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The silent cost of biodiversity loss: Unveiling its impact on institutional ownership

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ABSTRACT

Biodiversity loss poses significant challenges to global ecosystems, economies, and corporate practices. As institutional investors increasingly integrate Environmental, Social, and Governance (ESG) factors into their investment decisions, understanding the influence of biodiversity risk on institutional ownership becomes critical. This study investigates the impact of biodiversity risk on institutional ownership using a sample of U.S. companies from 2009 to 2023. Employing textual analysis of firms' 10-K filings to measure biodiversity risk, the findings reveal a significant negative association between biodiversity risk and institutional ownership. Companies facing higher biodiversity risks tend to experience a reduction in institutional ownership, likely due to concerns over increased financial and reputational risks. Heterogeneity analyses demonstrate that biodiversity risk significantly reduces the proportion of institutional investors in large companies, companies with higher profitability, companies with strong innovation capabilities, and high-growth companies. These results underscore the importance of incorporating biodiversity considerations into corporate risk management practices. The study offers practical implications for corporate managers and investors, emphasizing the need for proactive management of biodiversity-related risks. Keywords: Biodiversity Risk; Institutional Ownership; Firm-level Biodiversity Risk;

1. Introduction

Large shareholders, including institutional investors such as banks, mutual funds, pension funds, hedge funds, and insurance companies, play a critical role in corporate governance (Shleifer & Vishny, 1997). Over the past decades, institutional ownership has increased substantially, making institutions dominant shareholders (Ferreira & Matos, 2008). According to the Federal Reserve Board Flow of Funds Report, by early 2006, institutions owned over 60% of the U.S. stock market. Empirical research suggests that institutional investors help mitigate agency problems and reduce information asymmetry for small shareholders and potential investors (Chang, Kang, & Li, 2016; Crutchley, Jensen, Jahera, & Raymond, 1999; Ozdemir, 2020). As a result, institutional ownership has attracted significant academic and industry attention (Guo & Platikanov, 2019).

Most prior studies focus on how institutional ownership influences various corporate aspects, including corporate sustainability and responsibility (Benlemlih, Arif, & Nadeem, 2023; Cheng, Wang, & Wang, 2022; Dyck, Lins, Roth, & Wagner, 2019; García-Sánchez, Aibar-Guzmán, & Aibar-Guzmán, 2020; Ilhan, Krueger, Sautner, & Starks, 2023; Nofsinger, Sulaeman, & Varma, 2019), financial management (Chen, El Ghoul, Guedhami, & Wang, 2017; Khan, Srinivasan, & Tan, 2017), corporate performance (Duggal & Millar, 1999; Elyasiani & Jia, 2010; Lin & Fu, 2017), innovation (Aghion, Van Reenen, & Zingales, 2013; Rong, Wu, & Boeing, 2017), and corporate governance (Borochin & Yang, 2017; Schmidt & Fahlenbrach, 2017). Institutional investors, possessing greater resources and experience than non-institutional investors, exert substantial influence over corporate governance and decision-making (Velte, 2023). Consequently, firms actively seek to attract institutional investors. However, despite the growing focus on institutional ownership, relatively little research has examined its determinants (Gompers & Metrick, 2001). For example, Francis, Hasan, and Zhu (2021) find that political uncertainty during election years leads to reduced institutional holdings. Saleh, Zulkifli, and Muhamad (2010) identify a positive relationship between corporate social responsibility disclosure and institutional ownership in Malaysian firms. Similarly, Chung and Zhang (2011) suggest that institutional investors favor firms with strong governance to manage fiduciary responsibilities, monitoring costs, and liquidity concerns. Ferreira and Matos (2008) highlight institutional investors' preference for large firms with robust corporate governance.

Amid increasing concerns over environmental sustainability, biodiversity loss has emerged as a critical risk (Butt et al., 2013; Newton,

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2016). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reports that biodiversity loss is accelerating, undermining ecosystems vital to economic and societal stability (Bongaarts, 2019). The current global extinction rate is tens to hundreds of times higher than historical averages, with approximately one million species at risk of extinction in the coming decades without intervention (Bongaarts, 2019). The World Economic Forum (WEF) ranks biodiversity loss among the top five threats to the global economy (WEF, 2020). Human activities have altered 75% of terrestrial and 66% of marine ecosystems, making the global economy highly vulnerable given that over half of global GDP depends on natural capital (WEF, 2020). In response, the United Nations designated 2010 as the International Year for Biodiversity and declared 2011–2020 the Decade on Biodiversity (Carvajal, Nadeem, & Zaman, 2022; Hambali & Adhariani, 2024).

Academic research on biodiversity risk has traditionally been qualitative, focusing on assessment frameworks and mitigation strategies (Spangenberg, 2007; Ermgassen et al., 2022). More recently, scholars have begun employing quantitative methods to examine biodiversity risk at the corporate level. For instance, Giglio, Kuchler, Stroebel, and Zeng (2023) analyze how biodiversity risk affects economic activity and asset values, while Carvalho, Cojoianu, and Ascui (2023) document that 29% of the world's largest listed firms adopted biodiversity policies post-2018. Despite these advancements, quantitative research on biodiversity risk remains limited (Kalhoro & Kyaw, 2024). The relationship between biodiversity risk and institutional ownership remains largely unexplored, though it is potentially significant. Institutional investors – such as pension funds, insurance companies, and mutual funds – often integrate environmental, social, and governance (ESG) factors into investment decisions (Dyck et al., 2019). As a key ESG component, biodiversity is critical in corporate sustainability assessments. Unlike climate change risk, which investors have already factored into pricing (Ilhan et al., 2023), biodiversity risk remains under-researched with limited empirical evidence (Bach, Hoang, & Le, 2024). Firms facing higher biodiversity risk may encounter greater regulatory scrutiny, financial penalties, and reputational damage, potentially affecting their financial performance (Bach et al., 2024) and altering institutional investors' strategies. Given that institutional investors wield substantial influence in financial markets and corporate policies (Cox, Brammer, & Millington, 2004), shifts in their investment behavior in response to biodiversity risk could shape broader market trends and encourage corporate sustainability practices (Renneboog, Ter Horst, & Zhang, 2008).

This study seeks to address the research gap by investigating the impact of biodiversity risk on institutional ownership. Specifically, it examines whether biodiversity risk reduces institutional ownership. Using a sample of U.S. firms from 2009 to 2023, this study follows Giglio et al. (2023) in constructing a biodiversity regulatory exposure measure through textual analysis of firms' 10-K filings. Ordinary least squares (OLS) regression is employed to assess the relationship between biodiversity risk and institutional ownership. The findings indicate that biodiversity risk negatively affects institutional ownership, with robustness tests confirming the results.

Further analysis explores the mechanisms underlying this relationship. Biodiversity risk appears to deter institutional investors by increasing debt risk and damaging corporate reputation. Heterogeneity analyses reveal that biodiversity risk significantly reduces institutional ownership in large firms, highly profitable firms, innovative firms, and high-growth firms, but has an insignificant effect on small, low-profitability, low-innovation, and low-growth firms. The study offers practical implications for corporate managers and investors, emphasizing the need for proactive biodiversity risk management.

The remind of this paper is structured as follows: Section 2 reviews the relevant literature and theoretical frameworks, developing research hypotheses. Section 3 outlines the methodology, including data sources, sample selection, variable construction, and empirical design. Section 4 presents empirical findings, followed by discussion in Section 5. Section 6 concludes with key insights, theoretical and practical implications, and future research directions.

2. Literature review and hypothesis development

According to the United Nations, biodiversity refers to "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". Biodiversity is critically important for the multifunctionality of ecosystems and the maintenance and resilience of ecosystem functions (Lohbeck, Bongers, Martinez-Ramos, & Poorter, 2016). However, biodiversity is declining at an unprecedented rate due to overexploitation of natural resources, deforestation, and extensive pollution (Adler, Mansi, & Pandey, 2018; Hutchinson & Lucey, 2024; Panwar, Ober, & Pinkse, 2023).

Dasgupta (2021) argues that economic activity is the major reason for biodiversity loss. Consequently, the role of companies in incurring and preventing biodiversity loss has gained increasing visibility in academia across numerous areas such as management (Addison et al., 2020; Feger & Mermet, 2022; Gibassier, Maas, & Schaltegger, 2019; Panwar et al., 2023), economics (Giglio et al., 2023; Perrings et al., 2009; Rodríguez-Labajos & Martínez-Alier, 2013), political science (Barrett, Gibson, Hoffman, & McCubbins, 2006; Escobar, 1998; Smith, Paavola, & Holmes, 2019), sociology (Smith et al., 2019; Swanson, Brechin, & Roberts, 2023), international affairs (Petersson & Stoett, 2022; Ten Kate & Laird, 2000), and biology (Addison, Bull, & Milner-Gulland, 2019; MacDonald, 2010).

In the field of finance and economics, research on biodiversity at the firm level is three-fold. The first strand of literature focuses on creating the framework for corporate disclosure (Addison et al., 2019; Atkins & Maroun, 2018; Maroun & Ecim, 2024; Smith et al., 2019) and corporate biodiversity impact measurement (Kennedy, Fuchs, van Ingen, & Schoenmaker, 2023; Schaltegger, Gibassier, & Maas, 2023), incorporating biodiversity into business decision-making (Houdet, 2008; Macellari, Gusmerotti, Frey, & Testa, 2018; Nedopil, 2023), identifying business strategies for biodiversity protection (Panwar et al., 2023; Ermgassen et al., 2022). Kennedy et al. (2023), for instance, integrate resilience thinking into corporate biodiversity impact measurement and put forward a series of mechanisms of the relationship between biodiversity and ecosystem resilience. Nedopil (2023) draws on financial decision-making theory and proposes four principles to incorporate biodiversity into financial decision-making. Panwar et al. (2023) classify business biodiversity protection strategies into four types: conservation strategies, restoration strategies, compensation strategies, and reparation strategies.

The second strand of studies investigates the factors that motivate corporate biodiversity initiatives disclosure. Macro-level factors include national environmental performance (Hambali & Adhariani, 2024), national governance (Hambali & Adhariani, 2024), national economy (Hassan, Roberts, & Atkins, 2020), and industry sector (Hassan et al., 2020). Micro-level factors encompass corporate environmental performance (Hassan et al., 2020), board gender diversity (Haque & Jones, 2020; Issa & Zaid, 2023), board size (Hambali & Adhariani, 2024), independent directors (Hambali & Adhariani, 2024), sustainability committees (Hambali & Adhariani, 2024), investors (Ali, García-Sánchez, Aibar-Guzmán, & Rehman, 2024), partners (Hassan et al., 2020), assurance (Hassan et al., 2020), and environmental awards (Hassan et al., 2020). Hassan et al. (2020) use a sample of companies across 37 countries from 2016 to 2020 and find that national environmental performance, board size, and sustainability committees motivate corporate biodiversity initiatives disclosure, whereas national governance index and the proportion of independent directors are negatively associated with corporate biodiversity initiatives disclosure. They also find that the proportion of female board members has insignificant influence on corporate biodiversity initiatives disclosure. Haque and Jones (2020) draw on the data from European companies during the period of 2002 to 2016 and suggest that board gender diversity promotes the disclosure of corporate biodiversity initiatives and biodiversity impact

assessment. Their findings are also supported by Issa and Zaid (2023), whose work relies on data from non-financial companies in European countries from 2002 to 2021. Hassan et al. (2020) indicate that assurance provided by the Big 4, environmental awards, companies from high biodiversity risk industries, companies operating in developing countries, presence of biodiversity partners, and biodiversity attention (the number of specific biodiversity words in the company's reports) are positively associated with biodiversity/extinction disclosure. Ali et al. (2024) reveal that institutional investors enhance corporate biodiversity disclosure. Their positive impact is greater for investors with a long-term horizon.

The third group of research examines the effects of biodiversity risk at the firm level. Despite the importance of this strand of research, there is scarce evidence (Giglio et al., 2023). A crucial reason is the lack of comprehensive measurement for biodiversity risk which covers complex information and is difficult to quantify. Giglio et al. (2023) put forward a text-based measurement for firm-level biodiversity risk. They combine companies' 10-K statements with a Biodiversity Dictionary and adopt textual analysis to identify biodiversity-related texts in corporate reports.

Following the seminal work by Giglio et al. (2023), a few studies quantify the effects of biodiversity risk on companies (Ahmad & Karpuz, 2024; Bach et al., 2024; Garel, Romec, Sautner, & Wagner, 2023; Ma, Wu, & Zeng, 2024). Ahmad and Karpuz (2024) use the sample from United States public companies and analyze the association between biodiversity risk and corporate cash holding. Their results reveal that biodiversity risk significantly enhances corporate cash policy, especially for companies belonging to industries that are highly exposed to biodiversity risks, companies with financial constraints, and companies that face greater competition. Bach et al. (2024) examine the effects of biodiversity risk on the performance of United States companies between 2001 and 2021. They reveal that biodiversity risk is negatively associated with corporate performance. The decrease is more pronounced for companies belonging to biodiversity-sensitive industries and companies with fewer product innovations. Notably, biodiversity risk decreases sales growth and profitability, increases the cost of goods, and has no significant impact on operation expenses.

Garel et al. (2023) draw on a sample of international stocks and suggest that investors do not price companies' effects on biodiversity. This conclusion is supported by Giglio et al. (2023). Nevertheless, following the appendix and the launch of the Taskforce on Nature-related Financial Disclosures, biodiversity footprints significantly reduce stock prices. Using data from Chinese companies, Ma et al. (2024) assess the effects of the biodiversity risk index on stock market returns. Their work demonstrates that biodiversity risk is negatively associated with stock market returns, especially for companies operating in regions with larger areas of nature reserves, higher GDP, and non-state-owned enterprises. The impact of biodiversity risk also shows heterogeneity across biodiversity-sensitive industries. Notably, Ma et al. (2024) distinguish biodiversity physical risk and biodiversity transactional risk and suggest that biodiversity physical risk significantly reduces stock returns, whereas biodiversity transactional risk has no significant impact. Overall, research on corporate biodiversity responsibility spans multiple disciplines, reflecting its growing relevance in business sustainability.

Institutional ownership is the shareholding ratio of institutional investors that trade in the financial markets on behalf of individual investors (Chung & Zhang, 2011). Institutional investors are legal entities, including banks, mutual funds, pension funds, hedge funds, and insurance companies (Velte, 2023). According to Ruiz-Mallorquí and Santana-Martín (2011), institutional investors serve three roles. First, institutional investors with large and stable stakes in the company serve as an effective corporate governance mechanism (Chung & Zhang, 2011). They effectively monitor corporate management, curb opportunistic managerial behavior, reduce agency conflicts, and help improve corporate performance (Widhiadnyana & Ratnadi, 2018). Second, institutional investors with a short-term focus are less motivated to enhance corporate performance. Third, institutional investors cooperate with company managers to obtain private benefits at the expense of minority shareholders' wealth. Moreover, institutional investors also act as a signaling mechanism that reduces information asymmetry (Widhiadnyana & Ratnadi, 2018). Consequently, institutional investors create more growth opportunities for companies (Lo, Wu, & Kweh, 2017). Empirical research supports the above summary of institutional investors' roles in the company (Dana, 2015; Elyasiani & Jia, 2010; Lin & Fu, 2017; Michel, Oded, & Shaked, 2020).

Considering that different institutional investors may exert diverse influences, several scholars focus on institutional ownership type. According to Bushee and Noe (2000), institutional investors are categorized into long-term (dedicated) investors and short-term (transient) investors. According to institutional investors' portfolios, Bushee (2001) classifies institutional investors into short-term investors and quasi-exponential investors. Almazan, Hartzell, and Starks (2005) use supervision costs to divide institutional investors into positive investors and negative investors. In accordance with the shareholding ratio and holding period, Ferreira and Matos (2008) and Chen, Harford, and Li (2007) sort institutional ownership into transaction investors and stable investors. Ferreira and Matos (2008) classify institutional investors into independent and grey types. Independent investors include mutual fund managers and investment advisers. Grey investors are bank trusts, insurance companies, and other institutions. Guo and Platikanov (2019) divide institutions into pressure-sensitive investors (grey investors) versus pressure-insensitive investors (independent investors) and state-owned investors versus privately owned investors.

Another strand of research centers on the determinants of institutional ownership. Ferreira and Matos (2008) divide the determinants into two types: firm-level factors and country-level factors. They argue that at the firm level, firm size and corporate governance are important factors influencing institutional ownership. Notably, larger companies and those with high-quality corporate governance attract institutional owners. At the country level, they find that institutional owners prefer companies from countries where disclosure standards are strict. According to Han, Niu, and Su (2021), natural endowment factors and acquired factors can affect institutional ownership stability. Natural endowment factors include business connection (a mode where companies and their business partners collaborate based on shared business interests, with the goal of reducing transaction costs) and investment risk preference, whereas acquired factors include regulatory constraints (investment restrictions), market factors (performance ranking pressure), and firm factors (corporate profitability, corporate growth ability, corporate information disclosure, and corporate governance level). Han et al. (2021) suggest that business connection, investment risk preference, performance ranking, and corporate governance level reduce institutional ownership stability, while investment constraints, corporate profitability, corporate growth ability, and corporate information disclosure quality are positively associated with institutional ownership stability. Using the events of gubernatorial elections and a political uncertainty index, Francis et al. (2021) provide evidence that political uncertainty reduces institutional ownership. Guo and Platikanov (2019) draw on a sample of Chinese nonfinancial companies from 1999 to 2010 and demonstrate that companies with strong corporate governance levels, large size, older age, greater liquidity, less stock return volatility, and companies who are members of the CSI 300 index attract more institutional investors. Prior research on institutional ownership primarily examines its impact on firm-level outcomes, with fewer studies exploring its determinants.

To the best of our knowledge, the effects of biodiversity risk on institutional ownership are unexplored. From the perspective of business sustainable initiatives, there are a few studies close to the focus of this study. Using data from Malaysian listed companies from 2000 to

2005, Saleh et al. (2010) examine the effects of corporate social responsibility disclosure on institutional ownership. Their research confirms that corporate social responsibility disclosure attracts more institutional investors. Notably, institutional investors are concerned with employee relations and product dimensions of corporate social responsibility disclosure, while less interested in corporate community contribution practices. Cox et al. (2004) use a sample of United Kingdom companies and examine the effects of corporate social performance on institutional investors. They find that long-term institutional investors value companies with higher social performance. Mahoney and Roberts (2007) report a significantly positive association between corporate social performance and the number of institutional investors. The finding is consistent with Graves and Waddock (1994).

Another group of literature investigates the effects of carbon risk on institutional ownership. Bolton and Kacperczyk (2021), for instance, adopt the data of United States companies and reveal that institutional investors reduce their investment in companies with high scope 1 emission intensity, while they are less sensitive to carbon emissions. Despite several attempts in analyzing the effects of corporate social responsibility disclosure, corporate social performance, and carbon risk on institutional ownership, there is no empirical evidence on the association between biodiversity risk and institutional ownership. This study aims to address this gap by exploring the association between biodiversity risks and institutional ownership and the underlying mechanisms.

Agency theory discusses the relationship in which one or more principals delegate work to an agent or agency (Panda & Leepsa, 2017). A key assumption of this theory is that agents may act in self-interest, leading to agency problems. Institutional ownership can reduce such issues as institutional investors can effectively monitor corporate activities and prevent opportunistic behavior (Widhiadnyana & Ratnadi, 2018). Compared to individual investors, institutional investors possess more resources and experience and have a better ability to collect and process information, thus obtaining more information and knowledge about the market and making better investment decisions (Mahoney & Roberts, 2007; Velte, 2023). Their long-term engagement with firms often results from the impracticality of liquidating large holdings without affecting stock prices (Mahoney & Roberts, 2007). Consequently, institutional investors tend to be risk-averse (Mahoney & Roberts, 2007; Martínez-Ferrero & Lozano, 2021). Underpinning agency theory, Ozdemir (2020) explores the effects of board diversity on the performance of companies in the United States tourism sector and supports the agency theory explanations that effective monitoring is necessary for resolving the conflicts between the agency and principals. Institutional ownership is an external monitoring on both corporate management and the board of directors (Ozdemir, 2020). Institutional investors, who hold a large portion of a company's shares, are motivated to monitor managers and shape corporate behaviors to protect their interests, particularly in projects with high information asymmetries (García-Sánchez et al., 2020).

As the resource-based view of the firm proposes, a company is a set of tangible resources and intangible resources (Barney, 1991). Tangible resources are physical resources, such as human resources and financial resources, whereas intangible resources are those integrated into corporate routines or initiatives, such as corporate reputation and culture (Julienti Abu Bakar & Ahmad, 2010). These resources are rare, valuable, and difficult to substitute or imitate, serving as the main source of corporate sustained competitiveness (Barney, 1991; Madhani, 2010). As García-Sánchez et al. (2020) suggest, the resources and capabilities of companies decide corporate competitiveness and companies' response to external pressures. The natural resource-based view is founded on the resource-based view and highlights the key role of natural capital (Carvalho et al., 2023). This view underlines the effects of the constraints imposed by nature and holds that companies' future competitiveness relies on their capabilities to address environmental challenges (Hart & Dowell, 2011). Drawing on the natural resource-based view, Carvalho et al. (2023) assess the biodiversity risk exposure of companies across the world and stress the natural capital dependency risk of companies. Consequently, natural capital and biodiversity have become an important part of corporate competitiveness in recent decades.

Stakeholder theory holds that organizations should value the needs of all parties that are relevant to the organizations or their operation in any way (Freeman, 2010). A company can be considered as a collection of relationships among various stakeholders (Parmar, Freeman, Harrison, Wicks, Purnell et al., 2010), including internal stakeholders (such as employees, managers, corporate departments, and the board of directors), external stakeholders (such as shareholders, suppliers, creditors, the local community, and the natural environment), and remote stakeholders (such as competitors, consumers, media, government agencies, voters, and labor unions) (Sirgy, 2002). Boiral and Heras-Saizarbitoria (2017) support the premise of stakeholder theory by highlighting the salience of valuing the needs of stakeholders as biodiversity issues involve a wide range of parties. Stakeholders demand corporate environmental and social goals and ability to address associated risks (Velte, 2023).

According to legitimacy theory, corporate operations and business strategies must align with societal norms, values, and expectations to maintain legitimacy (Dowling & Pfeffer, 1975). In line with this theory, Bhattacharyya and Yang (2019) examine the relationship between advanced voluntary reporting frameworks and corporate accountability in addressing the biodiversity crisis. Their findings suggest that companies disclose biodiversity-related information as a means of preserving legitimacy, particularly in response to regulatory requirements mandating such disclosures for firms impacting biodiversity. Furthermore, companies with adverse biodiversity impacts must justify their actions and report on measures taken to mitigate biodiversity loss. Thus, to uphold legitimacy, firms are compelled to disclose biodiversity-related risks and the steps they take to address them.

This study integrates insights from agency theory, the natural resource-based view, stakeholder theory, and legitimacy theory to explore the impact of biodiversity risk on institutional ownership. As awareness of biodiversity conservation has grown, various regulations and policies – such as the Endangered Species Act (ESA), USAID's Biodiversity Policy, and the Environmental and Natural Resource Management Framework – have been enacted. Consequently, companies face increasing pressure from diverse stakeholders to enhance their biodiversity protection efforts. Velte (2023) argues that institutional investors prioritize sustainability considerations because they act as fiduciaries on behalf of others. Accordingly, sustainability issues play a significant role in institutional investors' evaluation processes (Velte, 2023). Biodiversity is particularly critical for corporate operations, as companies rely on natural capital (Winn & Pogutz, 2013).

Biodiversity regulatory exposure refers to the risks associated with biodiversity-related policies and regulations. For instance, the U.S. Endangered Species Act may impose restrictions on corporate activities, habitat protection regulations may limit land use, and forest conservation policies may influence corporate operations and trade (Giglio et al., 2023). As a result, biodiversity regulatory exposure can shape corporate behavior, influence resource availability, and ultimately affect corporate competitiveness and performance. Based on these theoretical perspectives and prior literature, the study proposes the following hypothesis:

Hypothesis 1. Biodiversity risk is negatively associated with institutional ownership.

Beyond restricting corporate behavior and limiting resources, biodiversity-related regulations and policies impose significant compliance costs on businesses (Zhou, Zhang, Wen, Zeng, & Chen, 2018). Under stringent regulatory frameworks, companies must allocate financial resources to mitigate their negative impact on biodiversity and

ecosystems. Non-compliance can lead to substantial fines (Zhang, Bi, Yuan, Ge, Liu et al., 2008). Firms with high biodiversity regulatory exposure may therefore face considerable financial burdens, increasing their risk of bankruptcy and negatively impacting overall operations. Institutional investors, who prioritize financial performance as a key determinant of future growth and stability (Mahoney & Roberts, 2007), may be deterred from investing in such firms. Moreover, due to their substantial ownership stakes, institutional investors may find it challenging to divest from financially unstable companies without adversely affecting stock prices (Mahoney & Roberts, 2007). Consequently, institutional investors perceive biodiversity risk as a financial liability and may reduce investments in companies with high biodiversity risk due to the associated increase in debt risk.

Hypothesis 2. Biodiversity risk reduces institutional ownership by increasing debt risk.

As public awareness of biodiversity conservation continues to rise and sustainability becomes a growing priority, companies must proactively address stakeholder concerns and minimize their negative environmental impact (Boiral & Heras-Saizarbitoria, 2017). Firms exposed to biodiversity risks risk losing legitimacy and suffering reputational damage (Bhattacharyya & Yang, 2019; Brammer & Pavelin, 2006; Treepongkaruna, 2024). Such reputational harm can lead to declines in financial performance (Gatzert, 2015) and erosion of customer loyalty (Andriana, Saparso, Fitrio, Emmywati, & Badaruddin, 2019). Given these risks, institutional investors are likely to reduce their investments in companies with high biodiversity regulatory exposure, as reputational damage can significantly impact corporate stability and investor confidence.

Hypothesis 3. Biodiversity risk reduces institutional ownership by disrupting corporate reputation.

3. Methodology

3.1. Data sources and sample selection

The sample includes all publicly listed U.S. firms with financial data available from Compustat between 2009 and 2023. The study builds on biodiversity risk exposure data from Giglio et al. (2023), based on 10-K statements, and expands the dataset to include more recent years. Using the same methodology as the original authors, biodiversity risk exposures were extracted from 10-K statements in the EDGAR database through dictionary-based textual analysis. The Biodiversity Dictionary included terms such as *biodiversity, ecosystem, habitat, species, deforestation,* and *wildlife*. The dataset now spans the period from 2000 to 2023.

The **biodiversity-Count Score** assigned a value of "1" if a firm's 10-K contained at least two biodiversity-related sentences; otherwise, the score was "0". The **biodiversity-Negative Score** used the BERT model for sentiment analysis to distinguish positive and negative mentions. The **biodiversity-Regulation Score** identified firms mentioning biodiversity and regulatory terms (e.g., *law, regulation, Act*), assigning a score of "1" if at least one regulatory-related biodiversity sentence was present.

Additionally, data on institutional investor shareholdings were obtained from Refinitiv. The sample period from 2009 to 2023 was selected to avoid distortions caused by the 2008 financial crisis and to utilize the most recent data available up to 2023. Firms with missing data on biodiversity risk, control variables, or institutional investor shareholdings were excluded from the analysis. These data filters resulted in a final sample of 2,650 firms and 10,739 firm-year observations. All the sample firms are publicly listed companies in the U.S.

3.2. Variable construction

3.2.1. Independent variable

This study employs biodiversity risk exposure data originally developed by Giglio et al. (2023), derived from 10-K filings. The dataset has been extended to cover the period from 2000 to 2023 using the same methodology as the original authors. This approach offers several advantages. First, 10-K reports, mandated by the U.S. Securities and Exchange Commission (SEC), ensure comprehensive and standardized disclosures, enhancing data reliability and comparability. These reports not only include structured financial metrics but also extensive unstructured textual data, enabling researchers to capture nuanced biodiversity-related information beyond traditional financial statements. This allows for detailed firm-level analysis, revealing differences in biodiversity risk exposure across industries and companies. Additionally, the use of dictionary-based textual analysis and sentiment classification with the BERT model ensures consistency and replicability, effectively distinguishing between positive and negative mentions of biodiversity, thereby preventing overestimation of risk. The availability of multi-year 10-K data also supports longitudinal analysis, allowing researchers to track changes in corporate risk exposure over time and how companies respond to evolving policies and environmental awareness.

This study selects biodiversity regulatory exposure as a measure of the biodiversity risk faced by firms because it directly reflects the impact of biodiversity-related regulations and policies on businesses. These regulations often impose compliance requirements, necessitating operational changes, increased costs, or strategic adjustments. Therefore, monitoring regulatory exposure provides a clearer picture of the potential risks and challenges firms may face due to regulatory changes.

In contrast, the biodiversity count index, proposed by Giglio et al. (2023), simply counts all biodiversity-related terms mentioned by a firm. While this index offers a broad overview of a company's engagement with biodiversity, it does not distinguish between risks and opportunities. The presence of biodiversity terms could indicate positive actions or strategies that enhance biodiversity, rather than risks. Thus, using the biodiversity count index might lead to an overestimation of biodiversity risk, as it does not exclusively focus on adverse impacts.

Furthermore, biodiversity regulatory exposure captures the dynamic nature of regulatory environments. As governments and international bodies continue to evolve their approaches to biodiversity conservation, businesses must adapt to new regulations, which can have significant financial and operational implications. This makes regulatory exposure a more precise and actionable metric for assessing biodiversity risk.

3.2.2. Dependent variable

We employed the Refinitiv database and utilized the institutional investor classification methodologies established by Bushee and Noe (2000) to calculate the overall proportion of institutional ownership, as well as the proportions of various subcategories.

First, we categorized institutional investors based on their expected investment horizons into three distinct types: Transient, Dedicated, and Quasi-Indexers. Both Dedicated and Quasi-Indexers are associated with providing companies with stable, long-term ownership, primarily due to their focus on sustained dividend income or capital appreciation. Dedicated institutions are characterized by significant average investments in their portfolio companies and exceptionally low turnover rates, which align with a relationship investing approach and a commitment to providing long-term, patient capital (Dowdell & Press, 2004; Porter, 1992). Similarly, Quasi-Indexers exhibit low turnover rates but tend to maintain diversified holdings, consistent with a passive buy-and-hold portfolio strategy that invests across a broad range of companies (Porter, 1992). In contrast, Transient institutions are defined by high portfolio turnover rates and extensive portfolio diversification.

These traits indicate that Transient institutions are typically short-term-focused investors whose interest in company stocks is driven by the potential for short-term trading gains (Porter, 1992).

Second, we categorized institutions according to fiduciary standards. To assess the impact of fiduciary restrictions, we divided institutions into four groups based on their legal form: bank trusts, insurance companies, investment advisers (including mutual fund companies), and pensions and endowments. Prior research has demonstrated that this classification reveals significant differences across institutions, particularly in their preferences for current earnings announcements and specific firm characteristics such as size and growth potential (Del Guercio, 1996; Lang & McNichols, 1997; Rodríguez-Labajos & Martínez-Alier, 2013). Banks, which manage equities on behalf of individuals and other institutions through their trust departments, are subject to stringent fiduciary requirements that drive them to avoid stocks that might be deemed imprudent by the courts (Badrinath, Gay, & Kale, 1989; Del Guercio, 1996). Pensions and endowments, encompassing private pensions, public pensions, and the endowments of universities and foundations, also operate under relatively strict fiduciary obligations. However, the prudent person standard has not been as rigorously enforced for pensions as it has been for bank trusts (Del Guercio, 1996; O'Barr & Conley, 1992).

3.3. Research model

To test the hypotheses, this study employs Ordinary Least Squares (OLS) regression analysis. It allows this project to estimate and interpret the relationships between biodiversity risk exposure and institutional ownership effectively. For firm i in industry j and year t, the baseline models used are as follows:

For firm i in industry j and year t, the baseline models used are as follows:

$$InstRioHorizon_{it} = BiodiversityRisk_{it} + Controls_{it} + firm\_dummy_i + year\_dummy_t + Industry\_dummy_j + \epsilon_{it}, \quad (1)$$

$$InstRioLegal_{it} = BiodiversityRisk_{it} + Controls_{it} + Industry\_dummy_j + firm\_dummy_i + year\_dummy_t + \epsilon_{it}, \quad (2)$$

Where $BiodiversityRisk_{it}$ represents the firm's biodiversity risk (Section 3.2.1), $InstRioHorizon_{it}$ and $InstRioLegal_{it}$ denote the two types of institutional investor shareholding percentages calculated using different methods*(see section 3.2.2), and $Controls_{it}$ contains control variables for the financial characteristics. As biodiversity risks vary across firms, sectors, and time, this project includes industry fixed effects ($Industry\_dummy_j$), firm fixed effects ($firm\_dummy_i$), and time fixed effects ($year\_dummy_t$). Standard errors are clustered at the firm level. Specific definitions of each variable are detailed in Appendix A.

3.4. Descriptive statistics

Table 1 presents the descriptive statistics for the variables used in this study, providing key insights into the sample characteristics. On average, biodiversity risk is disclosed in 12.6% of corporate reports across 10,789 observations. However, only 22.7% of firms (2,449 observations) report any biodiversity-related information, while 77.3% (8,340 observations) provide no disclosure, indicating a limited corporate focus on biodiversity risks. Institutional investor ownership, measured by *InsHor* and *InstRioLegal*, averages 22.7% and 21.8%, respectively, reflecting moderate but varied institutional engagement across firms. Firm size, proxied by the log of total assets, has a mean of 4.945, while the mean ROA of −0.226 suggests financial disparities, with some firms facing profitability challenges. *Tobin's Q*, averaging 3 with substantial variation, highlights differing investor perceptions of firm value. Additionally, negative average cash flow and low capital intensity suggest financial constraints and limited capital investment for many firms. These statistics underscore the heterogeneity of the sample, providing a solid foundation for analyzing the impact of biodiversity risk disclosure on institutional ownership.

4. Empirical results

4.1. Biodiversity risk and institutional investor holdings

Table 2 presents the empirical results on the relationship between biodiversity regulatory risk exposure and institutional investor holdings. Models (1) and (2) examine this impact using different classification standards: Model (1) categorizes institutional investors by investment horizon, while Model (2) classifies them based on fiduciary standards. The analysis employs OLS regression with firm, industry, and year fixed effects to control for unobserved heterogeneity. Clustered standard errors at the firm level address potential heteroskedasticity and serial correlation, ensuring robust statistical inference.

The results indicate a significant negative effect of biodiversity risk on institutional investor holdings, with a coefficient of −0.011 (significant at the 5% level). This suggests that a one-unit increase in biodiversity risk leads to a 1.1% decrease in institutional ownership. In practical terms, firms facing higher biodiversity regulatory risks may experience a decline in institutional investment, potentially restricting access to stable, long-term capital. These findings support Hypothesis 1 (H1), reinforcing the link between biodiversity risk and investor behavior. As outlined in Section 2, this effect may stem from debt risk and reputational concerns, which will be empirically tested later in this section.

Several control variables, including firm size, sales revenue, Tobin's Q, and capital intensity, exhibit positive and significant coefficients, indicating that larger firms with higher sales and market growth expectations attract more institutional investment. Firms with higher capital intensity also tend to secure greater investor interest due to the stability of long-term capital investments. However, cash flow is not statistically significant. The high R-squared values (0.843 and 0.836) suggest that the models explain a substantial portion of the variation in institutional ownership.

These findings highlight the growing importance of biodiversity risk in investment decisions and suggest that firms should adopt proactive biodiversity risk management and disclosure practices to maintain institutional investor confidence.

4.2. Robustness test

Robustness analysis is essential for verifying the reliability and consistency of empirical findings. By testing the main results across alternative model specifications, variable definitions, and sample adjustments, this analysis ensures that the observed relationships are not artifacts of specific assumptions (Angrist & Pischke, 2009).

Table 3 presents robustness tests using alternative definitions of key control variables, such as Return on Assets (ROA) and Tobin's Q, to confirm that the relationship between biodiversity risk and institutional investor holdings is not driven by a particular measurement approach. Across all model specifications, biodiversity risk consistently exhibits a significant negative effect on institutional investor holdings, reinforcing the robustness of the findings.

In Models (1) and (2), ROA2, defined as net income minus interest expense divided by total assets (Francis et al., 2021), and TOBINQ1, calculated as the market value of equity plus total debt divided by the sum of common equity and total debt (Aslan & Kumar, 2016), are used as alternative measures. The results indicate that biodiversity risk remains significant, while TOBINQ1 has a significant positive effect on institutional investor holdings at the 5% level.

In Models (3) and (4), the analysis employs ROA3, measured as income before extraordinary items divided by total assets, and TOBINQ2,

Table 1
Descriptive statistics.

Variable	N	Mean	SD	Min	Max
InstRioHorizon	10,789	0.227	0.156	0	0.504
InstRioLegal	10,789	0.218	0.151	0	0.486
BiodiversityRisk	10,789	0.126	0.401	0	3.401
ROA	10,789	−0.226	0.705	−4.090	0.597
Size	10,789	4.945	2.015	0.691	10.20
lnSale	10,789	4.188	2.336	0	9.417
TobinQ	10,789	3	5.943	0.462	46.12
CAP	10,789	0.0360	0.0510	0	0.267
Cashflow	10,789	−0.193	0.691	−4.013	0.623

This table presents descriptive statistics for variables related to biodiversity risk and firm-level characteristics in a sample of 10,789 observations. The variables include biodiversity risk metrics and key firm characteristics, such as return on assets (ROA), size, sales, Tobin's Q, capital investment (CAP), and cash flow.

Table 2
Baseline results: Effects of biodiversity risk on institutional investor holdings.

VARIABLES	(1) InstRioHorizon	(2) InstRioLegal
Biodiversity Risk	−0.011**	−0.011**
	(0.005)	(0.005)
Size	0.056***	0.054***
	(0.003)	(0.003)
ln_Sale	0.007***	0.007***
	(0.002)	(0.002)
TobinQ (TOBINQ2)	0.001***	0.001***
	(0.000)	(0.000)
Capital Intensity	0.080***	0.077***
	(0.024)	(0.023)
Cash Flow	−0.005	−0.003
	(0.010)	(0.009)
Constant	−0.089***	−0.089***
	(0.013)	(0.013)
Observations	9,959	9,959
R-squared	0.843	0.836
Firm FE	YES	YES
Year FE	YES	YES
Industry FE	YES	YES

This table presents the results of the baseline regression analysis examining the impact of biodiversity risk on institutional investor holdings across different classifications. The dependent variables are the proportion of institutional investor holdings based on investment horizons (InstRioHorizon) in column (1) and fiduciary standards (InstRioLegal) in column (2). Biodiversity risk is the key independent variable. The models control for firm characteristics including firm size (Size), logarithm of sales (ln_Sale), Tobin's Q (TOBINQ2), capital intensity (Capital Intensity), and cash flow (Cash Flow). All regressions include firm-fixed effects, year-fixed effects, and industry-fixed effects. The *t*-statistics are reported in parentheses. Statistical significance is denoted by *, **, and *** representing the 10%, 5%, and 1% significance levels, respectively.

which reflects the market-to-replacement value of assets (Francis et al., 2021). The findings continue to show a significant negative impact of biodiversity risk on institutional investor holdings, with TOBINQ2 significant at the 1% level.

Finally, in Models (5) and (6), ROA1, defined as EBITDA divided by total assets (Gantchev, Gredil, & Jotikasthira, 2019), and TOBINQ2 are examined. The results confirm the persistent negative relationship between biodiversity risk and institutional investor holdings, while ROA1 and TOBINQ2 both significantly influence institutional investor behavior.

The inclusion of firm, year, and industry fixed effects ensures robustness, while the high R-squared values indicate that the models explain a substantial portion of the variance in institutional ownership. These findings confirm that biodiversity risk remains a critical factor influencing institutional investor decisions, regardless of variable definitions.

To further validate the robustness of the findings, this study examines whether economic conditions influence the relationship between biodiversity risk and institutional ownership. By analyzing a subsample covering a different period, particularly one that includes major economic events like the 2008 financial crisis but excludes the COVID-19 pandemic, the study assesses the consistency of results across varying economic environments (Angrist & Pischke, 2009).

The subsample spans 2008 to 2020, compared to the 2009–2023 baseline regression period. This timeframe was selected to capture the long-term effects of the 2008 financial crisis on global markets while excluding distortions caused by the COVID-19 pandemic. Focusing on this period allows for a more comprehensive assessment of how biodiversity risk influences institutional investor behavior across different market conditions.

As shown in Table 4, the results confirm that biodiversity risk continues to have a significant negative impact on institutional investor holdings within this subsample. The coefficients for biodiversity risk are −0.016 and −0.015 in the two models, both statistically significant at the 1% level. These findings reinforce the conclusion that higher biodiversity risk leads to a reduction in institutional investor shareholdings, demonstrating that the observed effect persists across different economic environments.

4.3. Endogeneity test

4.3.1. Generalized method of moments

Endogeneity arises in regression analysis when an explanatory variable is correlated with the error term, leading to biased and inconsistent estimates. This issue can result from omitted variables, measurement error, or simultaneity, where biodiversity risk and institutional investor holdings may influence each other. Addressing endogeneity is critical to ensuring the validity and reliability of the estimated relationships. If left unaddressed, endogeneity could lead to misinterpretation of the impact of biodiversity risk on institutional ownership, undermining the robustness of the study's findings.

To mitigate endogeneity concerns, this study employs the extitGeneralized Method of Moments (GMM), an econometric technique that extends the method of moments by using instrumental variables correlated with endogenous regressors but uncorrelated with the error term. Unlike the traditional extitInstrumental Variables (IV) approach, which requires strong external instruments that can be difficult to identify, GMM leverages internal instruments – such as lagged values of the endogenous variables – allowing for more flexible assumptions regarding the error structure, heteroskedasticity, and autocorrelation (Angrist & Pischke, 2009).

This study applies GMM estimation to account for potential biases arising from unobserved heterogeneity, omitted variable bias, and reverse causality. Endogeneity may be present if unobserved factors simultaneously influence both biodiversity risk and institutional investor holdings, or if a bidirectional relationship exists, where biodiversity risk affects investor behavior, while investor decisions, in turn, shape a firm's biodiversity practices. GMM is particularly suited for panel data, as it uses lagged values of dependent and independent variables as internal instruments, producing more consistent and unbiased estimates.

The results confirm a significant negative impact of biodiversity risk on institutional investor holdings, with coefficients of −0.0096

Table 3
Replace measurement of control variables.

VARIABLES	(1) InsHor	(2) InstRioLegal	(3) InsHor	(4) InstRioLegal	(5) InsHor	(6) InstRioLegal
Biodiversity Risk	−0.011**	−0.010*	−0.011**	−0.010**	−0.011**	−0.010**
	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
TOBINQ1	0.000**	0.000**				
	(0.000)	(0.000)				
ROA3			−0.016	−0.018*		
			(0.011)	(0.009)		
TOBINQ2			0.001***	0.001***	0.001***	0.001***
			(0.000)	(0.000)	(0.000)	(0.000)
ROA1					−0.012***	−0.012***
					(0.003)	(0.003)
Observations	9,392	9,392	9,959	9,959	9,912	9,912
R-squared	0.842	0.836	0.843	0.837	0.842	0.836
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

This table presents the regression results examining the impact of biodiversity risk on institutional investor holdings using different measurements of control variables across six models. The dependent variables are the proportions of institutional investor holdings based on investment horizons (InsHor) and fiduciary standards (InstRioLegal). The key independent variable is biodiversity risk. Control variables include different measures of Return on Assets (ROA3, ROA1) and Tobin's Q (TOBINQ1, TOBINQ2) to ensure robustness. Robust standard errors are reported in parentheses. Firm, year, and industry fixed effects are included. Statistical significance is denoted by *, **, and *** corresponding to the 10%, 5%, and 1% levels, respectively.

Table 4
Adjust sample period.

VARIABLES	(1) InsHor	(2) InstRioLegal
Biodiversity Risk	−0.016***	−0.015***
	(0.005)	(0.005)
Size	0.051***	0.049***
	(0.004)	(0.004)
ln_Sale	0.008**	0.008***
	(0.003)	(0.003)
TOBINQ2	0.002***	0.002***
	(0.000)	(0.000)
Capital Intensity	0.065**	0.060**
	(0.026)	(0.025)
Cash Flow	0.001	0.004
	(0.010)	(0.009)
Constant	−0.066***	−0.066***
	(0.017)	(0.016)
Observations	7,437	7,437
R-squared	0.859	0.856
Firm FE	YES	YES
Year FE	YES	YES
Industry FE	YES	YES

This table presents the results from a subsample analysis covering the period from 2008 to 2020, designed to further validate the robustness of the impact of biodiversity risk on institutional investor holdings. The dependent variables are the proportions of institutional investor holdings based on investment horizons (InsHor) and fiduciary standards (InstRioLegal). The key independent variable, biodiversity risk, shows coefficients of −0.016 and −0.015 in the two models. Control variables included in the models are Return on Assets (ROA), firm size (Size), sales revenue (ln Sale), Tobin's Q (TOBINQ2), capital intensity, and cash flow (Cash Flow). The regression models incorporate firm, year, and industry fixed effects to account for unobserved heterogeneity. The R-squared values indicate the explanatory power of the models. Standard errors are robust to clustering at the firm level and are reported in parentheses. Significance levels are denoted by *, **, and ***, corresponding to the 10%, 5%, and 1% thresholds, respectively.

and −0.0100, both statistically significant. This finding suggests that as biodiversity risk increases, institutional investors reduce their holdings, highlighting their sensitivity to environmental risk factors. Additionally, the lagged holding ratio has a significant positive effect on current holdings, indicating inertia in institutional investors' decision-making.

Model diagnostics support the reliability of the GMM estimates. The *AR(1)* test p-values are all below 0.1, rejecting the null hypothesis and confirming first-order autocorrelation in the residuals. In contrast, the *AR(2)* test p-values exceed 0.1, failing to reject the null and indicating the absence of second-order autocorrelation, which validates the GMM assumption of no serial correlation in higher-order lags.

This study utilizes lagged first-period values of the dependent variables (*L1. InstHor* and *L1. InstRioLegal*) and control variables as instrumental variables. The lagged institutional ownership ratios are closely linked to current holdings, while their lagged nature prevents them from being influenced by contemporaneous external shocks, making them reliable instruments. Using internal instruments instead of external ones reduces the risk of introducing new biases, a common concern in IV estimation.

As shown in Table 5, the *Sargan test* p-values are 0.2104 and 0.1546, both above 0.05, failing to reject the null hypothesis of instrument validity. This indicates that the chosen instruments are appropriate, with no evidence of over-identification issues, ensuring the consistency and robustness of the GMM estimates.

Overall, these findings provide strong evidence that even after addressing endogeneity concerns, biodiversity risk remains a key determinant of institutional investor holdings, reinforcing the robustness of the study's conclusions.

4.3.2. Propensity score matching

To further address potential endogeneity, this study employs Propensity Score Matching (PSM) to mitigate biases arising from omitted variables, reverse causality, and measurement errors. PSM improves causal inference by matching firms exposed to biodiversity risk with similar firms that are not, controlling for confounding factors.

First, we convert the biodiversity risk variable into a binary indicator to identify firms exposed to biodiversity risk. We then estimate propensity scores using a logistic regression model, with control variables as independent variables. Firms are matched using nearest neighbor matching with a caliper of 0.05, ensuring precision and minimizing poor-quality matches. After matching, we conduct weighted regression analysis on the matched sample, incorporating firm, year, and industry fixed effects for consistency with the baseline model. As shown in Table 6, the PSM results confirm that firms exposed to biodiversity risk experience a significant decline in institutional investor ownership, reinforcing the robustness of our findings.

4.4. Heterogeneity analysis

This section examines how the relationship between biodiversity risk and institutional investor shareholdings varies across different firm characteristics, including size, profitability, innovation capability, and growth opportunities. The goal is to assess whether biodiversity risk affects institutional investor behavior differently depending on these factors. Heterogeneity analysis is essential for two key reasons. First,

Table 5
Endogeneity Test using GMM.

VARIABLES	(1) InsHor	(2) InstRioLegal
Biodiversity Risk	−0.0096**	−0.0100**
	(0.0042)	(0.0042)
L.InsHor	1.0786***	
	(0.0177)	
L.InstRioLegal		1.0914***
		(0.0173)
TOBINQ2	0.0007**	0.0009***
	(0.0003)	(0.0003)
Capital Intensity	0.0322**	−0.0219
	(0.0163)	(0.0153)
Size	0.0093***	0.0132***
	(0.0026)	(0.0026)
ln_Sale	0.0075***	0.0053***
	(0.0019)	(0.0019)
Cash Flow	−0.0064	−0.0031
	(0.0098)	(0.0097)
Constant	−0.0544***	−0.0650***
	(0.0086)	(0.0086)
Observations	7,654	7,654
AR(1) *p*-value	0.0000	0.0000
AR(2) *p*-value	0.3018	0.3054
Sargan Test *p*-value	0.2104	0.1546

This table presents the results of the dynamic panel data regression analysis using the Generalized Method of Moments (GMM). The dependent variables are the proportions of institutional investor holdings based on investment horizons (InsHor) in column (1) and fiduciary standards (InstRioLegal) in column (2). The key independent variable is biodiversity risk. The lagged dependent variables (L. InsHor and L. InstRioLegal) are included to account for the persistence of institutional investor holdings over time. The models also control for firm characteristics such as Tobin's Q (TOBINQ2), capital intensity, firm size (Size), logarithm of sales (ln Sale), and cash flow (Cash Flow). Robust standard errors are reported in parentheses.

Table 6
Endogeneity Test using PSM.

VARIABLES	(1) InsHor	(2) InstRioLegal
Biodiversity Risk Binary	−0.022**	−0.019*
	(0.011)	(0.011)
ROA2	−0.096***	−0.088**
	(0.036)	(0.036)
Size	0.036***	0.040***
	(0.010)	(0.010)
ln_Sale	0.008	0.006
	(0.007)	(0.007)
TOBINQ2	0.001	0.001
	(0.002)	(0.002)
Capital Intensity	0.064	0.052
	(0.049)	(0.046)
Cash Flow_0	0.100***	0.090**
	(0.037)	(0.036)
Constant	−0.005	−0.037
	(0.060)	(0.058)
Observations	1,575	1,575
R-squared	0.837	0.830
Firm FE	YES	YES
Year FE	YES	YES
Industry FE	YES	YES

This table presents the results of the dynamic panel data regression analysis using the matched sample from the Propensity Score Matching (PSM). The dependent variables are the proportions of institutional investor holdings based on investment horizons (InsHor) in column (1) and fiduciary standards (InstRioLegal) in column (2). The key independent variable is biodiversity risk. The models also control for firm characteristics such as Tobin's Q (TOBINQ2), capital intensity, firm size (Size), logarithm of sales (ln Sale), and cash flow (Cash Flow). Robust standard errors are reported in parentheses.

firms differ in their financial strength, innovation capacity, and growth potential, which may influence their response to biodiversity risks. Identifying these variations provides deeper insights into how institutional investors adjust their strategies based on firm-specific attributes. Second, by demonstrating whether the relationship holds across different firm subsets, heterogeneity analysis enhances the robustness of the findings, ensuring that the observed effects are not driven by a specific group but reflect broader investment patterns.

4.4.1. Firm size

This study examines firm size, measured by total assets, as a key factor influencing the relationship between biodiversity risk and institutional investor shareholding. Firm size is widely recognized as an indicator of a company's resources, market influence, and ability to withstand external risks (Madden, Fehle, & Fournier, 2006; Westhead, Wright, & Ucbasaran, 2001). By analyzing how institutional investors respond to biodiversity risk in firms of different sizes, this study provides deeper insights into investment behavior in the face of environmental challenges.

In capital markets, firm size often determines a company's resilience and adaptability to external risks. Larger firms generally possess greater resources, stronger market positions, and heightened regulatory scrutiny, which may lead them to adopt more robust strategies in response to policy changes (Udayasankar, 2008). However, they also face higher compliance costs and public pressure, which can affect investor confidence. In contrast, smaller firms may have greater flexibility to adapt quickly to regulatory changes but face lower external scrutiny due to their limited market influence (Cowen, Ferreri, & Parker, 1987).

This study selects total assets as the primary measure of firm size, as it captures both fixed and intangible assets, offering a comprehensive and stable representation of a firm's economic strength. Compared to alternatives like sales revenue or number of employees, total assets minimize distortions from industry differences and short-term market fluctuations.

As shown in Table 7, the analysis of large firms (Models 1 and 3) reveals that the coefficients for biodiversity risk are −0.013 and −0.013, statistically significant at the 10% and 5% levels, respectively. This indicates that institutional investors reduce their holdings in larger firms facing biodiversity-related regulatory risks, likely due to concerns over higher compliance costs and legal liabilities. These findings support our hypothesis that larger firms, due to their greater public visibility and regulatory exposure, are more vulnerable to investor divestment when facing biodiversity risks.

In contrast, for smaller firms (Models 2 and 4), the coefficients for biodiversity risk are not statistically significant, suggesting that biodiversity risk has no substantial impact on institutional investor holdings in these firms. Their lower regulatory burden, greater flexibility, and reduced public scrutiny may explain why institutional investors do not react as strongly to biodiversity risks in smaller firms.

4.4.2. Firm profitability

This study examines the heterogeneity in the impact of *biodiversity risk* on *institutional investor shareholdings* by grouping firms based on *Return on Equity (ROE)*, a key measure of profitability that reflects the return generated on shareholders' equity. Unlike other financial metrics, *ROE* directly links profitability to shareholder investment, making it particularly relevant for assessing investor decision-making. By segmenting firms by *ROE*, this study explores whether *institutional investors* respond differently to *biodiversity risks* in firms with varying profitability levels.

We hypothesize that profitability influences investor perceptions of environmental and regulatory risks (Brulhart, Gherra, & Quelin, 2019). In high-*ROE* firms, *biodiversity-related regulatory risks* may raise concerns about potential profit declines, prompting *institutional investors* to reduce their holdings. Conversely, in low-*ROE* firms, which are already less attractive to investors, additional environmental risks may have a negligible impact on investment decisions.

As shown in Table 8, the analysis of high-*ROE* firms (Models 1 and 3) reveals that *biodiversity risk* has a significant negative effect on *institutional ownership*, with coefficients of −0.013 and −0.012, both statistically significant at the 5% level. This suggests that *institutional investors* are particularly sensitive to *biodiversity risks* in high-profitability firms, as such risks can threaten future returns and increase investment uncertainty.

Table 7
Heterogeneity analysis based on firm size.

VARIABLES	(1) Big Size InsHor	(2) Small Size InsHor	(3) Big Size InstRioLegal	(4) Small Size InstRioLegal
Biodiversity Risk	−0.013*	−0.001	−0.013**	−0.009
	(0.007)	(0.009)	(0.006)	(0.007)
ROA2	−0.006	−0.010	−0.001	−0.011
	(0.036)	(0.007)	(0.037)	(0.007)
Size	0.024**	0.047***	0.030***	0.047***
	(0.010)	(0.005)	(0.009)	(0.005)
ln_Sale	0.003	0.012***	0.002	0.012***
	(0.007)	(0.004)	(0.007)	(0.004)
TOBINQ2	0.005**	0.001***	0.004**	0.001***
	(0.002)	(0.000)	(0.002)	(0.000)
Capital Intensity	0.056	0.038	0.032	0.033
	(0.056)	(0.028)	(0.052)	(0.028)
Cash Flow	0.043	0.005	0.035	0.007
	(0.039)	(0.007)	(0.042)	(0.007)
Constant	0.102	−0.061***	0.043	−0.065***
	(0.067)	(0.014)	(0.065)	(0.014)
Observations	2,477	2,394	2,477	2,394
R-squared	0.823	0.791	0.810	0.790
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

This table presents the results of the heterogeneity analysis examining the impact of biodiversity risk on institutional investor holdings (InsHor and InstRioLegal) across firms of different sizes. The sample is divided into two groups: large firms (big size) and small firms (small size), based on the total assets. The models control for key financial variables, including ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow, and include firm, year, and industry fixed effects. Robust standard errors are clustered at the firm level. Significance levels are indicated by *, **, and *** for the 10%, 5%, and 1% thresholds, respectively.

Table 8
Heterogeneity analysis based on return on equity.

VARIABLES	(1) High ROE InsHor	(2) Low ROE InsHor	(3) High ROE InstRioLegal	(4) Low ROE InstRioLegal
Biodiversity Risk	−0.013**	−0.016	−0.012**	−0.018
	(0.006)	(0.012)	(0.006)	(0.012)
ROA2	0.020*	−0.032**	0.017	−0.030**
	(0.012)	(0.014)	(0.012)	(0.014)
Size	0.050***	0.063***	0.049***	0.060***
	(0.005)	(0.004)	(0.005)	(0.004)
ln_Sale	0.004	0.008***	0.004	0.008***
	(0.005)	(0.003)	(0.005)	(0.003)
TOBINQ2	0.002***	0.001	0.002***	0.001
	(0.000)	(0.001)	(0.000)	(0.001)
Capital Intensity	0.053	0.072*	0.053*	0.067*
	(0.033)	(0.038)	(0.031)	(0.036)
Cash Flow	−0.019	0.014	−0.016	0.013
	(0.012)	(0.015)	(0.011)	(0.014)
Constant	−0.057*	−0.107***	−0.066**	−0.104***
	(0.029)	(0.017)	(0.029)	(0.017)
Observations	4,823	4,584	4,823	4,584
R-squared	0.862	0.850	0.854	0.847
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

This table presents the results of the heterogeneity analysis examining the impact of biodiversity risk on institutional investor holdings (InsHor and InstRioLegal) across firms with different levels of return on equity (ROE). The sample is divided into two groups: high ROE and low ROE firms. The models control for key financial variables, including ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow, and include firm, year, and industry fixed effects. Robust standard errors are clustered at the firm level. Significance levels are indicated by *, **, and *** for the 10%, 5%, and 1% thresholds, respectively.

For low-*ROE* firms (Models 2 and 4), the *biodiversity risk* coefficients (−0.016 and −0.018) are negative but not statistically significant, indicating no substantial impact on *institutional investor holdings*. Since these firms are already perceived as high-risk and less attractive to *institutional investors*, additional *biodiversity risks* do not significantly alter investment decisions.

These findings highlight that *institutional investors* prioritize profitability when assessing environmental risks, with *biodiversity concerns* playing a greater role in high-*ROE* firms, where potential earnings disruptions are more consequential.

4.4.3. Firm innovation capability

This study examines how *corporate innovation capability* influences the relationship between *biodiversity risk* and *institutional investor shareholding*. *Innovation capability* reflects a firm's adaptability to market changes and regulatory shifts, shaping its ability to navigate environmental risks. Highly innovative firms allocate significant resources to *R&D*, enhancing their competitive edge (Slater, Mohr, & Sengupta, 2014; Yam, Lo, Tang, & Lau, 2011). However, this also makes them more vulnerable to *biodiversity-related regulations* due to potential compliance costs and operational uncertainties (Blind, 2012; Spangenberg, 2007).

To measure *innovation capability*, this study uses *RD1* (Research and Development expense ratio), calculated as *R&D expenditures* divided by *total assets* (Dowdell & Press, 2004). This metric captures a firm's commitment to innovation while mitigating distortions from short-term market fluctuations.

As shown in Table 9, Models (1) and (3) analyze high-*RD1* firms, while Models (2) and (4) examine low-*RD1* firms. In highly innovative firms, the coefficient for *biodiversity risk* is −0.014 and statistically

Table 9
Heterogeneity analysis based on research and development intensity.

VARIABLES	(1) High RD1 InsHor	(2) Low RD1 InsHor	(3) High RD1 InstRioLegal	(4) Low RD1 InstRioLegal
Biodiversity Risk	−0.014**	−0.001	−0.014**	0.000
	(0.006)	(0.009)	(0.006)	(0.008)
ROA2	−0.003	0.029	−0.005	0.027
	(0.010)	(0.025)	(0.009)	(0.025)
Size	0.054***	0.058***	0.051***	0.058***
	(0.003)	(0.006)	(0.003)	(0.006)
ln_Sale	0.006**	0.013**	0.006**	0.011**
	(0.003)	(0.005)	(0.003)	(0.005)
TOBINQ2	0.001**	0.004***	0.001**	0.004***
	(0.000)	(0.001)	(0.000)	(0.001)
Capital Intensity	0.064**	0.140***	0.061**	0.135***
	(0.030)	(0.043)	(0.028)	(0.043)
Cash Flow	−0.003	−0.026	−0.002	−0.025
	(0.010)	(0.026)	(0.009)	(0.026)
Constant	−0.068***	−0.138***	−0.068***	−0.134***
	(0.016)	(0.026)	(0.016)	(0.025)
Observations	7,049	2,733	7,049	2,733
R-squared	0.837	0.873	0.833	0.863
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

This table presents the results of the heterogeneity analysis examining the impact of biodiversity risk on institutional investor holdings (InsHor and InstRioLegal) across firms with varying levels of research and development intensity (RD1). The analysis is split between high RD1 and low RD1 firms. The models control for financial variables including ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow. Firm, year, and industry fixed effects are included in the regressions. Robust standard errors are clustered at the firm level. Statistical significance is indicated by *, **, and *** corresponding to the 10%, 5%, and 1% significance levels, respectively.

significant at the 5% level, indicating that *biodiversity risk* leads to a notable reduction in *institutional investor holdings*. This supports the hypothesis that *institutional investors* perceive high-*R&D* firms as particularly sensitive to regulatory uncertainties, leading to higher investment risk. Given their substantial *R&D* investments, any regulatory disruptions could impact profitability and market competitiveness, prompting *institutional investors* to divest to minimize exposure.

Conversely, in firms with low *innovation capability*, *biodiversity risk* does not significantly affect *institutional investor holdings* (Model (2) coefficient: −0.001; Model (4) coefficient: 0.000, both insignificant). These firms tend to have more stable, mature business models, making them less reactive to environmental risks. As a result, *institutional investors* do not adjust their holdings based on *biodiversity concerns* in these companies.

These findings highlight that *institutional investors* prioritize regulatory stability when investing in high-*innovation* firms, while low-*innovation* firms remain largely unaffected by *biodiversity risk* in investment decisions.

4.4.4. Firm growth opportunities

This study further examines the impact of biodiversity risk on institutional investor shareholding by analyzing heterogeneity based on firms' growth opportunities. Growth opportunities reflect a company's potential for expansion and profitability, influencing long-term investment decisions (Cho & Pucik, 2005; Souder & Shaver, 2010). High-growth firms are typically attractive to investors due to their future earnings potential. However, biodiversity risks may raise concerns about regulatory constraints and operational uncertainties, potentially limiting growth and reducing investor confidence. In contrast, low-growth firms, often in a mature stage with stable market positions, are less likely to be significantly affected by biodiversity risks, making institutional investors less sensitive to these factors. Thus, we expect that biodiversity risk will have a stronger negative impact on institutional ownership in high-growth firms.

As shown in Table 10, biodiversity risk has a significant negative effect on institutional investor holdings in high-growth firms, with coefficients of −0.015 (Model 1) and −0.016 (Model 3), significant at the 10% and 5% levels, respectively. This supports the hypothesis that institutional investors perceive biodiversity risk as a potential threat to future growth and profitability, leading to reduced investment in high-growth firms exposed to such risks.

In contrast, for low-growth firms (Models 2 and 4), biodiversity risk does not significantly affect institutional investor shareholding, as indicated by statistically insignificant coefficients. These firms, characterized by stable market positions and limited expansion potential, are less influenced by external risks, making biodiversity concerns less relevant to investor decision-making.

These findings highlight that institutional investors are particularly sensitive to biodiversity risks when evaluating high-growth firms, whereas low-growth firms remain largely unaffected in investment decisions.

4.4.5. Firm debt risk

In the mechanism analysis of this study, this paper first chose to examine *corporate debt risk* as a key pathway, primarily because a company's *financial structure* significantly reflects its resilience or vulnerability in facing external risks. *Debt risk* is a core indicator of a company's *financial health*, directly impacting its *financing costs*, *liquidity*, and *financial stability* (Andriana et al., 2019; El Ghoul, Guedhami, Saadi, & Sassi, 2023). With the global focus on *environmental protection* and *sustainable development* intensifying, *biodiversity risk* has become a significant external challenge for companies. When a company faces *biodiversity-related regulations*, litigation, or market pressures, it may need to increase *debt financing* to cover compliance costs or environmental remediation expenses, thereby raising its *financial leverage* (Garel et al., 2023). Elevated *debt risk* not only increases the likelihood of *bankruptcy* but may also diminish the company's attractiveness in capital markets, prompting *investors* to reassess their portfolios.

Therefore, in this section, this study employed various metrics to measure *corporate debt risk*. First, as shown in the first column of Table 12, this study used the natural logarithm of *total liabilities* (*Leverage3*) as a metric. The primary advantage of this approach is that it smooths out extreme values and reduces the impact of differences in *company size*. By taking the logarithm, this study can better compare *debt levels* across companies of different sizes, minimizing bias from extreme liability values. Additionally, this metric provides a clear assessment of a company's overall *debt situation*, reflecting its financial flexibility in dealing with external risks. Second, in the second column, this study used the *debt-to-book leverage ratio* as a proxy variable, calculated as the ratio of *debt* to the sum of *debt* and *book equity*. This measure's advantage lies in its ability to directly assess a company's *financial*

Table 10
Heterogeneity analysis based on growth opportunities.

VARIABLES	(1) High Growth InsHor	(2) Low Growth InsHor	(3) High Growth InstRioLegal	(4) Low Growth InstRioLegal
Biodiversity Risk	−0.015*	−0.009	−0.016**	−0.007
	(0.008)	(0.009)	(0.008)	(0.009)
ROA2	0.000	−0.005	−0.001	−0.005
	(0.016)	(0.011)	(0.014)	(0.011)
Size	0.052***	0.067***	0.050***	0.065***
	(0.004)	(0.006)	(0.004)	(0.006)
ln_Sale	0.008**	0.001	0.008**	0.001
	(0.003)	(0.004)	(0.003)	(0.004)
TOBINQ2	0.001***	0.003**	0.001***	0.003***
	(0.000)	(0.001)	(0.000)	(0.001)
Capital Intensity	0.086***	0.045	0.083***	0.043
	(0.032)	(0.045)	(0.029)	(0.044)
Cash Flow	−0.007	0.004	−0.005	0.003
	(0.016)	(0.011)	(0.014)	(0.011)
Constant	−0.067***	−0.126***	−0.068***	−0.128***
	(0.017)	(0.027)	(0.017)	(0.027)
Observations	6,061	3,150	6,061	3,150
R-squared	0.839	0.880	0.835	0.871
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

This table presents the results of the heterogeneity analysis examining the impact of biodiversity risk on institutional investor holdings across firms with varying levels of growth opportunities. The analysis is split between high-growth and low-growth firms, as measured by the ratio of sales growth. The models control for financial variables including ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow. Firm, year, and industry fixed effects are included in the regressions. Robust standard errors are clustered at the firm level. Statistical significance is denoted by *, **, and *** corresponding to the 10%, 5%, and 1% significance levels, respectively.

leverage, reflecting the proportion of *debt* relative to *shareholder equity* (Petersson & Stoett, 2022). Compared to absolute debt levels, this ratio-based metric offers additional insights into the company's dependency on *debt* in its *capital structure*, effectively highlighting the robustness of the company's *capital structure* in managing *financial risk*. Lastly, in the third column, the dependent variable in the model is the ratio of *total liabilities* to *common equity*. This method, compared to others, focuses more on changes in *shareholder equity*, making it suitable for analyzing the safety margin of *shareholder capital* when facing *debt risk* (Hovakimian, Opler, & Titman, 2001). This metric not only reflects the company's *financial leverage* but also reveals the exposure of *shareholder equity* to risk.

According to the results shown in Table 12, the coefficients for *corporate biodiversity risk* across all three models are positive and statistically significant. This indicates that as a company faces higher *biodiversity risk*, its *liability levels* and *financial leverage* – i.e., *debt risk* – correspondingly increase. Companies may need more *financial resources* to invest or cover potential losses when addressing *biodiversity-related environmental challenges*, thus increasing their reliance on *external financing* (Nedopil, 2023). However, this increased *debt* can also lead to a decline in the company's *financial stability*, which negatively impacts *investor confidence*. As *biodiversity risk* escalates, so does the company's *financial leverage*. Higher *leverage* typically implies greater *financial risk*, which may result in greater *debt repayment pressure* in the future. If *biodiversity risk* increases a company's *compliance costs* or reduces its *revenue streams*, highly leveraged companies will face greater *financial difficulties*, making *institutional investors* more likely to reduce their shareholdings in these companies. Therefore, this empirical finding supports Hypothesis 2 proposed in Section 2.

4.5. Mechanism tests

4.5.1. Firm debt risk

This study investigates corporate debt risk as a key mechanism through which biodiversity risk influences institutional investor holdings. Debt risk serves as a critical indicator of financial health, affecting a firm's financing costs, liquidity, and overall stability (Andriana et al., 2019; El Ghoul et al., 2023). As environmental regulations and sustainability concerns intensify, biodiversity risk has emerged as a significant external challenge for firms. Companies facing biodiversity-related regulations, litigation, or market pressures may resort to increased debt financing to cover compliance costs or environmental remediation, leading to higher financial leverage (Garel et al., 2023). This heightened debt burden not only increases the likelihood of financial distress but may also reduce investor confidence, prompting portfolio adjustments.

To examine this mechanism, this study follows the three-step mediation effect testing method proposed by Baron and Kenny (1986) and Judd and Kenny (1981), with Table 11 representing the first step of the analysis. Specifically, this study employs three key debt risk metrics, as presented in Table 11. The first metric, *Leverage1*, is measured as the natural logarithm of total liabilities. This transformation smooths extreme values and accounts for firm size differences, facilitating a clearer comparison of debt levels across firms. The second metric, the debt-to-book leverage ratio, is defined as the ratio of total debt to the sum of debt and book equity. This measure directly captures a company's financial leverage, reflecting its reliance on debt financing and the strength of its capital structure (Petersson & Stoett, 2022). The third metric, the total liabilities-to-common equity ratio, assesses the exposure of shareholder capital to financial risk, offering insights into a firm's financial resilience (Hovakimian et al., 2001).

The results in Table 11 indicate that biodiversity risk has a positive and statistically significant impact on all three debt risk measures. Firms facing greater biodiversity risk tend to exhibit higher financial leverage and liabilities. Additionally, Table 12 (Columns 1–3) confirms that increased debt risk negatively affects institutional investor ownership. This supports the hypothesis that biodiversity risk indirectly influences investment decisions by heightening financial instability.

As firms allocate more financial resources to address biodiversity-related challenges, their reliance on external financing grows, increasing overall debt burdens (Nedopil, 2023). The rise in financial leverage exacerbates repayment pressure, particularly for firms constrained by regulatory compliance costs or environmental risks. Consequently, institutional investors perceive highly leveraged firms as riskier, prompting them to reduce their shareholdings.

These findings validate Hypothesis 2, demonstrating that biodiversity risk contributes to financial vulnerability, which, in turn, discourages institutional investment. The results underscore the importance of proactively managing biodiversity-related financial risks, as increased leverage may amplify exposure to economic downturns and regulatory

Table 11
Mechanism Test — Biodiversity risk and corporate reputation.

VARIABLES	(1) Leverage1	(2) Leverage2	(3) Leverage3	(4) Intangible Asset
Biodiversity_risk	0.121***	0.049**	0.045*	−0.009**
	(0.029)	(0.022)	(0.027)	(0.004)
ROA2	−0.264***	−0.297***	−0.185	−0.046*
	(0.079)	(0.090)	(0.121)	(0.027)
Size	0.746***	0.022*	−0.114***	0.028***
	(0.022)	(0.012)	(0.023)	(0.004)
ln_Sale	0.197***	0.021**	0.107***	0.006**
	(0.017)	(0.010)	(0.017)	(0.003)
TOBINQ2	0.004	−0.013***	0.040***	−0.002***
	(0.003)	(0.003)	(0.007)	(0.001)
Capital Intensity	−0.084	−0.084	−0.836***	−0.128***
	(0.149)	(0.122)	(0.222)	(0.026)
Cash Flow	0.034	0.259***	−0.199	0.033
	(0.079)	(0.091)	(0.121)	(0.028)
Constant	−0.492***	0.112**	0.572***	−0.031
	(0.085)	(0.054)	(0.100)	(0.019)
Observations	9,959	9,728	9,929	9,847
R-squared	0.977	0.655	0.814	0.866
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

This table presents the results of the mechanism analysis examining the impact of biodiversity risk on corporate debt risk and reputation. The first three columns (leverage1, leverage2, and leverage3) measure corporate debt risk using different approaches, while the fourth column (intangible asset) assesses corporate reputation. The models control for key variables (ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow) and include firm, year, and industry fixed effects. Robust standard errors are clustered at the firm level. Significance levels are indicated by *, **, and *** for the 10%, 5%, and 1% thresholds, respectively.

uncertainties. This, in turn, affects investor confidence and corporate valuation, emphasizing the need for firms to integrate biodiversity considerations into their financial risk management strategies.

4.5.2. Firm reputation

This study examines corporate reputation as the second mechanism through which biodiversity risk affects institutional investor holdings, given its critical role in long-term corporate success and sustainability. Corporate reputation influences stakeholder relationships, brand value, market position, and investor trust (Smith et al., 2019). In an investment landscape increasingly shaped by Environmental, Social, and Governance (ESG) standards, institutional investors prioritize firms with strong reputations (Guo & Platikanov, 2019; Kitchen & Laurence, 2003; Nofsinger et al., 2019). Poor biodiversity management or non-compliance with environmental regulations can damage corporate reputation, leading to negative public perception, decreased consumer confidence, and heightened investor concerns (Garel et al., 2023). Analyzing the role of corporate reputation in institutional investors' decision-making provides deeper insights into how reputational risks influence corporate governance and investment behavior.

To measure corporate reputation, this study employs the intangible assets-to-total assets ratio (Dyreng, Hanlon, Maydew, & Thornock, 2017). This metric encompasses brand value, patents, trademarks, and other intangible assets that directly reflect a company's reputation. Compared to alternative measures such as customer satisfaction or media coverage frequency, this ratio more comprehensively captures long-term investments in brand building, technological innovation, and market recognition. A higher intangible assets ratio typically indicates strong brand value and innovation capacity, both of which enhance corporate reputation. Additionally, this metric provides a stable and comparable assessment by mitigating the effects of short-term market fluctuations.

As shown in Table 11 (Column 4), biodiversity risk has a negative and statistically significant effect on corporate reputation, with a coefficient of −0.009 at the 5% level, indicating that higher biodiversity risk is associated with a decline in intangible assets. Furthermore, Table 12 represents the second step of the mediation effect testing process, following the three-step method proposed by Baron and Kenny (1986) and Judd and Kenny (1981). Specifically, Table 12 (Column 4) demonstrates that a weakened corporate reputation significantly reduces institutional investor ownership, providing support for Hypothesis 3. These findings suggest that ineffective biodiversity management can undermine brand value and consumer trust, leading to a decline in intangible assets and ultimately making firms less attractive to institutional investors (Treepongkaruna, 2024). When corporate reputation deteriorates, institutional investors may choose to divest due to concerns over future market performance and brand stability.

These results highlight the significant role of reputational risk in shaping institutional investment strategies, reinforcing the need for firms to proactively manage biodiversity risks to safeguard their reputation and maintain investor confidence.

4.6. Additional analysis

4.6.1. Biodiversity count score and negative score

To deepen the analysis, this study constructs two additional measures of biodiversity risk – the *Biodiversity Count Score* and *Biodiversity Negative Score* – following Giglio et al. (2023). These measures are derived from 10-K reports using regular expressions to identify biodiversity-related terms, based on the *New York Times Biodiversity News Index* dictionary.

The *Count Score* represents the frequency of biodiversity-related mentions relative to the total number of words in the 10-K report, capturing both risks and opportunities. To differentiate between positive and negative mentions, this study employs a *BERT*-based sentiment analysis model (Devlin, 2018) to assess the sentiment of biodiversity-related sentences, creating the *Biodiversity Negative Score* as a second measure of biodiversity risk exposure.

These alternative measures replace the *biodiversity risk* variable used in the baseline regression to examine their influence on *institutional investor holdings*. As shown in Table 13, when the *Count Score* is used as the explanatory variable, Models (1) and (2) reveal that it has no statistically significant impact on *institutional investor holdings* (coefficient = 0.003). This suggests that the mere frequency of biodiversity-related mentions in corporate reports does not influence *institutional investor decisions*. Similarly, when using the *Negative Score*, Models (3) and (4) show that it also has no significant effect on *institutional investor holdings* (coefficients = 0.001 and 0.002, respectively). These results imply that negative sentiment in biodiversity-related disclosures does not meaningfully alter *investor behavior*.

Table 12
Mechanism — Corporate debt risk, reputation, and institutional investors.

VARIABLES	(1) InsHor	(2) InstRioLegal	(3) InsHor	(4) InstRioLegal	(5) InsHor	(6) InstRioLegal	(7) InsHor	(8) InstRioLegal
Leverage1	−0.015***	−0.015***						
	(0.003)	(0.002)						
Leverage2			−0.008**	−0.008***				
			(0.003)	(0.003)				
Leverage3					−0.007***	−0.007***		
					(0.002)	(0.002)		
Intangible Asset							−0.047***	−0.050***
ROA2	−0.005	−0.007	−0.004	−0.006	−0.001	−0.004	0.014	0.015
	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Size	0.068***	0.066***	0.056***	0.054***	0.055***	0.053***	0.047***	0.043***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)
ln_Sale	0.010***	0.010***	0.007***	0.007***	0.008***	0.008***	−0.001	−0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
TOBINQ2	0.001***	0.001***	0.001***	0.001***	0.002***	0.002***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Intensity	0.080***	0.077***	0.081***	0.079***	0.082***	0.076***	−0.099***	−0.073***
	(0.024)	(0.023)	(0.024)	(0.023)	(0.024)	(0.023)	(0.028)	(0.027)
Cash Flow	−0.004	−0.002	−0.002	0.000	−0.007	−0.004	−0.007	−0.007
	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Constant	−0.097***	−0.097***	−0.088***	−0.088***	−0.085***	−0.085***	0.007*	0.012***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.004)	(0.004)
Observations	9,959	9,959	9,728	9,728	9,929	9,929	9,847	9,847
R-squared	0.844	0.838	0.841	0.835	0.843	0.837	0.872	0.868
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES

This table presents the results of the mechanism analysis examining the impact of corporate debt risk and reputation on institutional investors. The models control for key variables (ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow) and include firm, year, and industry fixed effects. Robust standard errors are clustered at the firm level. Significance levels are indicated by *, **, and *** for the 10%, 5%, and 1% thresholds, respectively.

These findings suggest that relying solely on the frequency or sentiment of biodiversity-related disclosures does not provide a robust basis for *institutional investor decision-making*. While these measures capture certain aspects of *biodiversity discourse*, they lack the granularity and contextual depth required to influence *investment decisions*. In contrast, the *Regulation Score* used in the baseline regression likely offers a more comprehensive assessment by framing *biodiversity risks* within a *regulatory context*—an aspect more directly relevant to *investors* concerned with compliance and potential liabilities. The *Count Score* and *Negative Score*, in isolation, fail to incorporate the broader financial and market dynamics that *institutional investors* consider when evaluating *risk exposure*.

4.6.2. Sub-type of institutional investor

This section examines how biodiversity risk influences different types of institutional investors by replacing the dependent variable with various investor categories. Following Bushee (2001), Bushee and Noe (2000), institutional investors are classified based on investment horizon (Dedicated Investors, Quasi-Indexers, and Transient Investors) and fiduciary standards (Bank Trusts, Insurance Companies, Investment Advisers, and Pensions & Endowments) (Table 14).

4.6.3. Investment horizon-based classification

The analysis reveals significant differences in how institutional investors with varying investment horizons respond to biodiversity risk. In Model (1), representing Dedicated Investors, the coefficient for biodiversity risk is 0.000 and statistically insignificant, indicating that these investors prioritize long-term value creation over short-term environmental risks. Similarly, in Model (2) for Quasi-Indexers, the biodiversity risk coefficient is −0.005 but remains statistically insignificant, suggesting that their diversified, passive investment strategy reduces the influence of biodiversity risk on their portfolio decisions.

In contrast, Model (3) for Transient Investors shows a statistically significant negative coefficient of −0.008 at the 1% level, indicating that these short-term investors are highly sensitive to biodiversity risk. Given their focus on short-term financial performance and market volatility, transient investors may adjust their portfolios in response to biodiversity concerns, fearing immediate financial impacts (Lang & McNichols, 1997; Porter, 1992).

4.6.4. Fiduciary standards-based classification

The study also finds variation in responses among institutional investors categorized by fiduciary standards. In Models (4) and (5) for Bank Trusts and Insurance Companies, the biodiversity risk coefficients are 0.000 and statistically insignificant, suggesting that these investors, constrained by strict fiduciary responsibilities and regulatory requirements, prioritize investment stability over environmental risk considerations (Badrinath et al., 1989; Del Guercio, 1996).

However, in Model (6) for Investment Advisers, biodiversity risk has a negative and statistically significant coefficient of −0.011 at the 5% level, implying that these investors are more proactive in assessing biodiversity risks and may reduce their holdings in firms facing such risks (Del Guercio, 1996). Conversely, in Model (7) for Pensions and Endowments, the coefficient for biodiversity risk is −0.000 and not significant, indicating that these long-term investors, who prioritize stable, long-term returns, are less influenced by biodiversity risks in their investment decisions (Del Guercio, 1996; O'Barr & Conley, 1992).

Overall, these findings highlight the heterogeneous investment behaviors in response to biodiversity risk, with short-term investors being more reactive, while long-term and risk-averse investors remain relatively unaffected (see Table 14).

4.6.5. The Kunming declaration

In October 2021, the United Nations Biodiversity Conference (COP15) marked the official release of the Kunming Declaration, a global commitment to biodiversity conservation and sustainable financial flows, akin to the Paris Agreement. This declaration heightened investor awareness of biodiversity risks while increasing regulatory uncertainties (Garel et al., 2023). To assess its impact, this study conducts an event study, examining whether institutional investors adjusted their holdings in response to the Kunming Declaration.

As shown in Table 15, Models (1) and (4) indicate that Biodiversity Regulation Score (Biodiversity Risk) has a significant negative impact on institutional investor holdings, with coefficients of −0.012 and −0.011, both statistically significant at the 5% level. This supports the hypothesis that higher biodiversity-related regulatory risks lead institutional investors to reduce their shareholdings. However, the moderating

Table 13
Additional test by biodiversity count score and negative score.

VARIABLES	(1) InsHor	(2) InstRioLegal	(3) InsHor	(4) InstRioLegal
Biodiversity Count Score	0.003	0.003		
	(0.005)	(0.005)		
Biodiversity Negative Score			0.001	0.002
			(0.005)	(0.005)
ROA2	−0.001	−0.003	−0.001	−0.003
	(0.010)	(0.009)	(0.010)	(0.009)
Size	0.056***	0.054***	0.056***	0.054***
	(0.003)	(0.003)	(0.003)	(0.003)
ln_Sale	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
TOBINQ2	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Capital Intensity	0.081***	0.079***	0.081***	0.079***
	(0.024)	(0.023)	(0.024)	(0.023)
Cash Flow	−0.005	−0.003	−0.005	−0.003
	(0.010)	(0.009)	(0.010)	(0.009)
Constant	−0.090***	−0.090***	−0.089***	−0.090***
	(0.013)	(0.013)	(0.013)	(0.013)
Observations	9,959	9,959	9,959	9,959
R-squared	0.842	0.836	0.842	0.836
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

This table presents the results of additional tests using biodiversity count score and negative score to examine their impact on institutional investor holdings, specifically InsHor and InstRioLegal. The models incorporate control variables including ROA2, Size, ln Sale, TOBINQ2, Capital Intensity, and Cash Flow. Firm, year, and industry fixed effects are included in all regressions. Robust standard errors are clustered at the firm level. Statistical significance is denoted by *, **, and *** corresponding to the 10%, 5%, and 1% levels, respectively.

Table 14
Sub-type of institutional investor.

VARIABLES	(1) DED2	(2) QIX2	(3) TRA2	(4) BNK2	(5) INS2	(6) IA2	(7) PE2
Biodiversity_risk	0.000	−0.005	−0.008***	0.000	0.000	−0.011**	−0.000
	(0.002)	(0.004)	(0.003)	(0.001)	(0.000)	(0.005)	(0.000)
ROA2	0.002	−0.009*	0.006	0.000	−0.000	−0.003	0.000
	(0.002)	(0.005)	(0.006)	(0.001)	(0.000)	(0.008)	(0.000)
Size	0.001*	0.036***	0.019***	0.007***	0.001***	0.045***	0.001***
	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)
ln_Sale	0.000	0.006***	0.001	0.001***	0.001***	0.004**	0.001***
	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)
TOBINQ2	0.000	0.000***	0.001***	0.000***	0.000	0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Intensity	−0.009	0.044**	0.051***	0.019***	0.003***	0.050**	0.003***
	(0.007)	(0.018)	(0.011)	(0.004)	(0.001)	(0.021)	(0.001)
Cash Flow	−0.002	0.004	−0.007	−0.001	0.000	−0.002	−0.000
	(0.002)	(0.005)	(0.006)	(0.001)	(0.000)	(0.008)	(0.000)
Constant	0.003	−0.058***	−0.031***	−0.022***	−0.005***	−0.057***	−0.004***
	(0.004)	(0.009)	(0.006)	(0.002)	(0.001)	(0.012)	(0.001)
Observations	9,959	9,959	9,959	9,959	9,959	9,959	9,959
R-squared	0.708	0.837	0.752	0.810	0.701	0.819	0.708
Firm FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES

This table presents the regression results analyzing the impact of biodiversity risk on different sub-types of institutional investors, namely Dedicated Investors (DED2), Quasi-Indexers (QIX2), Transient Investors (TRA2), Bank Trusts (BNK2), Insurance Companies (INS2), Investment Advisers (IA2), and Pensions and Endowments (PE2). The models include control variables such as ROA2, Size, ln_Sale, TOBINQ2, Capital Intensity, and Cash Flow. Firm, year, and industry fixed effects are included in all regressions. Robust standard errors are clustered at the firm level. Statistical significance is denoted by *, **, and *** corresponding to the 10%, 5%, and 1% levels, respectively.

effects of the Kunming Declaration (1.treat#c.Biodiversity Risk) are not significant (coefficients of 0.003 in Model (1) and 0.001 in Model (4)). This suggests that, while the Kunming Declaration raised awareness, it has not immediately altered the impact of biodiversity regulation risks on institutional investor behavior (Garel et al., 2023).

In Models (2) and (5), the coefficients for the Negative Score are 0.003 and 0.004, respectively, but not statistically significant, indicating that negative sentiment alone does not significantly affect institutional investor holdings, consistent with previous findings. However, the interaction term (1.treat#c.Biodiversity Negative Score) in Model (5) has a coefficient of −0.018, statistically significant at the 10% level, though insignificant in Model (2). This suggests that following the Kunming Declaration, investor sensitivity to negative biodiversity sentiment increased, amplifying the perceived risks associated with negative biodiversity mentions (Pastor & Veronesi, 2012). Investors may now view negative biodiversity sentiment as a compliance and reputational risk, prompting reductions in holdings of affected companies.

In Models (3) and (6), the coefficients for the Count Score are 0.001 in both models and not statistically significant, while the moderating effects of the Kunming Declaration (1.treat#c.Biodiversity Count Score) have coefficients of 0.009 and 0.007, also not statistically significant. This indicates that simply mentioning biodiversity-related terms does not significantly impact institutional investor decisions, reinforcing the notion that investors focus on substantive regulatory and reputational risks rather than generic biodiversity discourse.

Table 15
The Kunming Declaration.

VARIABLES	(1) InstRioHorizon	(2) InstRioHorizon	(3) InstRioHorizon	(4) InstRioLegal	(5) InstRioLegal	(6) InstRioLegal
Biodiversity_risk	−0.012**			−0.011**		
	(0.005)			(0.005)		
1.treat#c.Biodiversity_risk	0.003			0.001		
	(0.005)			(0.005)		
biodiversity negative score		0.003			0.004	
		(0.005)			(0.004)	
1.treat#c.biodiversity negative score		−0.008			−0.009*	
		(0.006)			(0.005)	
biodiversity count score			0.001			0.001
			(0.006)			(0.006)
1.treat#c.biodiversity count score			0.009			0.007
			(0.008)			(0.007)
ROA2	−0.001	−0.001	−0.001	−0.003	−0.003	−0.003
	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
size	0.056***	0.056***	0.056***	0.054***	0.054***	0.054***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ln_sale	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
TOBINQ2	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
capital_intensity	0.080***	0.081***	0.081***	0.077***	0.078***	0.079***
	(0.024)	(0.024)	(0.024)	(0.023)	(0.023)	(0.023)
cash_flow	−0.005	−0.005	−0.005	−0.003	−0.003	−0.003
	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Constant	−0.089***	−0.089***	−0.090***	−0.089***	−0.089***	−0.090***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Observations	9,959	9,959	9,959	9,959	9,959	9,959
R-squared	0.843	0.842	0.842	0.836	0.836	0.836
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES

This table presents the regression results examining the impact of biodiversity risk (biodiversity count score, biodiversity negative score, and Biodiversity_risk) on institutional investor holdings (InstRioHorizon and InstRioLegal) and the moderating effect of The Kunming Declaration. Control variables include ROA2, size, ln_sale, TOBINQ2, capital_intensity, and cash_flow. All models include firm, year, and industry fixed effects. Robust standard errors are clustered at the firm level. Statistical significance is denoted by *, **, and *** corresponding to the 10%, 5%, and 1% levels, respectively.

Overall, these findings suggest that while the Kunming Declaration increased awareness of biodiversity risks, its immediate effect on investor behavior remains limited, except in cases where biodiversity risks are framed negatively. This underscores the importance of regulatory clarity and investor perception in shaping biodiversity-related investment decisions.

5. Discussion

In the baseline regression, this study reveals a significant negative impact of biodiversity risk on institutional investor holdings. This indicates that as biodiversity risk rises, institutional investors are more inclined to reduce their investments in the affected companies. The results on control variables show that companies with larger size, higher sales revenue, and stronger market growth expectations tend to be more attractive to institutional investors. Companies with higher capital intensity also draw more investment due to the long-term stability of their capital investments. These findings underscore the importance of biodiversity risk in investment decisions, suggesting that companies should adopt more proactive measures in managing and disclosing biodiversity risks to maintain and attract institutional investor trust and support.

In mechanism analyses, this study analyses whether biodiversity risk influences institutional ownership through corporate debt risk and corporate reputation. This study finds that biodiversity risk significantly increases corporate debt risk. This suggests that biodiversity risk significantly increases corporate debt risk. As discussed before, companies may require additional financial resources to address biodiversity-related environmental challenges, leading to greater reliance on external financing (Nedopil, 2023). Increased debt undermines companies' financial stability and investor confidence, thus reducing institutional ownership. Moreover, this study reveals that biodiversity risk is significantly negatively associated with corporate reputation. Companies with higher biodiversity risk have lower proportion of intangible assets to total assets. Intangible assets are vital to corporate reputation. If a company fails to manage biodiversity risk effectively, its reputation will be undermined, harming its brand value and consumer confidence, and lowering the value of intangible assets (Treepongkaruna, 2024). Therefore, institutional investors may reduce their holdings in companies with higher biodiversity risk due to concerns about the reputation damage incurred by biodiversity risk and the potential negative effects of bad reputation on the company's performance and brand value.

Heterogeneous analyses focus on the heterogeneous effects of a set of corporate features in the association between biodiversity risk and institutional ownership. This study shows that biodiversity risk significantly decreases the institutional ownership of large companies. Large companies may face increased regulatory pressure and compliance costs in response to biodiversity risks due to their wider market presence and higher public visibility (Brammer & Pavelin, 2006). Hence, institutional investors may choose to reduce their investments in these companies. The influence of biodiversity risk for small companies is insignificant, suggesting that biodiversity risk does not influence institutional investor shareholding proportions in smaller companies. Smaller companies have higher levels of flexibility, which allows them to adapt more quickly to regulatory changes. In addition, small companies have relatively smaller market influence and lower regulatory pressure concerning biodiversity. In terms of profitability, this paper demonstrates that biodiversity risk has negative effects on the institutional ownership of companies with high profitability and an insignificant impact on their counterparts. For investors, companies with high profitability are regarded as "high return" companies. However, biodiversity risk undermines these companies' profitability and increases future uncertainties. These concerns lead institutional investors to decrease their holdings in such companies. The findings reflect the heightened sensitivity of institutional investors to external risks in

companies with high profitability. Companies with low profitability are less attractive to institutional investors and often viewed as high-risk investments. Consequently, biodiversity risk has an insignificant impact on their investment appeal.

This study also focuses on corporate innovation abilities. This study finds that the negative effects of biodiversity risk on institutional ownership are significant for companies with strong innovation capabilities and insignificant for those with weak innovation capabilities. This result provides evidence that institutional investors are particularly concerned about the additional costs and risks that highly innovative companies may confront under strict biodiversity regulations. When these companies invest heavily in technological innovation and new product development, they may face great uncertainties, which may harm their future profitability and market competitiveness. Hence, in response to biodiversity risk, institutional investors may reduce their shareholdings in companies with strong innovation abilities to mitigate potential investment risks.

Growth ability is another corporate feature of our focus. This study finds that biodiversity risk significantly reduces institutional ownership in high-growth firms; the effects of biodiversity risk are insignificant for their counterparts. When high-growth companies face biodiversity risks, investors are concerned with the negative effects caused by these risks on companies' expansion and profitability. Hence, institutional investors may reduce their shareholdings in high-growth companies to mitigate potential investment risks. Typically, low-growth companies, who are in a mature stage, have stable market share and growth rates and limited potential for future expansion. Changes in the external environment have less impact on the operations of these companies. Our findings suggest that investors may factor in low-growth companies' limited growth potential and stable market position, which makes biodiversity risk a less salient factor in their investment decisions.

In further analyses, this study delves into the effects of biodiversity disclosure, the effects on the sub-type of institutional investors, and the moderating impact of biodiversity-related regulations. Firstly, this study calculates the Count Score and Negative Score of biodiversity-related terms to measure corporate biodiversity disclosure. This study finds that the Count Score and Negative Score have an insignificant impact on institutional ownership. This suggests that relying solely on the frequency of biodiversity-related terms or the sentiment analysis of those terms is not robust enough for institutional investors to make investment decisions. This study highlights that while these measurements capture certain aspects of corporate biodiversity disclosure, they lack the granularity and context necessary to meaningfully influence investor behavior and fail to capture the broader financial and market dynamics that institutional investors consider when evaluating risk exposure.

In contrast, the Regulation Score used in the baseline regression offers a more comprehensive assessment of how biodiversity risks are framed within a regulatory context. This study argues that the Regulation Score is more directly relevant to investors concerned with compliance and potential liabilities. Additionally, this paper explores the diverse effects of biodiversity risk on the sub-type of institutional investors. The results demonstrate that biodiversity risk is negatively associated with transient investors and investment advisers and has no significant influence on other types of institutional investors. This suggests that dedicated investors prioritize long-term value creation over short-term market fluctuations or environmental risks, making them less sensitive to biodiversity risk. Quasi-indexers typically follow a broadly diversified, passive investment strategy, which likely diminishes the impact of biodiversity risk on their overall investment decisions.

This study also provides evidence that transient investors are highly sensitive to biodiversity risk. Compared to long-term investors, short-term investors are more concerned with uncertainties and volatility that could impact a company's short-term performance, leading them to react more strongly to biodiversity risk (Lang & McNichols, 1997; Porter, 1992). Bank trusts and insurance companies operate under strict fiduciary responsibilities and regulatory constraints, which lead them to prioritize investment stability and low-risk opportunities (Badrinath et al., 1989; Del Guercio, 1996). Hence, the impact of biodiversity risk on their investment decisions is limited. Investment advisers are more attuned to companies with high biodiversity risk (Del Guercio, 1996). Pensions and endowments typically have longer investment horizons and focus on stability, so biodiversity risk is less influential in their investment decisions (Del Guercio, 1996; O'Barr & Conley, 1992).

Moreover, this study relies on the release of the Kunming Declaration and analyzes the moderating effects of this event. This study shows that the Kunming Declaration has an insignificant effect on the association between biodiversity risk and institutional ownership and the association between the Count Score and institutional ownership. However, the Kunming Declaration positively moderates the relationship between the Negative Score and institutional ownership. This indicates that although the declaration has raised awareness of biodiversity issues, its direct influence on investor behavior may not be immediately evident in the short term (Garel et al., 2023).

6. Conclusion

The increasing focus on sustainable development has heightened awareness of biodiversity protection and the risks associated with biodiversity loss. Given the intrinsic link between business activities and biodiversity decline, corporate-level research on biodiversity risk has gained prominence (Kennedy et al., 2023). However, empirical evidence on the effects of biodiversity risk remains scarce (Carvalho et al., 2023). While institutional ownership has been widely examined in the literature, the specific influence of biodiversity risk on institutional investors remains unexplored. To address this gap, this study investigates the impact of biodiversity risk on institutional ownership.

Using a dataset of publicly listed U.S. companies from 2009 to 2023, the findings indicate that biodiversity risk is negatively associated with institutional ownership. This relationship remains robust across various robustness and endogeneity tests. Mechanism analyses reveal that biodiversity risk deters institutional investors by increasing debt risk and damaging corporate reputation. Heterogeneity analyses show that this effect is more pronounced in large firms, high-growth firms, profitable firms, and companies with strong innovation capabilities. Additionally, the study finds that biodiversity risk significantly reduces holdings by transient investors and investment advisers, while other types of institutional investors remain unaffected. Notably, while the Kunming Declaration does not influence the overall relationship between biodiversity risk and institutional ownership, it strengthens the negative association when biodiversity risk is measured using sentiment-based indicators.

These findings have important implications for corporate managers, institutional investors, and policymakers. For corporate managers, the results suggest that institutional investors consider biodiversity risk in their investment decisions, particularly in large, high-growth, profitable, and innovation-driven firms. This underscores the need for companies to integrate biodiversity considerations into their strategic planning, enhance transparency in sustainability disclosures, and implement measurable biodiversity initiatives to mitigate investment-related concerns. From an investor perspective, the study highlights that institutional investors assess biodiversity risk alongside financial risks, such as debt exposure and reputational damage, rather than relying solely on the frequency or sentiment of biodiversity-related disclosures. This suggests that companies must go beyond rhetorical commitments and provide substantive evidence of their biodiversity strategies to attract long-term institutional investment. For policymakers, the study underscores that biodiversity-related regulatory risks influence corporate behavior and financial performance. Regulatory frameworks should be designed to incentivize biodiversity-conscious business practices while considering their broader economic impact.

Table A.1
Variable definitions and sources.

Variable	Definition	Source
1. Biodiversity-Related Variables		
Biodiversity Count Score	Natural logarithm of the sum of the frequencies of biodiversity-related terms + 1	–
Biodiversity Negative Score	Natural logarithm of the sum of frequencies +1 after sentiment scoring of biodiversity-related terms using Bert	–
Biodiversity Risk	Natural logarithm of the sum of the frequencies of simultaneous occurrences of biodiversity-related terms and legal-related terms + 1	–
2. Firm Characteristics		
Firm Size	Natural logarithm of total assets (log(at))	Compustat
Sales	Natural log of the firm's total sales (ln sale)	Compustat
3. Profitability and Cash Flow		
ROA1	Earnings before interest, taxes, depreciation, and amortization divided by the book value of assets at the beginning of the year (ebitda/at)	Compustat
ROA2	Defined as (pi-xi)/at (Pretax Income-Extraordinary Items)/Total Assets	Compustat
ROA3	Income before extraordinary items (ib) divided by total assets (ib/at)	Compustat
Cash Flow	The sum of net income, depreciation scaled by total assets	Compustat
Capital Intensity	Capital expenditures divided by total assets	Compustat
4. Market Valuation		
Tobin's Q1	(Book value of debt + market value of equity)/(book value of debt + book value of equity)	Compustat
Tobin's Q2	Ratio of market value to replacement value of the firm's assets, defined as (prcc f * csho + lt - txditc)/at	Compustat
5. Leverage Measures		
Leverage1	Natural logarithm of total liabilities (ln(lt+1))	Compustat
Leverage2	The book leverage ratio, defined as debt/(debt + book value of equity)	Compustat
Leverage3	Total liabilities divided by total liabilities plus common equity (lt/(lt + ceq))	Compustat
6. R&D and Intangible Assets		
R&D Intensity	RD1 m; Research and development expense ratio, measured as xrd/at. Missing values in xrd are set to zero. Alternative: divided by sales	Compustat
Intangible Assets	Intangible assets (INTAN) scaled by total assets (TA)	Compustat
ROE	Net income (ni) divided by book value of equity (ni/ceq)	Compustat
7. Institutional Holdings		
InsHor	DED1+QIX1+TRA1	Refinitiv
InstRioLegal	BNK1+INS1+IA1+PE1	Refinitiv
DED1	Percent of shares held by dedicated institutions	Refinitiv
QIX1	Percent of shares held by quasi-indexer institutions	Refinitiv
TRA1	Percent of shares held by transient institutions	Refinitiv
BNK1	Percent of shares held by banks	Refinitiv
INS1	Percent of shares held by insurance companies	Refinitiv
IA1	Percent of shares held by investment advisers	Refinitiv
PE1	Percent of shares held by pensions and endowments	Refinitiv

Well-structured policies can encourage firms to integrate biodiversity risk management into their operations, aligning corporate incentives with sustainability objectives.

While this study provides novel insights, several limitations present opportunities for future research. First, the focus on U.S. firms may limit the generalizability of the findings. Future research should examine how biodiversity risk affects institutional ownership in different countries, considering variations in regulatory frameworks, market structures, and cultural attitudes toward sustainability. Second, future studies could extend the analysis beyond institutional investors to explore how biodiversity risk influences other stakeholders, such as customers, employees, and suppliers. A broader perspective could provide a more comprehensive understanding of biodiversity risk's impact on corporate valuation and stakeholder relationships. Third, further research could distinguish between sustainable and non-sustainable institutional investors to assess whether biodiversity risk exerts differential effects across investor types. Such an analysis would provide deeper insights into the evolving role of sustainability considerations in institutional investment strategies. By addressing these gaps, future research can enhance our understanding of how biodiversity risk shapes corporate finance and investment decisions in an increasingly sustainability-conscious market.

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Appendix A. Variable definitions

See Table A.1.

Data availability

No.

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