 130, 107319.
Thorne, L., Mahoney, L.S., Manetti, G., 2014. Motivations for issuing standalone CSR reports: a survey of Canadian firms[J]. Account. Audit. Account. J. 27 (4), 686–714.
Tian, Y., Chen, H., 2025. Eco-innovation under pressure: how biodiversity risks shape corporate sustainability strategies[J]. Financ. Res. Lett. 73, 106615.
Tong, X., Yang, B., 2025. The peer effects of corporate social responsibility performance on innovation outputs: Evidence from China. J. Manage. Sci. Eng. Vol. in-press, No. in-press. Available at https://doi.org/10.1016/j.jmse.2025.03.003.
Wagner, M., 2023. Business, biodiversity and ecosystem services: evidence from large-scale survey data[J]. Bus. Strateg. Environ. 32 (5), 2583–2599.
Wu, D., Sun, Q., Zhang, W., Xu, G., Chan, K.C., Qin, J., 2024. Does information content of a corporate social responsibility report matter for stock mispricing? Evidence from China[J]. Int. Rev. Financ. Anal. 95, 103507.
Wu, W., Firth, M., Rui, O.M., 2014. Trust and the provision of trade credit[J]. J. Bank. Financ. 39, 146–159.

Xia, F., Chen, J., Yang, X., Li, X., Zhang, B., 2023. Financial constraints and corporate greenwashing strategies in China[J]. Corp. Soc. Responsib. Environ. Manag. 30 (4), 1770–1781.
Xue, X., Hu, N., 2023. Economic policy uncertainty and imitation behaviors of corporate social responsibility practices: evidence from China[J]. Financ. Res. Lett. 89, 102753.
Xue, X., Wang, L., Hu, N., 2024. Economic policy uncertainty and corporate social responsibility disclosure similarity: evidence from China[J]. Br. Account. Rev. 56 (5), 101305.
Yao, D., He, S., Zheng, M., 2024. Quality disclosure strategies for small business enterprises under consumer loss aversion. J. Manage. Sci. Eng. 9 (1), 62–87.
Yu, E.P., Van Luu, B., Chen, C.H., 2020. Greenwashing in environmental, social and governance disclosures[J]. Res. Int. Bus. Financ. 52, 101192.
Zerbini, F., 2017. CSR initiatives as market signals: a review and research agenda[J]. J. Bus. Ethics 146 (1), 1–23.
Zhang, G., 2023. Regulatory-driven corporate greenwashing: evidence from "low-carbon city" pilot policy in China[J]. Pac.-Basin Financ. J. 78, 101951.
Zhang, L., Shan, Y.G., Chang, M., 2021. Can CSR disclosure protect firm reputation during financial restatements?[J]. J. Bus. Ethics 173, 157–184.
Zhang, X., Li, N., 2024. Management myopia and corporate innovation in China: focus on the moderating role of equity incentives[J]. Int. Rev. Financ. Anal. 96, 103733.
Zhao, Y., Qu, X., Lucey, B., 2025. Managerial myopia and biodiversity alignment—evidence from China[J]. Int. Rev. Financ. Anal. 100, 103974.