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Biodiversity risk or climate risk? Which factor affects corporate ESG rating divergence

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ABSTRACT

This study compares the impact of firm-level climate risk and biodiversity risk on corporate environmental, social, and governance (ESG) rating divergence among Chinese listed firms. Analyzing a comprehensive dataset from 2015 to 2022, we provide novel empirical evidence that firm-level biodiversity risk exposure exerts a significant mitigating effect on corporate ESG rating divergence. In contrast, the effect of climate risk on ESG divergence does not show such statistically significant negative impact, even after considering potential lag effects. Furthermore, we show that biodiversity risk exposure reduces ESG divergence through enhancing ESG information disclosure and improving transparency. We also find the mitigating effect is more pronounced in firms with lower analyst and research reports coverage, and in firms that independently or voluntarily disclose ESG reports. These findings prove that firm-level biodiversity risk management has a significant impact on corporate sustainable performance assessment.

1. Introduction

Sustainable development has emerged as a central focus in recent economic research, with climate risk and biodiversity risk as two critical environmental challenges in shaping business sustainability (Giglio et al., 2023). While climate risk has long dominated sustainability discussions, biodiversity loss emerges as another critical threat to ecological and economic stability (Flammer et al., 2025 Kopnina et al., 2024). Climate change, manifested through extreme weather events, rising sea levels, and increasing climate-related disasters, poses significant financial and operational risks to firms worldwide (Ginglinger & Moreau, 2023; Li, Shan, et al., 2024). Meanwhile, biodiversity loss driven by habitat destruction and pollution threatens ecosystem services and economic activity (Carvalho et al., 2023). The 2024 Global Risks Report highlights biodiversity loss and ecosystem collapse alongwith extreme climate events as the most severe global risks for the next decade.[1] This escalating crisis poses systemic risks to global economic stability and long-term development sustainability.

Biodiversity loss and climate risk are deeply interacted, collectively affecting ecosystem regulatory functions and amplifying uncertainties in sustainable development. Ecological degradation and increasing severe climate change pose significant economic risks to corporates' resilience and long-term development. In the digital era, firms face great pressure from investors, regulators, and other stakeholders to address both climate and biodiversity risks in their sustainability strategies (Bassen et al., 2024; Ilhan et al., 2023). Consequently, organizational accountability for climate risk and biodiversity impacts has become imperative considerations in policy formulation and corporate governance. There is growing recognition of the need for both climate risk and biodiversity disclosure, urging firms to systematically assess and report their environmental impacts and mitigation strategies (Addison et al., 2019 Li et al., 2024). However, despite this growing trend, corporate disclosures on biodiversity and climate risks remain limited. Research indicates that only a small number of companies disclose information regarding biodiversity risks or conservation initiatives (Nedopil, 2023; Schaltegger et al., 2023), while climate risk disclosures also vary widely in scope and reliability. Many firms provide insufficient or inconsistent information, makes it challenging for external stakeholders to accurately assess their environmental risk exposure and sustainability commitments. Therefore, corporate exposure on climate and biodiversity risks may serve as a

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[1] WEF_The_Global_Risks_Report_2024.pdf

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key indicator of environmental responsibility, which affect external evaluations of ESG performance. This study specifically examines the impact of firm-level climate risk and biodiversity risk exposure on corporate ESG divergences, and aims to provide insights into which environmental risk factor exerts a more significant influence.

Given the rising importance of ESG considerations in investment decisions, ESG ratings have become a crucial tool for evaluating and comparing corporate sustainability and risk management capabilities (Billio et al., 2021). However, as investors' ESG investment decisions heavily rely on ratings from third-party rating agencies, concerns have emerged regarding the reliability and consistency of these assessments. Substantial discrepancies between ESG ratings assigned by different agencies have been widely documented (Berg et al., 2022). Such divergence not only raises uncertainties for investors and potentially undermining the effectiveness of sustainable investment practices. However, there are gaps in existing research on how specific environmental risks affect ESG rating divergence. By investigating whether corporate climate risk and biodiversity risk exposure have important implications for ESG rating divergence, our study aims to address an important gap in corporate ESG research and contribute to promote corporate sustainable development.

Existing studies have explored the determinants of ESG rating divergence from different perspectives (Chatterji et al., 2016; Kimbrough et al., 2024). Prior studies broadly attribute ESG divergence to two main factors. One factor is variations in rating agency methodologies (Billio et al., 2021), and the other factor is firms' characteristics (Kimbrough et al., 2024). On the one hand, inconsistency in rating methodologies, scopes, and evaluation frameworks, as well as variations in the interpretation of ESG concepts among different raters (Chatterji et al., 2016) result in ESG rating divergence. On the other hand, the completeness and quality of corporate ESG disclosures play a critical role in shaping rating outcomes. When firms selectively disclose information, or provide deceitful report to avoid negative perceptions (Garcia-Torea et al., 2020), rating agencies may struggle to accurately assess their ESG performance, which further exacerbates rating divergence.

Recently, regulatory bodies have taken actions to enhance ESG disclosure transparency. For instance, the Kunming-Montreal Global Biodiversity Framework obliges major corporations and financial institutions to regular report their biodiversity risks. Likewise, the European Union's Corporate Sustainability Reporting Directive (CSRD) compels firms to develop biodiversity action plans and disclose climate impacts, risks and their interactions strategies periodically. These regulatory shifts have prompted firms to integrate both climate and biodiversity risks into their strategic frameworks, which not only aligning with emerging standards, but also to improving transparency through enhanced public disclosures. With increasing environmental challenges and regulatory pressures, firms are increasingly exposed to climate and biodiversity risks, yet their impact on ESG divergence remains largely unexplored. Prior studies suggest that firms with stronger commitments to sustainability are more likely to provide comprehensive non-financial disclosures (Dhaliwal et al., 2012), leading to greater transparency. Corporate managers may issue higher-quality reports and reduce earnings manipulation, which mitigets information asymmetry with external stakeholders (Cui et al., 2018).

Based on the above analysis, we argue that firms with higher exposure to climate risk or biodiversity risk will lead to lower ESG rating divergence. These firms have stronger incentives to enhance environmental transparency to show sustainability commitment and mitigates uncertainty. On the one hand, improved environmental information disclosure helps stakeholders gain a clear understanding of corporate sustainable practices (Friske et al., 2023; García-Sánchez et al., 2023). The increased transparency may also facilitate more consistent ESG assessment by rating agencies. On the other hand, a comprehensive approach to manage climate risk or biodiversity risk provides rating agencies with a clearer understanding of corporate long-term commitment to sustainability. Better risk management for climate or biodiversity risks is likely to foster greater convergence in corporate environmental performance assessment, contributing to a reduction in overall ESG rating divergence.

Using a sample of Chinese listed firms from 2015 to 2022, we empirically investigate the impact of firm-level climate risk and biodiversity risk exposure on corporate ESG rating divergence. We select the Chinese market as our research setting because China plays a pivotal role in advancing global biodiversity governance and sustainable develpoment. Chinese capital market is steadily incorporating climate adaptation and biodiversity issues into ESG practices, encouraging companies to enhance biodiversity concern as a part of their environmental engagement. Accordingly, Chinese listed firms provide an appropriate sample for this study, with findings could offer meaningful implications for other emerging economies to pursue sustainable transitions.

Our findings suggest that firm-level biodiversity risk exposure has a significant negative effect on ESG rating divergence, with greater corporate biodiversity risk exposure results in lower divergence in ESG ratings. Interestingly, we observe that the impact of climate risk exposure on ESG rating divergence is not statistically significant. This relationship remains consistently robust across a series of tests in which we address potential endogenienty issues, confirming that biodiversity risk exposure plays a crucial role in mitigating ESG rating divergence. Mechanism analysis reveals that enhanced ESG information disclosure and improved transparency are two key potential channels. Furthermore, we find biodiversity risk exposure, is more pronounced in firms with lower external attention, firms that disclose ESG reports along with annual reports, and firms that voluntarily disclose ESG report. It indicates that corporate biodiversity risk exposure may reduce ESG rating divergence by improving information transparency.

Our research makes several contributions in three major aspects. First, we extend the growing body of research on the potential economic impact of corporate biodiversity risk exposure. While previous research has examined the effects of corporate biodiversity management on financial factors such as cash holdings (Ahmad & Karpuz, 2024), crash risk, and stock pricing (Bassen et al., 2024; Garel et al., 2024), much of this work has focused on financial risk rather than corporate sustainable strategies. Our study finds that corporate biodiversity exposure can reduce ESG rating divergence while climate risk exposure does not exhibit a statistically significant impact. It implies that climate issues may have become a mainstay of ESG, and rating agencies derive limited incremental informational value from corporate climate risk exposure. In contrast, biodiversity risk management offers rating agencies scarce and differentiated signals, helping reduce discrepancies in ESG assessments.

Second, our research enriches the literature regarding the factors influencing ESG rating divergence. Existing studies have examined ESG rating divergence from the perspectives of rating agency methodologies, assessment frameworks, and corporate disclosure practices (Berg et al., 2022). Our study specifically focuses on the impact of corporate biodiversity risk exposure. We provide empirical evidence that corporate biodiversity risk exposure significantly reduces ESG divergence. This finding enriches the literature on factors affecting ESG divergence and extends the theoretical understanding of the relationship between ESG disclosure, particularly specific type of enviromental information, on ESG rating divergence (Christensen et al., 2022). Notably, our research focuses on China, the world's second-largest economy and a key emerging market, providing empirical evidence on the role of biodiversity concern in corporate sustainable development. Our finding enriches the understanding of how emerging enviromantal issues shape ESG rating convergence in emerging and developing economies.

Finally, our study expands the application of information asymmetry theory within the context of biodiversity finance by exploring the mechanisms between corporate biodiversity risk exposure and ESG divergence. Our findings suggest that corporate biodiversity risk

exposure reduces ESG divergence through increasing ESG disclosure and enhancing information transparency, considering both the quantity and the quality of information disclosures. We also find that firms independently disclose ESG reports or voluntarily publish ESG report lead to a more pronounced impact. Overall, it enriches the literature on information asymmetry in the context of ESG ratings and extends the theoretical boundaries of environmental risk and sustainable development (Christensen et al., 2022).

The remainder of this paper is organized as follows. In Section 2, we review related literature and develop our hypothesis. In Section 3, we describe the research design. In Section 4, we present our main empirical results and robustness tests. In Section 5, we explore the mechanisms and conduct heterogeneity analysis. Section 6 provides our conclusion.

2. Literature review and hypothesis development

2.1. Literature review

2.1.1. Climate risk

The series of risks caused by climate change has a significant impact on the sustainable development of the global economy and society. At the firm level, climate risk involves potential financial losses and operational vulnerabilities arising from extreme weather events and the firm's exposure to climate-related threats. Extensive research in corporate finance has explored the relationship between climate risk and firm performance. For example, extreme weather events, such as droughts, floods, and storms, can directly damage production facilities and disrupt operations, posing risks to asset value and business sustainability (Ginglinger & Moreau, 2023). Firms that are greater exposed to climate risk are likely to have worse performance (Bas & Paunov, 2025; Pankratz et al., 2023).

More pertinent to our research are several studies that have explored the linkages between climate risk, corporate disclosure practices and firm performance. Growing investor and market attention to corporate environmental performance has led to the integration of climate risk into investment decisions and increased calls for enhanced disclosure (Matsumura et al., 2024). Flammer et al. (2021) finds that rising shareholder pressure drives corporate managers to enhance disclosure and manage climate risk exposure, and firms that voluntarily disclosure climate risks tend to receive higher valuations. Similarly, Vestrelli et al. (2024) observes a positive correlation between climate risk disclosure and firm value. From the perspective of the signal theory, corporate climate-related information disclosure is expected to enable analysts and other external stakeholders to understand the efforts in addressing climate risk (Friske et al., 2023) and enhances corporate transparency. Lin and Wu (2023) discovers that firms with higher exposure to climate risk face a lower stock price crash risk, which implies that transparent climate risk exposure helps mitigate financial risk. Moreover, Matsumura et al. (2024) finds that firms with more climate risk disclosure leads to lower corporate risk.

Overall, existing studies have offered valuable insights, but there is still several potential limitations. Recent research attention predominantly focuses on the financial and market performance impacts of climate risk, with relatively less attention given to its potential effects on corporate sustainability and ESG rating practice. Therefore, this study aims to explore the relationship between corporate climate risk exposure and ESG rating divergence.

2.1.2. Biodiversity risk and corporate sustainability

Biodiversity is the cornerstone of ecosystem services that sustain life, holding immense ecological and economic value for human societies (Gamfeldt et al., 2008). However, with the combined impacts of natural factors and human activities, biodiversity is experiencing unprecedented large-scale loss, threatening sustainable economic growth. It not only disrupts ecological stability, but also posing a significant threat to economic development. While research on biodiversity risk in financial economics remains limited, recent studies highlight its importance at the firm level.

Both physical and transition risks related to biodiversity loss increase uncertainties in corporate operations, which ultimately affect long-term corporate sustainability (Giglio et al., 2023). Facing these risks, companies are increasingly recognizing the necessity to address biodiversity risk as a core aspect of corporate sustainability. As consumers of natural resources, organizations bear a moral responsibility to the environment (Jones, 2003), making them play a key role in mitigating biodiversity loss. In response to the growing pressure, firms are incorporating biodiversity considerations into their management practices through enviromantal commitments and enhancing disclosures in sustainability reports (Adler et al., 2017). Empirical evidence suggests that nearly 50% of the world's top 500 companies mentioned biodiversity in their annual reports, with about one-third firms have explicit biodiversity commitments (Addison et al., 2019). These reports serve as important communication tools, providing insights into corporate approaches and responses regarding biodiversity. By improving corporate transparency, such disclosures enable external stakeholders to make more accuracy assessment (Smith et al., 2019), thereby reducing information asymmetry and promoting sustainability.

Despite the growing emphasis on biodiversity as an integral part of corporate sustainability management (Adler et al., 2017; Jones & Solomon, 2013), the economic implications of corporate biodiversity risk exposure and management remain underexplored. A few studies have explored the economic impacts of corporate biodiversity management (Bassen et al., 2024). Ahmad and Karpuz (2024) finds that companies exposed to higher biodiversity risks tend to increase their cash reserves. Bassen et al. (2024) argues that effective biodiversity management could reduce the stock price crash risk. Garel et al. (2024) highlights the growing demand for biodiversity risk premium of global investors. These studies primarily focus on financial outcomes with little understanding of the broader environmental performance, particularly in relation to ESG performance. As Garel et al. (2024) points out, ESG-related risks are receiving growing attention in both academic and business communities. Corporate biodiversity risk exposure may directly impact information disclosure and transparency, fostering a more transparent market environment that supports corporate sustainability (Smith et al., 2019). Given the increasing reliance of ESG ratings on environmental disclosures, firms that actively manage and disclose biodiversity risks may provide more accurate signals to rating agencies, thereby reducing ESG rating divergences. Therefore, the role of corporate biodiversity risk exposure in mitigating ESG divergence and advancing sustainability requires further empirical evidence.

2.1.3. ESG divergence

As ESG practices have deepened, significant discrepancies have emerged in ratings assigned by different agencies to the same company, which is know as a phenomenon of ESG rating divergence (Chatterji et al., 2016). Such phenomenon has attracted extensive academic debate regarding the factors driving ESG rating divergence and its potential consequencesThe factors influencing ESG rating divergence can be divided into two main categories with rating agencies methodology and companies characteristics.

From the rating agencies' methodology, each agency operates with its own distinct characteristics and ESG evaluation frameworks, which often result in differences in assessing a company's ESG performance. Rating agencies frequently use varied assessment standards and methodologies, which can lead to divergent ratings for the same firm (Berg et al., 2022). Furthermore, the quality and availability of corporate ESG disclosure play a direct role in shaping rating outcomes (Billio et al., 2021; Kotsantonis & Serafeim, 2019). Incomplete, outdated, or unreliable ESG information can lead to inconsistent ratings. Even when evaluation methods are similar, different agencies may draw different conclusions, exacerbating ESG divergence.

From the companies characteristics perspective, ESG information

disclosure is fundamental to the rating process. The extent and quality of corporate ESG disclosure is expected to significantly influence ESG rating divergence (Caglio et al., 2020). Christensen et al. (2022) argues that increased ESG disclosure could lead to greater rating divergence. This is because rating agencies must interpret the disclosed information, and unless there is a consensus on social responsibility and ESG metrics, more disclosure may only add to the variation in ratings. Moreover, disclosure related to environmental and social aspects plays a particularly crucial role in driving the divergence (Christensen et al., 2022). However, Kimbrough et al. (2024) argues that voluntary ESG reporting enhances transparency and helps reduce ESG rating divergence, especially when the disclosure focuses on environmental and social aspects. Furthermore, companies adhering to GRI (Global Reporting Initiative) guidelines for ESG reporting tend to experience lower ESG divergence. This suggests that standardized ESG disclosure may be conducive to mitigate rating divergence. In addition to disclosure practices, firm size and industry also influence ESG divergence. Rubino et al. (2024) finds that smaller firms and firms in less environmentally sensitive industries tend to have greater ESG rating divergence.

In summary, the literature on ESG rating divergence does not specifically reveal the role of climate risk or biodiversity risk exposure in ESG rating divergence. Nonetheless, studies discover various factors contributing to the phenomenon, with environmental management and disclosure transparency playing key roles in shaping corporate behavior. Given the increasing relevance of biodiversity focus in corporate sustainability practices, this study aims to fill this gap by investigating the impact of corporate biodiversity risk exposure on ESG rating divergence.

2.2. Hypothesis development

Corporate engagement with climate or biodiversity issues determine their exposure to environmental risks (Giglio et al., 2023). Changes in environmental quality profoundly impact ecosystems, human development, and social welfare, prompting heightened awareness of ecological issues and reinforcing the demand for sustainable development. Confronted with climate risk as well as biodiversity risk that threaten sustainable development, corporates are expected to take corresponding measures. An increasing number of stakeholders and institutions are now advocating for companies to disclose climate-related and biodiversity-related information in their sustainability reports (Adler et al., 2017;Ilhan et al., 2023; Krueger et al., 2020).

As a driving force for ecological civilization, ESG performance has gained considerable attention from various stakeholders. Theoretically, ESG information enhances external stakeholders' understanding and mitigate information asymmetry. Corporate ESG practices cultivate reputation by signaling steadfast commitments to long-term sustainability. However, inconsistencies in ESG rating methodologies, evaluation criteria, and disclosure standards have led to significant discrepancies in corporate ESG ratings, namely ESG rating divergence. Similar to the divergence observed in analyst forecasts, ESG rating divergence reflects underlying issues of information asymmetry and opacity in ESG performance assessments. Prior research suggests that increasing information disclosure and enhanced transparency reduce forecast divergence and uncertainty among analysts (García-Sánchez et al., 2023; Schiemann & Tietmeyer, 2022). Higher transparency and more comprehensive ESG disclosure may help mitigate ESG rating divergence, thereby fostering corporate sustainability.

Amid evolving global sustainable development goals and disclosure initiatives, firms are increasingly taking actions to strengthen their environmental responsibility commitments. Many firms are now incorporating climate risk and biodiversity considerations into their strategic planning and operational management while proactively disclosing ESG-related information to communicate their commitments and actions to stakeholders (Addison et al., 2019). We believe that the heightened climate risk and corporate biodiversity risk exposure is expected to improve transparency and help bridge the trust gap between firms and outside parties, thereby reducing ESG rating divergence.

As companies' exposure to climate risk and biodiversity risks increases, managers tend to face greater pressure and be more sensitive to their environmental exposures, which prompts them to enhance their information disclosure. By disclosing more environmental information, companies can show their commitment to sustainability and demonstrate accountability, reducing misinterpretations and disagreements arising from information gaps. For example, insufficient disclosure of biodiversity or climate-related information may reflect that management fail to fully recognize these issues, potentially undermining external stakeholders' confidence. Given that shareholders increasingly consider sustainability factors in investment decisions, inadequate disclosure could lead to reduced investor interest and heightened uncertainty (Flammer et al., 2021). Insufficient information also makes it challenging for external institutions to accurately assess corporate ESG performance.

Moreover, increased climate risk exposure or biodiversity risk exposure is supposed to reflect a broader commitment to sustainability, and intensify the focus on social responsibility. Greater risk exposure may prompt firms to improve reports' comprehensiveness and transparency, reducing disagreements and uncertainty caused by opaque information. For instance, when biodiversity loss or climate risk poses a significant loss to a company, strengthening internal governance quality and oversight will become imperative. They may try to minimize information withholding and possible earnings manipulation to improve the quality of accouting information (Cui et al., 2018; Kim et al., 2012). Additionally, when external regulators and market participants have a stronger monitor on the corporate information disclosure, firms will have a greater incentive to ensure transparency, as these disclosures play a critical role in shaping investor decisions and market perceptions.

Based on the above analysis, we argue that companies facing high exposure to climate and biodiversity risk are more likely to experience lower ESG divergence with more accurate information disclosure. Therefore, we propose our baseline hypotheses:

Hypothesis 1. Firm-level climate risk exposure affects corporate ESG rating divergence.

Hypothesis 2. Firm-level biodiversity risk exposure negatively affects corporate ESG rating divergence.

3. Research design

3.1. Sample selection and data source

To test our hypothesis, we use data from Chinese A-share listed firms in the Shanghai and Shenzhen stock exchanges from 2015 to 2022 as the initial sample and applies the following data processing criteria. First, we exclude firms in the financial industry due to their distinct financial structure. Second, we remove firms categorized as special treatment, including ST, PT, or *ST firms, to avoid potential biases from financially distressed companies. Third, we exclude observations with missing key variables. Finally, to mitigate the impact of extreme values, we winsorize the main continuous variables at the 1% and 99% threshold. After applying these adjustments, our final sample consists of 25,560 firm-year observations from 4394 firms.

We obtain data for this study from multiple sources. Data on the firm-level biodiversity risk exposure (He et al., 2024) and climate risk exposure (Lei et al., 2023) are sourced from the Global Climate Risk Integration Database of the Carbon Neutrality and Climate Finance Laboratory of the CAS Research Center on Fictitious Economy & Data Science. ESG rating data is obtained from four Chinese major ESG agencies, Huazheng, Wind, SynTao Green Finance, and Fin-ESG. Our sample period starting in 2015 is chosen because calculating ESG rating divergence requires each firm to be covered by at least two rating agencies, with Huazheng begin issuing ratings in 2009 and SynTao Green Finance in 2015. Furthermore, firm-level accounting and

financial data are primarily sourced from the China Stock Market and Accounting Research Database (CSMAR) database, while data on ESG report information are sourced from the Chinese Research Data Services Platform (CNRDS).

3.2. Variables and empirical model

3.2.1. Independent variable

Researchers have employed various approaches to assess climate risk in prior literature, including carbon emission (Bolton & Kacperczyk, 2021), extreme weather events (Pankratz et al., 2023) and climate policy uncertainty (He et al., 2024; He et al., 2025b), primarily focusing on the perspective of external environment or macro-level policies while overlooking the subjective recognition and response of managers. When climate risks are important to a firm's future prospects, managers tends to emphasize climate issues in their reporting or conference (Dzieliński et al., 2024). Management decisions shape corporate environmental strategy, and their perception of climate risk is undoubtedly a key factor affecting climate exposure. Based on this, we choose the managerial climate attention index constructed by Lei et al. (2023) as the corporate climate risk exposure variable. We choose this approach because it represents a perceived or subjective dimension of risk exposure, complementing more objective environmental indicators. It acknowledges that managerial attention can influence the perception of climate risks and, in turn, shaping corporate decision-making and risk management practices. This index is developed through text analysis of the "Management Discussion and Analysis" (MD&A) sections of corporate financial reports of Chinese listed companies, employing machine learning to create a climate expansion dictionary, and counting the frequency of climate-related terms, ultimately constructing the managerial climate attention index (MCA).

For corporate biodiversity risk exposure (Biorisk), there is no standardized approach, as research on firm-level biodiversity finance is still an emerging field. Existing research has utilized various methods to measure biodiversity risk exposure, including the biodiversity score constructed by Giglio et al. (2023) based on 10-K filings (Ahmad & Karpuz, 2024), the Earth Vitality Index (Stolbov, Shchepeleva, & Parfenov, 2025), and the Chinese Biodiversity Risk Index developed by He et al. (2024) using corporate annual reports (Zhou et al., 2025). Given that our study focuses on Chinese firms, the biodiversity disclosures in corporate annual reports not only reflect corporate attention and commitment to biodiversity, but also providing both quantitative and qualitative data to assess their biodiversity risk exposure.

We employ annual data from the corporate biodiversity index developed by He et al. (2024) as the primary explanatory variable in this study. Specifically, drawing on the biodiversity dictionary by Giglio et al. (2023) and incorporating Chinese firms' unique context, He et al. (2024) constructs a Chinese biodiversity dictionary. As legally binding and publicly available documents, annual reports provide a reliable and comprehensive source for measuring firm-level disclosure behaviors. Then they perform text mining on the annual reports of Chinese listed companies to calculates the frequency of biodiversity-related terms, thereby constructing a firm-year-level biodiversity exposure index (Biorisk). A higher index value indicates greater biodiversity risk exposure. To facilitate interpretation of regression coefficients in economic terms, we multiply the original index by 100. Furthermore, considering the complexity of terms and character-based features in the dictionary, following He et al. (2024), we develop two alternative measures of biodiversity risk exposure. They refer to the frequency of Chinese terms from the biodiversity dictionary (Biowords) and the ratio of characters related to biodiversity terms to the total number of characters in the annual reports (Biochar). In the subsequent robustness checks, we substitute the primary measure of corporate biodiversity risk exposure with these alternative indicators to assess the impact of corporate biodiversity risk exposure on ESG rating divergence.

3.2.2. Dependent variable: corporate ESG rating divergence

The core dependent variable in this study is corporate ESG rating divergence (ESGdif4). We obtain ESG rating data from four Chinese major ESG rating providers, Huazheng, Wind, SynTao Green Finance, and Fin-ESG. Given that the accessibility of ESG data facilitates more informed investment decisions and promotes greater market efficiency, we select these four ESG rating agencies as data sources due to their high data accessibility and widespread adoption. Biodiversity is also one of the key indicators in their rating systems. There is no unified standard for measuring ESG rating divergence to date. Thus, this study follows the research methods of Serafeim and Yoon (2023), using the standard deviation of corporate ESG ratings as the primary regression variable. Specifically, the ESG ratings from Huazheng, Wind, and FIN-ESG are categorized into 9 levels, ranging from low to high as follows, C, CC, CCC, B, BB, BBB, A, AA, and AAA. We assign values from 1 to 9 to the ratings, where C corresponds to 1, CC corresponds to 2, CCC corresponds to 3, and so on. In contrast, the ESG rating from SynTao Green Finance, consists of 10 categories, from low to high: D, C-, C, C+, B-, B, B+, A-, A, and A+. Following the same approach, the ratings are assigned values from 0 to 9, with D receiving a value of 0, C- assigned 1, C assigned 2, and so forth. After organizing the ESG ratings from the four rating systems, we calculate the standard deviation of the ESG rating scores to obtain the corporate ESG rating divergence (ESGdif4).

3.2.3. Empirical model

Our empirical analysis focuses on the relationship between corporate biodiversity risk exposure and ESG rating divergence. To achieve this, we construct the following baseline model:

$$ESGdif4_{i,t} = \beta_0 + \beta_1 ER_{i,t} + \gamma Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where i and t denote firm and year, respectively. $ESGdif4_{i,t}$ represents the ESG rating divergence of listed firm i in year t, while $ER_{i,t}$ indicates our variables of interest. It denotes corporate climate risk or biodiversity risk exposure. $Controls_{i,t}$ represents a series of firm operating and corporate governance characteristics variables that may influence ESG rating divergence. Specifically, it includes firm size (Size), firm age (Firmage), financial leverage (Lev), return on assets (Roa), ownership structure (Soe), operating net cash flow (Cashflow), board size (Board), the proportion of independent directors (Inddirect), equity balance (Balance), and whether the firm is audited by one of the Big Four accounting firms (Big4). We also control for firm (μ_i) and year (λ_t) fixed effects. $\varepsilon_{i,t}$ is the residual. Robust standard errors are clustered at the firm level. See detailed variable definitions in Table 1.

4. Empirical Results

4.1. Summary statistics

Table 2 reports the descriptive statistics for variables used in the baseline analysis, including the mean, median, standard deviation, and minimum and maximum value. Our core dependent variable, ESG rating divergence (ESGdif4), has a mean value of 0.796, indicating that the widespread presence of ESG rating divergence among Chinese listed firms and the considerable variation in ESG performance across firms. The maximum value of ESGdif4 reaches 4.243, suggesting that certain firms exhibit exceptionally high ESG rating divergence. MCA varies from 0 to 0.109, with a standard deviation of 0.012, indicating notable differences in climate risk perception among managers across Chinese firms. Furthermore, the mean value of corporate biodiversity risk exposure variable (Biorisk) is 0.028, with a minimum of 0 and a maximum of 2.690. This implies significant variation in corporate biodiversity risk exposure, reflecting uneven emphasis on biodiversity governance and disclosure across firms, which may influence market participants' perception of corporate sustainability. The leverage variable has a mean value of 0.41, return on assets is 0.043, the board size

Table 1
Variable definitions.

Symbol	Definition
ESGdif4	Assign values to the ESG rating indicators from Huazheng, WIND, SynTao Green Finance, and FIN-ESG, and then calculate their standard deviation.
Biorisk	The frequency of biodiversity-related terms in corporate annual reports.
MCA	Corporate managerial climate attention index based on text analysis of MD&A sections in corporate annual reports.
Size	The natural logarithm of total assets.
Lev	Ratio of firm's total liabilities to total assets.
Roa	Ratio of firm's net profits to total assets.
Cashflow	Net cash flows from operating activities divided by total assets
Firmage	The natural logarithm of the age of the firm.
Soe	A dummy variable equal to if the firm belong to state-owned enterprises, and 0 otherwise.
Board	The nature logarithm of the number of board members.
Inddirect	Number of independent directors divided by total directors.
Balance	The ratio of the shareholdings of the 2nd to 5th largest shareholders to that of the largest shareholder.
Big4	A dummy variable equal to 1 if the auditor is from one of the Big Four accounting firms, and 0 otherwise.
ESGdif6	Assign values to the ESG rating indicators from Huazheng, WIND, SynTao Green Finance, FIN-ESG, Bloomberg ESG scores, and FTSE Russell ESG scores, and then calculate their standard deviation.
Green_area	The ratio of landscaped green spaces within the built-up area of the company's region.
Word	The logarithm of the total word count in corporate CSR report plus one.
Sentence	The total sentence count in corporate CSR report.
Absda	The absolute value of corporate discretionary accruals estimated using the modified Jones model, adjusted by year and industry.
Opaque	The cumulative discretionary accruals over the past five years.

Table 2
Descriptive statistics.

Variables	(1)	(2)	(3)	(4)	(5)
	N	mean	sd	min	max
ESGdif4	25,560	0.796	0.755	0.000	4.243
Biorisk	25,560	0.028	0.094	0.000	2.690
MCA	24,013	0.015	0.012	0.001	0.109
Size	25,560	22.276	1.302	19.996	26.660
Lev	25,560	0.410	0.201	0.059	0.911
Firmage	25,560	2.981	0.301	1.386	4.159
Roa	25,560	0.043	0.068	−0.249	0.232
Cashflow	25,560	0.050	0.068	−0.156	0.248
Soe	25,560	0.324	0.468	0.000	1.000
Board	25,560	2.106	0.195	1.609	2.639
Inddirect	25,560	0.378	0.053	0.333	0.571
Balance	25,560	0.770	0.604	0.037	2.825
Big4	25,560	0.062	0.240	0.000	1.000

Notes: This table reports summary statistics of the main variables. See all variables definition in Table 1.

averages 2.106. And sample firms have 37.8 % independent directors in the board. These values align with those in prior studies (Li et al., 2024).

Additionally, following Li et al. (2024), we examine the sample distribution across different years, as summarized in Appendix A. We find an upward trend in corporate biodiversity risk exposure and climate risk, which indicates the increasing awareness of environmental risk perception and disclosure among firms. Meanwhile, corporate ESG rating divergence has also experienced a gradual increase, implying firms are facing growing external evaluative uncertainty regarding their sustainability performance. This rising uncertainty may undermine the effectiveness of resource allocation and could pose challenges to corporate long-term green transition efforts. Similarly, we also examine the sample distribution across different industries, as summarized in Appendix B and C. We find that, compared with firms in other industries, those in the water conservancy and environmental sector as well as the agriculture, forestry, animal husbandry, and fishery sector, exhibit significantly higher levels of biodiversity risk exposure. We do not observe significant industry-level variations in terms of climate risk or ESG rating divergence. The distribution of sample sizes across industries is also generally consistent withLi et al. (2024).

Table 3 reports the correlation coefficients of our main variables. It shows that the correlation coefficients of the vast majority of variables are below 0.4, indicating no significant covariance. It is worth noting that the correlation coefficient between Size and Lev is 0.496, which is generally consistent with the findings of Li et al. (2025). Furthermore, we also calculate the variance inflation factor (VIF) for the main variables, as shown in the Appendix D. We find that all VIF values are well below the threshold of 10, with the average VIF value being only 1.35. This further confirms that there is no significant multicollinearity in this study.

4.2. Baseline results

Table 4 presents the results of baseline model with the relationships between climate risk, biodiversity risk exposure, and ESG rating divergence. Columns (1) and (3) of Table 4 present the impact of corporate climate risk and biodiversity risk exposure on ESG rating divergence without control variables, while Columns (2) and (4) show the results when control variables are included. Column (5) examines the joint impact of climate risk and biodiversity risk on ESG rating divergence. In columns (1) and (3), we do not find a significant association between corporate climate risk and ESG rating divergence, the coefficient for the MCA variable is negative but statistically insignificant, indicating that climate risk does not have a significant effect on reducing ESG rating divergence. This is contrary to our expectation. Interestingly, in Column (5), the coefficient for MCA turns positive, yet remains statistically insignificant. Therefore, we choose to reject Hypothesis 1.

In contrast, Hypothesis 2 is strongly confirmed by our analysis. The results in Columns (2), (4), and (5) consistently show that the coefficient for biodiversity risk exposure is negative and statistically significant at the 1% level. These results indicate that greater corporate biodiversity risk exposure is associated with lower ESG rating divergence, supporting Hypothesis 2. Furthermore, using the results in column (4) as an example, we examine the economic significance of the coefficients. The coefficient of −0.4785 implies that a one standard deviation increase in biodiversity risk exposure is associated with a decrease in ESG rating divergence of approximately 0.045 units (−0.4785 × 0.094), which accounts for approximately 5.7% of the sample mean of ESG rating divergence (0.796).

The statistical insignificance of MCA in relation to ESG rating divergence may be indicative of the inherent time lag between firms' exposure to climate risk and their ability to develop and disclose meaningful climate commitments. Firms exposed to climate risk may need time to take climate strategies, and these actions may not immediately reflect in their ESG ratings. This suggests that the observable impact on ESG rating divergence may take time to manifest, and therefore, and we guess the effects might be pronounced over a longer horizon.

To account for this potential lag effect, we further apply a lagged model in our analysis. Nevertheless, Hypothesis 1 get clearly rejected. Table 5 presents the results. Even with the lagged approach, the coefficients for *MCA* remain statistically insignificant. Whereas the coefficients for *Biorisk* remain statistically significant and negative, suggesting that corporate biodiversity risk exposure has a more immediate and noticeable impact on reducing ESG rating divergence, further conforming Hypothesis 2. These findings highlight the direct and tangible link between biodiversity risk exposure and ESG rating divergence, emphasizing the distinct nature of biodiversity risks in shaping corporate sustainability.

Table 3
Correlation coefficient.

Variables	ESGdif4	Biorisk	MCA	Size	Lev	Firmage	Roa	Cashflow	Soe	Board	Inddirect	Balance	Big4
ESGdif4	1.000												
Biorisk	0.011*	1.000											
MCA	0.079***	0.144***	1.000										
Size	0.135***	0.076***	0.202***	1.000									
Lev	0.061***	0.072***	0.169***	0.496***	1.000								
Firmage	0.145***	0.033***	0.072***	0.168***	0.176***	1.000							
Roa	−0.080***	−0.042***	−0.031***	−0.009	−0.371***	−0.108***	1.000						
Cashflow	0.048***	−0.051***	−0.014**	0.086***	−0.155***	−0.005	0.427***	1.000					
Soe	−0.015**	0.024***	0.094***	0.387***	0.283***	0.245***	−0.120***	−0.014**	1.000				
Board	−0.019***	0.021***	0.068***	0.261***	0.132***	0.096***	−0.010*	0.041***	0.267***	1.000			
Inddirect	0.033***	−0.002	−0.039***	−0.011*	−0.007	−0.018***	−0.004	0.004	−0.050***	−0.583***	1.000		
Balance	0.021***	−0.019***	−0.014**	−0.121***	−0.104***	−0.066***	0.012*	−0.028***	−0.241***	0.013**	−0.032***	1.000	
Big4	0.061***	−0.001	0.003	0.331***	0.098***	0.017***	0.029***	0.069***	0.121***	0.071***	0.029***	−0.029***	1.000

Note: This table reports the Pearson correlation coefficients of main variables. See detailed definition in Table 1. *, **, and *** indicates statistical significance at 10 %, 5 %, and 1 % levels, respectively.

4.3. Robustness checks

4.3.1. Alternative independent variable

We employ alternative metrics to measure corporate biodiversity risk exposure. The regression results using these alternative measures are reported in Table 6. Column (1) presents the results using *Biowords*, the frequency of Chinese terms from our biodiversity dictionary, as a proxy; while column (2) presents results using *Biochar*, the ratio of characters associated with biodiversity terms to the total characters in annual reports. In both cases, the coefficients for corporate biodiversity risk exposure remains significantly negative, indicating that the alternative measures do not alter our primary finding.

4.3.2. Alternative dependent variable

We further test the robustness of our results by adopting alternative measures for the dependent variable, ESG rating divergence. The results using alternative ESG rating divergence metrics are reported in Table 6, columns (3) and (4). In column (3), we calculate the difference between the maximum and minimum values of corporate ESG rating in the year, and take the ESG rating extreme (ESGrange4) as a proxy variable for corporate ESG rating divergence. In column (4), we incorporate two additional rating agencies, Bloomberg and FTSE Russell. Using the established methodology, we calculate the standard deviation of the ratings across these six agencies (ESGdif6) to serve as another proxy variable for ESG rating divergence. In this case, the Bloomberg ESG ratings rounded the composite scores by 10 % and the FTSE Russell ESG ratings rounded the composite scores by 200 %, before computing the standard deviation. The results consistently show that the coefficient on corporate biodiversity risk exposure remains significantly negative, thereby reinforcing our finding that increased biodiversity risk exposure is associated with a reduction in ESG rating divergence.

4.3.3. Instrumental variable regression

Although there appears to be no clear reverse causality between corporate biodiversity risk exposure and ESG rating divergence, to ensure the robustness of our empirical results, we employ regional green area ratio (Green_area) and the industry annual average biodiversity risk exposure (Ind_bio) as instrumental variables in a two-stage least squares (2SLS) regression.

First, green areas, as an integral part of the regional ecosystem, provide habitats and ecological corridors for biodiversity, often being strongly linked to biodiversity levels. Additionally, the development of green areas is typically prioritized by local governments, which may indirectly influence companies' perceptions of biodiversity risk. Therefore, the regional green area ratio is expected to be correlated with corporate biodiversity risk exposure, satisfying the relevance condition. Second, the green area coverage is primarily influenced by geographical and natural factors, which are generally unrelated to corporate decision-making and not directly controlled by firms. Hence, the regional green area ratio meets the requirements for an instrumental variable. Moreover, the biodiversity risk exposure of the industry is clearly correlated with the corporate own biodiversity risk exposure, but it does not directly affect ESG rating divergence.

Columns (1) and (2) of Table 7 present the 2SLS regression results with instrumental variables. The results indicate that corporate biodiversity risk exposure still has a significant negative impact on ESG rating divergence. The weak instrument test for both instrumental variables, measured by the Wald F-statistic, indicating that the chosen instruments are statistically valid. The *p*-value of the Sargan-Basman test statistic exceeds 0.1, indicating no evidence of overidentification and supporting the validity of the two instrumental variables.

4.3.4. PSM

To address potential sample selection bias in the results, we define firms exposed to biodiversity risk as the treatment group and those without exposure as the control group. We apply the Propensity Score

Table 4
The impact of firm-level climate risk, biodiversity risk exposure and on corporate ESG rating divergence: Baseline results.

Variables	(1)	(2)	(3)	(4)	(5)
	ESGdif4	ESGdif4	ESGdif4	ESGdif4	ESGdif4
MCA	**−1.0100**	**−0.2680**			**0.0745**
	(−1.18)	(−0.31)			(0.09)
Biorisk			**−0.5322*****	**−0.4785*****	**−0.4932*****
			(−3.67)	(−3.63)	(−3.61)
Size		−0.0680***		−0.0665***	−0.0659***
		(−4.81)		(−4.70)	(−4.66)
Lev		0.3623***		0.3878***	0.3600***
		(6.90)		(7.38)	(6.86)
Firmage		0.7184***		0.8526***	0.7136***
		(4.64)		(5.58)	(4.62)
Roa		−0.3196***		−0.3278***	−0.3194***
		(−3.45)		(−3.60)	(−3.45)
Cashflow		0.3905***		0.4037***	0.3912***
		(5.34)		(5.60)	(5.35)
Soe		0.0386		0.0320	0.0401
		(1.11)		(0.91)	(1.16)
Board		−0.0656		−0.0622	−0.0632
		(−1.14)		(−1.09)	(−1.10)
Inddirect		−0.1907		−0.1713	−0.1853
		(−1.08)		(−0.98)	(−1.05)
Balance		−0.0143		−0.0234	−0.0149
		(−0.79)		(−1.30)	(−0.82)
Big4		−0.0200		−0.0087	−0.0219
		(−0.37)		(−0.16)	(−0.41)
Constant	0.1051***	−0.3550	0.0963***	−0.7674	−0.3890
	(7.92)	(−0.68)	(10.18)	(−1.48)	(−0.75)
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Observations	24,013	24,013	25,560	25,560	24,013
R-squared	0.465	0.471	0.456	0.463	0.471

Note: The table reports the results of estimating model (1). This table presents the link between climate risk (MCA), corporate biodiversity risk exposure (Biorisk) and ESG rating divergence (ESGdif4). Columns (1) and (3) report the impact of corporate climate risk and biodiversity risk exposure on ESG rating divergence without control variables, only controls for firm and year dummies are included, while columns (2) and (4) show the results when control variables are included. Column (5) presents the results when both climate risk and biodiversity risk are included in the model to examine their joint impact on ESG rating divergence. See all variables definition in Table 1. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

Matching (PSM) method to match the two groups. Following He et al. (2024), we classify a firm as exposed to biodiversity risk if biodiversity-related keywords appear more than twice in its annual report. Considering that pooled matching regression may lead to time mismatching, which could impair the effective control of time fixed effects, and that period-by-period matching might match treatment group firms in different periods with different control group firms, resulting in an unstable control group and potential bias, we use both pooled matching and period-by-period matching methods simultaneously during the matching process. The covariates used for matching are the same as the control variables in the baseline regression.

Table 8 report corresponding results. Column (1) presents the results from nearest-neighbor 1:2 matching using the mixed matching method, while column (2) reports the results from nearest-neighbor 1:2 matching using the period-by-period method. Additionally, we apply kernel matching and radius matching methods, with results presented in Columns (3) and (4), respectively. After using multiple matching methods, the coefficient for Biorisk remains significantly negative, consistent with the baseline results. This suggests that even after addressing potential sample selection bias, the negative impact of corporate biodiversity risk exposure on ESG rating divergence remains robust, reinforcing the core conclusion of our study.

4.3.5. Apply further controls and alternative the cluster level

To control for potential omitted variable issues at the industry, city, and year levels, we extend the baseline model by incorporating interaction fixed effects for "industry-year" and "city-year" to further examine the impact of corporate biodiversity risk exposure on ESG rating divergence. Columns (1) and (2) of Table 9 report the regression results, with the coefficient for biodiversity risk exposure remaining significantly negative.

To mitigate the potential impact of heteroscedasticity and autocorrelation on the results, we have clustered the standard errors at the firm level in the previous regressions. However, recognizing that ESG rating divergence may vary across industries, we recalculated the standard errors by clustering at the industry level. The results are shown in Column (3) of Table 9. Additionally, given the possibility of regional differences in ESG rating divergence across regions, we also cluster standard errors at the city level and re-estimate the model. The corresponding results are reported in Column (4) of Table 9. After adjusting the clustering level to industry and city levels, the regression results consistently show that the coefficient for Biorisk remains significantly negative. Therefore, the core conclusions of our study remain robust.

5. Further analysis

5.1. Exploring the channels

Following our research hypothesis, we investigate the mechanism through which corporate biodiversity risk exposure affects ESG rating divergence, giving emphasis on the role of information transmission. Specifically, we focus on two key aspects: ESG disclosure and information transparency. ESG disclosure reflects the extent and comprehensiveness of sustainability-related information provided by firms, while information transparency captures the clarity and reliability of such disclosures.

We argue that corporate biodiversity risk exposure may contribute to reducing ESG rating divergence by enhancing ESG information

Table 5
The impact of lagged firm-level climate risk, biodiversity risk exposure and on corporate ESG rating divergence.

Variables	(1)	(2)	(3)
	ESGdif4	ESGdif4	ESGdif4
L.MCA	**−0.9851**		**−0.7738**
	(−0.93)		(−0.73)
L.Biorisk		**−0.2701***	**−0.2984***
		(−1.85)	(−1.91)
Size	−0.0370**	−0.0368**	−0.0359**
	(−2.38)	(−2.41)	(−2.30)
Lev	0.3430***	0.3555***	0.3425***
	(5.96)	(6.35)	(5.95)
Firmage	0.3473*	0.3301*	0.3447*
	(1.91)	(1.87)	(1.89)
Roa	−0.7305***	−0.7489***	−0.7301***
	(−7.25)	(−7.67)	(−7.25)
Cashflow	0.1538*	0.1675**	0.1548*
	(1.89)	(2.10)	(1.91)
Soe	0.0078	0.0191	0.0091
	(0.20)	(0.51)	(0.23)
Board	−0.0072	−0.0017	−0.0052
	(−0.11)	(−0.03)	(−0.08)
Inddirect	−0.0771	−0.0607	−0.0748
	(−0.39)	(−0.31)	(−0.38)
Balance	−0.0011	0.0029	−0.0015
	(−0.05)	(0.14)	(−0.07)
Big4	0.0057	0.0153	0.0048
	(0.10)	(0.27)	(0.08)
Constant	−0.0714	−0.0526	−0.0915
	(−0.12)	(−0.09)	(−0.15)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	20,043	21,132	20,043
R-squared	0.419	0.413	0.420

Note: The table reports the results after considering the lagged effect. This table presents the link between climate risk (*MCA*), corporate biodiversity risk exposure (*Biorisk*) and ESG rating divergence (*ESGdif4*). Columns (1) and (2) report the impact of lagged corporate climate risk and lagged biodiversity risk exposure on ESG rating divergence, respectively. Column (3) presents the results when both lagged climate risk and lagged biodiversity risk are included in the model to examine their joint impact on ESG rating divergence. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

Table 6
Robustness check: alternative biodiversity risk exposure and ESG rating divergence measure.

Variables	Alternative biodiversity risk exposure measure		Alternative ESG rating divergence measure	
	(1)	(2)	(3)	(4)
	ESGdif4	ESGdif4	ESGrange4	ESGdif6
Biowords	**−0.7177*****			
	(−3.67)			
Biochar		**−1.2791*****		
		(−3.63)		
Biorisk			**−0.6766*****	**−0.4966*****
			(−3.77)	(−3.16)
Size	−0.0663***	−0.0667***	−0.0298	−0.0748***
	(−4.69)	(−4.72)	(−1.34)	(−4.68)
Lev	0.3877***	0.3879***	0.3624***	0.4500***
	(7.38)	(7.38)	(4.58)	(8.00)
Firmage	0.8517***	0.8518***	1.4231***	1.0469***
	(5.57)	(5.57)	(6.36)	(6.46)
Roa	−0.3277***	−0.3278***	−0.6148***	−0.4576***
	(−3.60)	(−3.60)	(−4.47)	(−4.97)
Cashflow	0.4035***	0.4037***	0.6246***	0.4024***
	(5.60)	(5.60)	(5.65)	(5.36)
Soe	0.0320	0.0318	0.0136	0.0524
	(0.91)	(0.90)	(0.26)	(1.37)
Board	−0.0621	−0.0620	0.0091	−0.0155
	(−1.08)	(−1.08)	(0.10)	(−0.25)
Inddirect	−0.1707	−0.1703	−0.0519	−0.0000
	(−0.98)	(−0.97)	(−0.19)	(−0.00)
Balance	−0.0235	−0.0236	−0.0238	−0.0182
	(−1.30)	(−1.31)	(−0.85)	(−0.95)
Big4	−0.0088	−0.0089	−0.0084	−0.0206
	(−0.16)	(−0.17)	(−0.10)	(−0.38)
Constant	−0.7690	−0.7614	−3.3295***	−0.9707*
	(−1.49)	(−1.47)	(−4.22)	(−1.74)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	25,560	25,560	25,560	25,560
R-squared	0.463	0.463	0.531	0.359

Note: This table reports the regression results of corporate biodiversity risk exposure on ESG rating divergence after using alternative biodiversity risk exposure measure and ESG rating divergence measure. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

disclosure. According to information asymmetry theory, information barriers are a key driver of discrepancies in ESG ratings. Firms may withhold critical ESG-related information, leading different rating agencies to form divergent assessments of their ESG performance. Theoretically, by increasing ESG information disclosure, firms can mitigate information asymmetry and enable external stakeholders to gain a more comprehensive understanding of their ESG practices, thereby reducing rating divergence. Notably, more extensive ESG reports tend to provide richer information, which has been associated with lower ESG rating discrepancies (Caglio et al., 2020).

First, increased ESG disclosure serves as a strategic signal to the market, conveying corporate commitment to sustainability and its proactive engagement with ESG-related initiatives (Addison et al., 2019). This signaling effect fosters mutual trust with information users, reducing risks associated with information asymmetry and uncertainty, ultimately leading to lower ESG rating divergence. Second, enhanced ESG disclosure indicates a firm's responsiveness to sustainability imperatives, which may improve its reputation and mitigating uncertainty risks. Lastly, as investors are increasingly prioritizing biodiversity considerations (Garel et al., 2024), more extensive ESG disclosure could attract greater attention from external stakeholders. This heightened external scrutiny can reinforce corporate accountability and further reducing ESG rating divergence (Rubino et al., 2024). Therefore, enhanced ESG disclosure is one potential mechanism through which corporate biodiversity risk exposure reduces ESG rating divergence.

To validate the ESG disclosure mechanism, given the data accessibility, we use the total word count (Word) and total sentence count (Sentence) in corporate CSR reports as proxies for ESG information disclosure. The total word count and total sentence count are both log-transformed with an added constant of one. In general, longer reports tend to contain more information. Prior studies suggest that the length of CSR reports reflects the extent of information disclosed to some degree. Longer voluntary reports may indicate higher credibility and signal a stronger willingness and greater transparency in corporate disclosure (Caglio et al., 2020;Nazari et al., 2017). The selection of CSR reports is based on the fact that, although CSR reports are not fully equivalent to ESG reports, they contain significant content related to ESG issues, particularly regarding corporate management of environmental responsibility and sustainable development efforts. Table 10 presents the regression results examining the effect of corporate biodiversity risk exposure on ESG information disclosure. Columns (1) and (2) report the results with the total word count as the proxy for information disclosure, while columns (3) and (4) present the results using the total sentence count. We observe that in all four regression results, the coefficients for corporate biodiversity risk exposure is significantly positive. This suggests that corporate biodiversity risk exposure has a substantial positive effect on ESG information disclosure, which aligns with our expectation.

Table 7
Robustness test: instrument variable.

Variables	First stage	Second stage
	(1)	(2)
	Biorisk	ESGdif4
Green_area	**0.0006****	
	(2.37)	
Ind_bio	**0.4039*****	
	(16.47)	
Biorisk		**−2.2414****
		(−2.16)
Size	0.0049***	−0.0574***
	(7.21)	(−4.46)
Lev	−0.0045*	0.3788***
	(−1.75)	(8.45)
firmage	−0.0080	0.8324***
	(−1.27)	(7.61)
Roa	0.0031	−0.3214***
	(0.73)	(−4.27)
Cashflow	0.0023	0.4080***
	(0.59)	(5.95)
Soe	0.0030*	0.0376
	(1.87)	(1.33)
Board	0.0040	−0.0549
	(1.42)	(−1.13)
Inddirect	0.0125	−0.1492
	(1.49)	(−1.02)
Balance	−0.0008	−0.0250*
	(−0.93)	(−1.67)
Big4	−0.0039*	−0.0163
	(−1.75)	(−0.41)
Firm FE	YES	YES
Year FE	YES	YES
Observations	25,199	25,199
R-squared		0.457
Cragg-Donald Wald F	139.82 (10 % maximal IV size = 19.93)	
Sargan statistic	Chi-sq P-value = 0.2011	

Note: This table reports the results of IV testing. We use the regional green area ratio (green_area) and the industry annual average biodiversity risk exposure (Ind_bio) as instrumental variables for a two-stage least squares regression. Columns (1) and (2) report the results of the two-stage least squares regression based on the instrumental variables. Cragg-Donald Wald F statistic represents the weak identification test. Sargan statistic represents the overidentification test of all instrumental variable. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

Table 8
Robustness test: PSM.

Variables	Pooled matching	Period-by-period matching	Kernal matching	Radius matching
	(1)	(2)	(3)	(4)
	ESGdif4	ESGdif4	ESGdif4	ESGdif4
Biorisk	**−0.5085*****	**−0.2085***	**−0.4785*****	**−0.4894*****
	(−3.54)	(−1.73)	(−3.63)	(−3.71)
Size	−0.0688***	−0.0831***	−0.0665***	−0.0659***
	(−4.30)	(−4.91)	(−4.70)	(−4.68)
Lev	0.3503***	0.3022***	0.3878***	0.3824***
	(5.96)	(4.96)	(7.38)	(7.31)
Firmage	0.8281***	0.8657***	0.8526***	0.8025***
	(5.23)	(5.20)	(5.58)	(5.29)
Roa	−0.2986***	−0.3070***	−0.3278***	−0.3392***
	(−2.84)	(−2.89)	(−3.60)	(−3.73)
Cashflow	0.4212***	0.3798***	0.4037***	0.3997***
	(5.05)	(4.45)	(5.60)	(5.54)
Soe	0.0491	0.0540	0.0320	0.0299
	(1.26)	(1.22)	(0.91)	(0.85)
Board	−0.0436	−0.0838	−0.0622	−0.0647
	(−0.70)	(−1.29)	(−1.09)	(−1.13)
Inddirect	−0.0150	−0.2041	−0.1713	−0.1619
	(−0.08)	(−1.02)	(−0.98)	(−0.93)
Balance	−0.0263	−0.0045	−0.0234	−0.0193
	(−1.31)	(−0.21)	(−1.30)	(−1.11)
Big4	−0.0946*	−0.0957*	−0.0087	−0.0096
	(−1.71)	(−1.76)	(−0.16)	(−0.18)
Constant	−0.7767	−0.3999	−0.7674	−0.6421
	(−1.39)	(−0.68)	(−1.48)	(−1.25)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	18,805	19,000	25,560	25,512
R-squared	0.494	0.512	0.463	0.466

Note: This table reports the results of PSM testing exploring the association between corporate biodiversity risk exposure and ESG rating divergence. We take firms exposed to biodiversity risks as the treatment group, and which without biodiversity exposure as the control group. In the matching process, we used both pooled matching, period-by-period matching, kernal matching and radius matching methods. Columns (1) reports the result after nearest neighbor 1:2 matching using the pooled matching method. Columns (2) reports the result after nearest neighbor 1:2 matching using the period-by-period matching method. Columns (3) and (4) report the results after kernel matching and radius matching regressions, respectively. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

In terms of economic significance, for example, the regression coefficient in column (4) of Table 10 is 1.3118, suggesting a 1 % increase in the standard deviation of corporate biodiversity risk exposure leads to an average 2.1 % increase in ESG information disclosure (=0.094*1.3118/5.8089). These findings fully demonstrates that corporate biodiversity risk significantly enhances ESG disclosure, validating the mechanism.

Given that some firms may not issue CSR reports, there may be potential sample seletion issues arise from the absence of data. We can only obtain the corresponding textual data when companies issue CSR reports. For firms that have not issued such reports, we are unable to obtain equivalent measures. Therefore, for consistency and accuracy of the data, we have excluded companies that have not issued CSR reports from the relevant empirical analysis. To address this issue, we have conducted some additional analysis. The disclosure behavior is selective, firms do not disclose reports may differ from those that do in aspects such as external monitoring. We conducted an additional subgroup test, dividing the sample into firms that disclose reports and those that do not, as shown in Appendix E. Specifically, we treat firms with missing CSR report word count and sentence count data as non-disclosing companies. The results show that, in the group of non-disclosing companies, the effect of corporate biodiversity risk exposure on reducing ESG rating divergence is more significant and statistically meaningful. This further supports our analysis that increasing ESG information disclosure is a potential mechanism for reducing ESG rating divergence in relation to corporate biodiversity risk exposure.

Second, we argue that corporate biodiversity risk exposure may contribute to reducing ESG rating divergence by enhancing information transparency. Compared to other countries, ESG rating divergence is more pronounced in China due to insufficient information disclosure and low information quality and transparency (Wang et al., 2024). Information disclosure not only requires sufficient quantity but also needs to ensure adequate quality. According to signaling theory, higher information transparency allows firms to signal high-quality information to the external environment, which can foster greater trust among stakeholders and mitigating uncertainty risks (Chen et al., 2023).

On one hand, high-quality reports provide data on corporate overall performance, helping investors and other stakeholders assess the firm's current situation and long-term prospects, leading to more effective decision-making (Ferracuti & Stubben, 2019). On the other hand, according to information risk pricing theory, when a company's information quality is poor, it faces higher risk premiums, which harms its reputation and undermines sustainable development. Additionally, increased transparency makes it more difficult to conceal false or

Table 9
Robustness test: additional controls and alternative the cluster method.

Variables	Apply further controls		Alternative the cluster level	
	(1)	(2)	(3)	(4)
	ESGdif4	ESGdif4	ESGdif4	ESGdif4
Biorisk	**−0.3255****	**−0.4639****	**−0.4785****	**−0.4785****
	(−2.91)	(−3.31)	(−3.62)	(−2.90)
Size	−0.0827***	−0.0745***	−0.0665***	−0.0665***
	(−5.93)	(−4.78)	(−4.25)	(−2.90)
Lev	0.3742***	0.4358***	0.3878***	0.3878***
	(7.14)	(7.31)	(6.63)	(6.73)
Firmage	0.5993***	0.8726***	0.8526***	0.8526***
	(3.98)	(5.19)	(3.74)	(3.03)
Roa	−0.2915***	−0.3312***	−0.3278***	−0.3278***
	(−3.22)	(−3.32)	(−3.46)	(−3.90)
Cashflow	0.3825***	0.4335***	0.4037***	0.4037***
	(5.27)	(5.38)	(6.95)	(6.53)
Soe	0.0219	0.0171	0.0320	0.0320
	(0.60)	(0.43)	(0.85)	(0.87)
Board	−0.0294	−0.0553	−0.0622	−0.0622
	(−0.52)	(−0.88)	(−1.25)	(−1.22)
Inddirect	−0.1225	−0.1228	−0.1713	−0.1713
	(−0.72)	(−0.64)	(−0.83)	(−1.07)
Balance	−0.0259	−0.0179	−0.0234*	−0.0234
	(−1.45)	(−0.92)	(−1.76)	(−1.39)
Big4	−0.0172	−0.0166	−0.0087	−0.0087
	(−0.33)	(−0.29)	(−0.17)	(−0.18)
Constant	0.8227	−0.1463	−0.7674	−0.7674
	(1.54)	(−0.24)	(−1.07)	(−1.47)
Firm FE	YES	YES	YES	YES
Year FE	NO	NO	YES	YES
Year*Ind FE	YES	NO	NO	NO
Year*City FE	NO	YES	NO	NO
Observations	25,560	25,560	25,560	25,560
R-squared	0.634	0.652	0.463	0.463

Note: This table reports the results after adding high-dimensional fixed effects and adjusting the cluster level. Column (1) reports the result when we further add control for the "industry-year" interaction fixed effects. Column (2) reports the result when we further add control for the "city-year" interaction fixed effects. Column (3) reports the result with standard errors clustered at the industry level. Column (4) reports the result with standard errors clustered at the city level. Simultaneously, we also include firm and year fixed effects in these specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

negative information (Cui et al., 2018; Kim et al., 2012). This allows external stakeholders to gain a more comprehensive and accurate understanding of corporate ESG practices, thereby improving information quality, and ultimately reducing ESG rating divergence. Therefore, information transparency is another potential mechanism through which corporate biodiversity risk exposure reduces ESG rating divergence.

To test the information transparency mechanism, we use the absolute value of discretionary accruals (Absda) and the cumulative discretionary accruals over the past five years (Opaque) as proxies for information transparency. A smaller value of discretionary accruals correlates with better information quality and higher transparency. Table 11 reports the results of corporate biodiversity risk exposure on information transparency. The results show that the coefficient of corporate biodiversity risk exposure is significantly negative at the 1 % level, indicating that increased corporate biodiversity risk exposure significantly reduces earnings manipulation and improves information transparency. As corporate biodiversity risk exposure increases, information transparency improves, which is consistent with our previous analysis. From the perspective of economic significance, for instance, the coefficient for biodiversity risk exposure in column (4) of Table 11 is −0.0884, indicating that a 1 % increase in the standard deviation of corporate biodiversity risk exposure results in a 2.96 % increase in information transparency relative to its mean (=0.094*0.0884/0.2812). In sum, these findings validate the information transparency mechanism.

Table 10
Exploring the channels: ESG information disclosure.

Variables	ESG information disclosure			
	(1)	(2)	(3)	(4)
	Word	Word	Sentence	Sentence
Biorisk	**0.8055****	**0.6131***	**1.5648****	**1.3118****
	(2.32)	(1.82)	(2.37)	(1.98)
Size		0.1908***		0.1951***
		(5.79)		(2.95)
Lev		−0.2353**		−0.0855
		(−2.23)		(−0.41)
Firmage		0.1471		0.4631
		(0.62)		(1.09)
Roa		−0.0634		−0.0366
		(−0.39)		(−0.10)
Cashflow		0.1191		0.1363
		(1.08)		(0.57)
Soe		0.0492		0.2822*
		(0.76)		(1.76)
Board		0.0736		0.1023
		(0.72)		(0.53)
Inddirect		0.2135		−0.4309
		(0.80)		(−0.85)
Balance		−0.0037		−0.0528
		(−0.12)		(−0.85)
Big4		0.0497		0.0698
		(0.76)		(0.60)
Constant	9.2710***	4.3299***	5.6103***	−0.3137
	(528.95)	(4.42)	(157.31)	(−0.16)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	5878	5878	5878	5878
R-squared	0.160	0.174	0.110	0.117

Note: This table reports the results for the ESG information disclosure mechanism. The dependent variables in columns (1) and (2) are the total word count of CSR reports, while those in columns (3) and (4) are the number of sentences in CSR reports. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

5.2. Heterogeneity analysis

5.2.1. External attention

The existence of ESG rating divergence is a kind of noise in existing ESG ratings, which affects the accuracy of predictions of future information and the efficiency of capital market information (Avramov et al., 2022; Serafeim & Yoon, 2023). Theoretically, increased information transparency can reduce this noise, thus mitigating ESG rating divergence. In the external information environment, the degree of external attentionvaries, potentially impacting their information transparency. We propose that the mitigating effect of corporate biodiversity risk exposure on ESG rating divergence may differ depending on the level of external attention. Analyst coverage and research report coverage play crucial roles in corporate external information environment, serving as intermediaries and bridges that facilitate information transmission and enhance transparency. Consequently, firms receiving lower external attention may experience lower information transparency, which could influence the effectiveness of biodiversity risk exposure in reducing ESG rating divergence.

Therefore, followingHe et al. (2025a), we use the number of analysts coverage and the number of research reports issued as proxies for external attention. Based on the median value of the sample, we then divide the firms into high and low external attention groups firms and conduct separate regression analyses for each group. Table 12 present the corresponding results. We find that the coefficients of corporate biodiversity risk exposure are negative in all groups. However, in columns (1) and (3), the coefficients are significantly negative at the 5 % level. Using the Chow test, the results are statistically significant at the 5

Table 11
Exploring the channels: Information transparency.

Variables	Information transparency			
	(1)	(2)	(3)	(4)
	Absda	Absda	Opaque	Opaque
Biorisk	**−0.0332****	**−0.0283****	**−0.0930****	**−0.0884****
	(−3.38)	(−2.61)	(−3.07)	(−3.00)
Size		0.0013		−0.0096
		(0.83)		(−1.35)
Lev		0.0366***		0.0793***
		(6.33)		(3.57)
Firmage		0.0120		0.0847
		(0.98)		(1.33)
Roa		−0.1750***		0.1063***
		(−10.86)		(3.90)
Cashflow		−0.0263**		0.0096
		(−2.12)		(0.39)
Soe		−0.0095***		0.0134
		(−3.17)		(1.20)
Board		0.0039		0.0243
		(0.72)		(1.34)
Inddirect		0.0044		0.0676
		(0.29)		(1.39)
Balance		0.0034**		0.0060
		(1.97)		(1.03)
Big4		−0.0044		0.0291**
		(−0.97)		(2.16)
Constant	0.0550***	−0.0220	0.2895***	0.1319
	(49.87)	(−0.47)	(72.80)	(0.57)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	22,956	22,956	13,824	13,824
R-squared	0.002	0.051	0.013	0.021

Note: This table reports the results for the information transparency mechanism. The dependent variables in columns (1) and (2) are the absolute values of discretionary accruals of operating profits, whereas those in columns (3) and (4) are the cumulative values of discretionary accruals over the past five years. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

% level, indicating substantial inter-group coefficient differences. These results suggest that the mitigating effect of biodiversity risk exposure on ESG rating divergence is more pronounced in firms with lower external attention, such as those with fewer analyst coverage and fewer research reports published. These findings further confirm that corporate biodiversity risk exposure reduces ESG rating divergence by improving information transparency, which provides indirect evidenceto support our research hypothesis.

5.2.2. ESG report characteristics

The impact of corporate biodiversity risk exposure on ESG rating divergence may also vary depending on the characteristics of corporate ESG reporting disclosures. In light of the studies by Dhaliwal et al. (2012) and Krueger et al. (2024), we focus on the heterogeneous impact of corporate ESG report published along with annual reports and independent reports, as well as mandatory and voluntary disclosure. If ESG reports are published along with corporate annual reports, they may fail to adequately convey the company's efforts and achievements in the field of sustainable development to external stakeholders. In contrast, independent ESG reports place greater emphasis on delivering non-financial information to various stakeholders (Dhaliwal et al., 2012). The publication of independent ESG reports demonstrates corporate proactive stance in engaging with a broad range of stakeholders to communicate its ESG strategies, and also reflects its commitment to transparent and systematical disclosure of ESG practices. Therefore, compared to ESG reports published with annual reports, the release of an independent ESG report may be a more significant indication of a company's enhanced transparency.

Table 12
Cross-sectional heterogeneity: external attention.

Variables	Analyst coverage		Report coverage	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
	ESGdif4	ESGdif4	ESGdif4	ESGdif4
Biorisk	**−0.6121****	−0.2795	**−0.5587*****	−0.3497
	(−2.58)	(−1.11)	(−2.60)	(−1.36)
Size	0.0182	0.2327***	0.0110	0.2069***
	(0.70)	(7.05)	(0.42)	(6.30)
Lev	0.1838*	0.0147	0.2351**	0.0667
	(1.95)	(0.13)	(2.44)	(0.61)
Firmage	0.8867***	0.8655***	0.8019***	0.8050***
	(3.14)	(2.84)	(2.84)	(2.68)
Roa	−0.7499***	0.1218	−0.7934***	0.1290
	(−4.28)	(0.57)	(−4.46)	(0.62)
Cashflow	0.4344***	0.2320	0.5047***	0.2290
	(3.49)	(1.44)	(4.03)	(1.47)
Soe	−0.1253*	0.0262	−0.1192*	0.0629
	(−1.73)	(0.29)	(−1.70)	(0.68)
Board	0.0055	−0.1099	0.0779	−0.0878
	(0.05)	(−0.94)	(0.66)	(−0.78)
Inddirect	0.1704	−0.0708	0.2147	−0.0418
	(0.53)	(−0.21)	(0.61)	(−0.13)
Balance	−0.0390	−0.1041**	−0.0345	−0.0922**
	(−1.32)	(−2.36)	(−1.17)	(−2.18)
Big4	−0.0664	0.0583	−0.0006	0.0570
	(−0.69)	(0.71)	(−0.01)	(0.71)
Constant	−2.8480***	−6.9830***	−2.6543***	−6.3440***
	(−2.93)	(−6.21)	(−2.71)	(−5.70)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	8850	7734	8581	8008
R-squared	0.473	0.356	0.480	0.355
P-value	0.021		0.047	

Note: This table presents the results on the heterogeneity of external attention regarding the impact of biodiversity risk exposure on ESG rating divergence. The dependent variables in columns (1) and (2) are analyst coverage, while those in columns (3) and (4) represent research report coverage. The reported p-value indicates the significance of coefficient differences, derived from the Chow test based on the estimation results of the interaction model. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

Moreover, the depth and transparency of disclosed information may also be influenced by different disclosure requirements or corporate intentions behind disclosure. For instance, mandatory disclosures typically follow government or regulatory guidelines, following legal frameworks and industry standards. These disclosures are strictly regulated to ensure the standardized and comparable nature of the information (Krueger et al., 2024). Conversely, voluntary disclosures allow companies greater flexibility to selectively disclosure information according to their strategic priorities. Thus, voluntary disclosure of ESG reports is generally associated with lower transparency and comparability.

To further examine the impact of corporate biodiversity risk exposure on ESG rating divergence, we classify corporate ESG reports into two categories: reports published along with annual reports and independent reports, as well as mandatory and voluntary disclosures. Table 13 report the results. Columns (1) and (2) show the results for ESG reports published along with annual reports and for independent ESG reports, respectively. Columns (3) and (4) present the results for mandatory and voluntary ESG disclosures. We observe that the coefficients of corporate biodiversity risk exposure in columns (1) and (4) are significantly negative at the 1 % level. The Chow test results are significant. These results indicate that when firms disclose ESG reports alongside their annual reports or voluntarily disclose ESG reports, the mitigating effect of biodiversity risk exposure on ESG rating divergence

Table 13
Cross-sectional heterogeneity: ESG report disclosure type.

Variables	Alongside annual reports	Independent disclosure	Mandatory disclosure	Voluntary disclosure
	(1)	(2)	(3)	(4)
	ESGdif4	ESGdif4	ESGdif4	ESGdif4
Biorisk	**−0.4180*****	−0.4189	−0.4764	**−0.3121*****
	(−3.90)	(−1.09)	(−0.73)	(−3.39)
Size	−0.0950***	0.0181	−0.0340	−0.0763***
	(−6.08)	(0.46)	(−0.40)	(−5.65)
Lev	0.3488***	0.1050	0.1279	0.3397***
	(6.20)	(0.75)	(0.46)	(6.69)
Firmage	0.8432***	−0.0718	−1.5352***	0.8840***
	(5.20)	(−0.22)	(−2.62)	(6.27)
Roa	−0.3283***	0.1997	1.0353***	−0.3429***
	(−3.25)	(0.94)	(2.80)	(−3.78)
Cashflow	0.4427***	0.0460	0.0014	0.3987***
	(5.51)	(0.29)	(0.01)	(5.46)
Soe	−0.0336	0.0254	−0.0844	−0.0022
	(−0.87)	(0.28)	(−0.40)	(−0.07)
Board	−0.0442	0.0366	0.0374	−0.0775
	(−0.72)	(0.32)	(0.21)	(−1.40)
Inddirect	−0.1928	0.0721	0.2432	−0.2564
	(−1.03)	(0.22)	(0.58)	(−1.48)
Balance	−0.0262	−0.0351	−0.0730	−0.0138
	(−1.34)	(−0.75)	(−0.77)	(−0.78)
Big4	−0.0899	0.0421	0.0674	−0.0348
	(−1.34)	(0.51)	(0.62)	(−0.61)
Constant	−0.2459	0.0437	5.6719**	−0.6510
	(−0.44)	(0.03)	(2.12)	(−1.32)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	18,169	7364	2730	22,803
R-squared	0.542	0.248	0.158	0.512
P-value	0.006		0.025	

Note: This table presents the results on the heterogeneity of ESG report characteristics regarding the impact of biodiversity risk exposure on ESG rating divergence. Columns (1) and (2) respectively present the results for ESG reports published alongside annual reports and for independent ESG reports, while columns (3) and (4) for mandatory and voluntary ESG disclosures. The reported p-value indicates the significance of coefficient differences, derived from the Chow test based on the estimation results of the interaction model. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels, respectively.

is more pronounced, which aligns with our expectations. In other words, when ESG information is less comprehensive and transparent, biodiversity risk exposure plays a more significant role in reducing ESG rating divergence. These results provide additional robust support for the previous findings.

6. Conclusion

An increasing body of evidence in the financial economics literature suggests how climate risk and ecosystem degradation affect corporate sustainability (Bassen et al., 2024; Krueger et al., 2020; Sautner et al., 2023). In this study, we contribute to the emerging discussion on the impact of corporate climate risk and biodiversity risk exposure on ESG rating divergence. Using a dataset of Chinese A-share listed companies from 2015 to 2022, we find that corporate biodiversity risk exposure significantly reduces ESG rating divergence, while the effect of corporate climate risk on ESG rating divergence does not show a statistically significant negative impact, even after considering potential lag effects. After a series of robustness tests and endogeneity concerns, we verify the robustness of biodiversity risk exposure in reducing ESG rating divergence. We further explored the underlying mechanisms and identify two key channels through which biodiversity risk exposure reduces ESG rating divergence with enhanced ESG information disclosure and increased firm transparency. Additionally, we find that for companies facing lower external monitoring pressure, such as lower analyst coverage and research report coverage, corporate biodiversity risk exposure further alleviates ESG rating divergence. Another key finding is that the characteristic of corporate ESG report disclosures is an important factor in this mitigating effect. Specifically, when companies independently disclose ESG reports or voluntarily disclose them, the impact of biodiversity risk exposure on ESG rating divergence is more pronounced. These results further confirm that the negative impact of biodiversity risk exposure on ESG rating divergence is primarily achieved through improved information transparency.

Overall, the core finding of this study indicates that corporate biodiversity risk has a broader impact on corporate sustainable development. Our study provides new perspectives and empirical evidence on the influence of climate and biodiversity risk exposure on ESG rating divergence, offering valuable insights for corporate managers, market investors, and policymakers in addressing climate and biodiversity risks.

Firstly, corporate managers should prioritize identifying and disclosing biodiversity risks while actively addressing environmental and social responsibility challenges. Although most managers are aware of the climate risk, they should also incorporate biodiversity risk consideration into their daily management, and promote the formulation and implementation of ESG strategies. Moreover, companies need to continuously improve the comprehensiveness and completeness of their ESG reports to ensure the clear and detailed transmission of non-financial information, enhancing transparency. This will help improve external investors' perceptions of the company, reduce divergence in ESG ratings, and increase market trust in the company.

Secondly, in addition to focusing on climate risk, as conveyed by the research of Garel et al. (2024), market investors should also focus on their portfolio exposure to biodiversity risk, and we call for more supervision of corporate actions accordingly to make more forward-looking and accurate investment decisions.

Lastly, policymakers should further improve policies related to biodiversity protection, effectively guiding listed firms and enhancing awareness and management capabilities concerning biodiversity risks. The government can strengthen regulations and standards to require companies to fully consider and disclose biodiversity risks in their daily operations, thereby raising their social responsibility awareness. Additionally, policymakers may consider standardizing the content and format of information disclosures to enhance the quality and comparability of information.

Our study has several limitations. Firstly, we restrict the sample to Chinese A-share listed companies. Chinese listed companies' biodiversity related action may generally slower than their European counterparts in terms of climate risk and biodiversity risk adaptation and mitigation, as well as ESG disclosure practices. Future research could further validate the generalizability of these conclusions by incorporating multinational samples from diverse regions. Secondly, in our analysis, we use the word and sentence count of CSR reports as proxies for ESG information disclosure. While this approach provides a quantitative measure, it may fail to comprehensively capture the quality and depth of the report content. The quality and content of CSR reports may vary significantly, and the method may overlook the actual value and complexity of the information disclosed. Future research could consider adopting more comprehensive disclosure metrics for a more exhaustive analysis.

Author statement

The manuscript has not been published previously or under consideration for publication elsewhere. We declare there are no conflicts of interest regarding this submission.

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Appendix A. Appendix

Appendix A. Sample distribution by year.

Year	Biorisk			MCA			ESGdif4		
	N	Percent	Mean	N	Percent	Mean	N	Percent	Mean
2015	2351	9.200	0.019	2310	9.20	0.012	2351	9.200	0.137
2016	2504	9.800	0.023	2472	11.46	0.012	2504	9.800	0.153
2017	2928	11.46	0.025	2842	9.80	0.012	2928	11.46	0.151
2018	3069	12.01	0.026	3013	12.01	0.013	3069	12.01	0.998
2019	3195	12.50	0.028	3061	13.88	0.013	3195	12.50	1.053
2020	3549	13.88	0.029	3348	12.50	0.013	3549	13.88	1.040
2021	4003	15.66	0.033	3409	15.50	0.022	4003	15.66	1.111
2022	3961	15.50	0.033	3558	15.66	0.019	3961	15.50	1.170
Total	25,560	100	0.028	24,013	100	0.015	25,560	100	0.796

Appendix B. SampleA distribution by industry – Biorisk and MCA.

Industry	Biorisk			MCA		
	N	Percent	Mean	N	Percent	Mean
Accommodation and catering	53	0.21	0.028	51	0.21	0.007
Agriculture, forestry, animal husbandry, fishery	281	1.10	0.149	275	1.10	0.013
Construction	585	2.29	0.103	572	2.29	0.015
Cultural, sports and entertainment	381	1.49	0.019	372	1.49	0.008
Education	56	0.22	0.008	56	0.22	0.009
Electricity, heat, gas and water production and supply	816	3.19	0.030	790	3.19	0.045
General	79	0.31	0.018	78	0.31	0.015
Health and social work	90	0.35	0.016	90	0.35	0.011
Information transmission, software and information technology services	1967	7.70	0.024	1785	7.70	0.012
Leasing and business services	396	1.55	0.016	387	1.55	0.008
Manufacturing	16,921	66.20	0.020	15,773	66.20	0.014
Mining	557	2.18	0.051	539	2.18	0.020
Real estate	707	2.77	0.023	692	2.77	0.008
Residential services, repairs and other services	5	0.02	0.004	5	0.02	0.005
Scientific research and technical services	394	1.54	0.032	356	1.54	0.016
Transportation, warehousing and postal services	727	2.84	0.024	693	2.84	0.011
Water conservancy, environment and public facilities management	437	1.71	0.205	413	1.71	0.033
Wholesale and retail trade	1108	4.33	0.015	1086	4.33	0.009
Total	25,560	100	0.028	24,013	100	0.015

Appendix C. Sample distribution by industry – ESGdif4.

Industry	ESGdif4		
	N	Percent	Mean
Accommodation and catering	53	0.21	0.684
Agriculture, forestry, animal husbandry, fishery	281	1.10	0.799
Construction	585	2.29	0.694
Cultural, sports and entertainment	381	1.49	0.902
Education	56	0.22	0.669
Electricity, heat, gas and water production and supply	816	3.19	0.777
General	79	0.31	0.901
Health and social work	90	0.35	1.042
Information transmission, software and information technology services	1967	7.70	0.862
Leasing and business services	396	1.55	0.913
Manufacturing	16,921	66.20	0.803
Mining	557	2.18	0.905
Real estate	707	2.77	0.637
Residential services, repairs and other services	5	0.02	1.105
Scientific research and technical services	394	1.54	0.790
Transportation, warehousing and postal services	727	2.84	0.784
Water conservancy, environment and public facilities management	437	1.71	0.758

(*continued on next page*)

(*continued*)

Industry	ESGdif4		
	N	Percent	Mean
Wholesale and retail trade	1108	4.33	0.621
Total	25,560	100	0.796

Appendix D. Multicollinearity test.

	VIF	1/VIF
Biorisk	1.030	0.973
MCA	1.070	0.931
Size	1.800	0.556
Board	1.760	0.567
Lev	1.640	0.610
Inddirect	1.580	0.634
Roa	1.420	0.702
Soe	1.350	0.740
Cashflow	1.240	0.808
Big4	1.140	0.880
Firmage	1.080	0.925
Balance	1.070	0.932
Mean VIF	1.350	

Note: This table reports the results of variance inflation factors (VIF) for main variables. All variables' VIF values are well below the threshold of 10, suggesting no significant multicollinearity exist in the regression model.

Appendix E. Subsample analysis by CSR report disclosure.

Variables	Disclose	Non-disclose
	(1)	(2)
	ESGdif4	ESGdif4
Biorisk	−0.2057	**−0.3996*****
	(−0.43)	(−3.97)
Size	−0.0239	−0.0828***
	(−0.54)	(−5.67)
Lev	0.1639	0.3344***
	(1.08)	(6.12)
Firmage	0.0657	0.7988***
	(0.19)	(4.92)
Roa	0.2954	−0.3639***
	(1.26)	(−3.68)
Cashflow	0.0950	0.4562***
	(0.55)	(5.79)
Soe	−0.0387	−0.0157
	(−0.47)	(−0.43)
Board	0.0814	−0.0609
	(0.67)	(−1.01)
Inddirect	0.4097	−0.2366
	(1.14)	(−1.30)
Balance	0.0090	−0.0279
	(0.18)	(−1.49)
Big4	0.1250	−0.0683
	(1.26)	(−1.09)
Constant	0.3337	−0.3102
	(0.24)	(−0.56)
Firm FE	YES	YES
Year FE	YES	YES
Observations	5878	19,682
R-squared	0.274	0.525
P-value	0.000	

Note: Columns (1) and (2) present the results for firms that disclose and do not disclose ESG reports, respectively. Firms with missing CSR report word count and sentence count data are treated as non-disclosing firms. The reported p-value indicates the significance of coefficient differences, derived from the Chow test based on the estimation results of the interaction model. We include firm and year fixed effects in all specifications. Robust t-statistics are reported in parentheses below the coefficient estimates and standard errors are clustered at the firm level. ***, **, * indicates statistical significance at 1 %, 5 %, and 10 % levels,

respectively.

Data availability

Data will be made available on request.

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