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Internal governance, external pressure, and biodiversity disclosure

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ABSTRACT

The declining rate of biodiversity due to land, water, and air pollution is alarming. Thus, stakeholders expect firms to engage with cleaner operational processes to preserve biodiversity and share their practices with biodiversity disclosure. To provide a catalyst for biodiversity engagement and disclosure, we explore two important mechanisms: the internal by examining board structure; and the external governance mechanisms by signing the United Nations Global Compact (UNGC) commitment and by checking individual country's public governance quality measured by Worldwide Governance Indicators (WGI). Our initial empirical analysis assesses their association with biodiversity disclosure, followed by an assessment of the substitutive or complementary role of these two governance mechanisms in spurring biodiversity disclosure. Analyzing 46,564 observations affiliated with nine sectors and 47 countries, we find that directors with other corporate affiliations as well as independent and female directors spur biodiversity disclosure. Furthermore, the UNGC signatory commitment and WGI stimulate firms' biodiversity disclosure. Although UNGC signatory status and board structure are substitutes for driving biodiversity disclosure, the interaction effect of WGI with boards of directors is not uniform. For example, WGI and directors affiliated with other corporations are substitutes, but WGI and independent directors are complements in spurring biodiversity disclosure.

1. Introduction

Biodiversity refers to the variety of life on Earth (Carvajal et al., 2022; Haque & Jones, 2020). "It includes the vast array of genetically distinct populations within species, as well as the full variety of species and communities, and ecosystems of which they are parts" (Haque & Jones, 2020, p.1). The loss of biodiversity is considered among the top 10 global risks (World Economic Forum, 2021) that pose significant threats to the quality of human life and the economic survival of many businesses (Boiral & Heras-Saizarbitoria, 2017; Carvajal et al., 2022; Haque & Jones, 2020). Research evidence even suggests that pandemics caused by biodiversity loss and habitat demolition increase the transmission of diseases and viruses (Talbot & Boiral, 2021). Consequently, internal and external stakeholders exert pressure on companies to report and reduce their impacts on biodiversity (Amin et al., 2021). Therefore, organizations must demonstrate their commitment to protecting the natural environment and take managerial action to address the effects of their operations on biodiversity (Amin et al., 2021; Haque & Jones, 2020). Companies need to disclose biodiversity information to discharge their accountability and stewardship for biodiversity and to increase corporate transparency (Bhattacharyya & Yang, 2019; Haque & Jones, 2020).

A country with a vigorous public governance environment is likely to pressure companies to engage in responsible and transparent practices, including those related to sustainability (Jacoby et al., 2019). Furthermore, because reporting on social and environmental issues is voluntary there are a variety of global standards, such as the Global Reporting Initiative (GRI) and the United Nations Global Compact (UNGC), that provide guidelines and suggest principles for reporting on these issues (Kimbro & Cao, 2011). The UNGC is the world's largest voluntary corporate social responsibility (CSR) initiative (Kimbro & Cao, 2011; Schembera, 2018). Signatory companies need to adhere to the 10 principles in support of environmental protection, human rights, and anti-corruption practices (Martinez-Ferrero et al., 2020).[1] External

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[1] The UNGC's 7th, 8th, and 9th principles are specifically dedicated to environmental responsibility (UNGC, 2023).

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governance factors are likely to interact with internal governance mechanisms, such as the board structure, in pressuring organizations to drive managerial action to report and minimize their impact on biodiversity.

Biodiversity reporting is a topic-specific part of sustainability reporting dedicated to disclosures related to biodiversity. It receives the least attention from firms compared to other dimensions of environmental reporting (Helfaya et al., 2023; Moufty et al., 2021). The extant literature extensively explores corporate responsibility to conserve biodiversity crises (Gaia & Jones, 2020), and examines numerous drivers of biodiversity reporting (Amin et al., 2021; Bhattacharyya & Yang, 2019). Although numerous studies have examined the effect of board characteristics on sustainability reporting (e.g. Al-Shaer & Zaman, 2018; Jizi, 2017), only a few have investigated the effect of board gender diversity (Carvajal et al., 2022; Haque & Jones, 2020; Issa & Zaid, 2023) and board size (Mahyuddin et al., 2022) on the extent of biodiversity disclosure.[2] Importantly, most studies have ignored the possible effects of other board characteristics, such as board affiliation and independence. Regarding the effect of UNGC's principles on firms' sustainability decisions, prior literature shows that firms adopting UNGC's standards are more likely to have better environmental, social, and governance (ESG) performance or disclosure (Ortas et al., 2015; Voegtlin & Pless, 2014).

Moreover, the existing literature on the effect of a country's public governance on biodiversity disclosure is scant. Available empirical research has failed to address the effect of both internal governance mechanisms, such as board affiliation and board independence, and external governance, such as the UNGC and public governance indicators, on biodiversity disclosure. Moreover, no studies have examined the complementary or substitutional effects of institutional context and board structure on corporate biodiversity disclosure. It is necessary to comprehensively look at the internal and external governance mechanisms simultaneously and their interactive impact on corporate commitment to biodiversity disclosure.

This study contributes to existing research in multiple ways. First, this work is among the first to empirically examine the impact of internal governance factors (board affiliation, board independence, and board gender diversity) on a firm's commitment to biodiversity disclosure. Recent studies have focused on the impact of board gender diversity (Carvajal et al., 2022; Haque & Jones, 2020; Issa & Zaid, 2023) and board size (Mahyuddin et al., 2022) on biodiversity disclosures. Other board characteristics are worthy of investigation, as they are part of monitoring power and could be associated with biodiversity disclosures. Second, prior studies have examined the effect of UNGC adoption on ESG performance (Ortas et al., 2015; Voegtlin & Pless, 2014). Unlike these studies, we examine the impact of UNGC signatory status on biodiversity disclosure, which is one of the unique aspects of environmental sustainability. Third, we explore whether public governance is associated with biodiversity disclosure and provide a comprehensive investigation into the association between the six indicators of public governance and biodiversity reporting.[3] This part of the investigation is helpful in driving policy making implications.

Fourth, we are the first to investigate whether external governance in the institutional context (i.e. UNGC signatories and public governance indicators) and board structure form a substitute, joint, or complementary effect on corporate commitment to biodiversity disclosure[4] Fifth, we use a global sample, which allows us to assess biodiversity disclosure in different international contexts. Global empirical research contributes to both the theoretical and practical aspects of corporate biodiversity (Issa & Zaid, 2023). In addition to our main analysis using an international sample, we deepen our investigation by splitting our sample into different contexts, such as the United States of America (USA), Europe, and emerging markets. This helps us explore whether the outcomes are context bounded and draw implications for different sets of countries. Sixth, our investigation based on polluting and non-polluting sectors is helpful in inferring sectoral implications for biodiversity disclosure.

Finally, our evidence contributes to institutional theory and resource dependence theory (RDT) in justifying the individual and substitutional or complementary effects of internal and external governance factors on corporate biodiversity disclosure. Our study focuses on an important issue within ESG disclosure and governance. It highlights internal and external drivers of corporate commitment to biodiversity disclosure, an underexplored area in existing research that is as crucial as reporting on climate change issues.

The remainder of the paper is structured as follows. Section 2 discusses biodiversity reporting and global reforms. Section 3 provides the theoretical framework. Section 4 provides an empirical literature review and hypotheses development. In Section 5, we set out the research methodology in terms of the sample, data, and model. Section 6 reports and discusses the empirical results, and Section 7 provides a summary and conclusions.

2. Biodiversity reporting and internal and external governance reforms

Companies disclose information about their biodiversity related practices in their sustainability reports to inform stakeholders and show their commitment to the environment (Boiral, 2016; Talbot & Boiral, 2021). Disclosures need to be reliable, accurate, and complete to reflect an actual image of corporate performance to foster stakeholders' engagement and allow information users to make useful decisions (Boiral, 2016). Assessing the reliability of sustainability reports has been associated with the adoption of recognized guidelines and standards due to the voluntary nature of sustainability information (Boiral, 2016). As biodiversity is not often explicitly reported on in sustainability reports, companies tend to follow reporting schemes such as the GRI, which provides standards on how to report on biodiversity. The United Nations Environment Program (UNEP) through its Convention on Biological Diversity provides businesses with guidance for reporting their actions related to biodiversity, and notes the role of the GRI (UNEP, 2018).

The GRI is an international independent standard setting organization that helps businesses recognize and reveal their effects on sustainability issues, such as climate change, human rights and corruption. *GRI 304: Biodiversity 2016* was the original GRI biodiversity disclosure standard (GRI, 2016). Companies that follow GRI standards need to describe their strategy and management approach in terms of prevention, management, and avoidance of harmful corporate activities endangering natural habitats. The typology of actions for reporting biodiversity includes three main themes: commitment, engagement, and measurement. The recent publication of *GRI 101: Biodiversity 2024* (GRI, 2024) provides a revision of *GRI 304: Biodiversity 2016* to provide internationally agreed best practices and associate with recent developments and the relevant authoritative intergovernmental tools in the field of biodiversity.

The carbon disclosure project (CDP) is another reporting scheme that

[2] Sustainability reporting is also known as CSR reporting in early literature, or environmental, social, and governance (ESG) reporting in more recent literature.

[3] These indicators are voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption.

[4] Here, we feel obliged to note that UNGC does not impose regulatory/binding policies; it just requires a commitment to the principles from the engaged organizations.

sets up a framework to help firms report their greenhouse gas (GHG) emissions, as well as resource consumption, such as water and the preservation of forestry (CDP, n.d.; Wang, 2023).

The International Integrated Reporting Council (IIRC), now part of the IFRS Foundation, created an international reporting framework that includes information on biodiversity and ecosystem health (IIRC, n.d.). The IIRC's responsibility was to create a globally accepted framework for accounting for sustainability, one that draws together financial, environmental, social, and governance information in a clear, concise, consistent, and comparable format, that is, in an 'integrated' format. The Sustainability Accounting Standard Board (SASB), now also part of the IFRS Foundation, provided sustainability accounting standards that identify topics aimed specifically at sustainability, including biodiversity (SASB, n.d.). In 2021, the IFRS Foundation created the International Sustainability Standards Board (ISSB), which is building upon the work of the IIRC and the SASB (ISSB, n.d.; Krivogorsky, 2024).

The Taskforce on Nature related Financial Disclosures (TNFD) is a key initiative developed following the path of the Taskforce on Climate-related Financial Disclosures (TCFD). This initiative is a corporate governed and market led effort established to "develop and deliver a risk management and disclosure framework for organizations to report and act on evolving nature-related risks" (TNFD, 2022). It provides a set of recommendations and guidelines to allow corporations to incorporate nature into decision making (TNFD, 2022) and develop strategies for managing the impact of business operations on biodiversity (Irvine-Broque & Dempsey, 2023). The goal of this initiative is to identify how changes to biodiversity may create financial risks and opportunities for firms and shareholders (Irvine-Broque & Dempsey, 2023). The TNFD disclosures are structured around the four recommendation pillars of governance, strategy, risk and impact management, and metrics and targets (TNFD, 2022).

Finally, the UNGC provides a framework for developing, implementing, and disclosing practices on biodiversity and ecosystem amenities. It aligns organizations' strategies and operations with ten universal principles related to human rights, labor, environment, and anti-corruption (Kimbro & Cao, 2011). Companies can refer to the 2030 Agenda for Sustainable Development Goals (SDGs) in their sustainability reports. Some of these goals, such as Goal 14 (life below water) and Goal 15 (life on land), are related to biodiversity, and companies can frame their biodiversity responsibilities around the SDGs. Despite the various corporate reporting practices on biodiversity, they remain understudied, and more research is needed to investigate the validity and reliability of current reporting practices (Boiral, 2016).

Corporate governance reforms are related to the board's best practices and are considered the main approach to address corporate governance issues. For example, financial reporting practices were reformed in the USA with the Sarbanes-Oxley Act of 2002 and in the United Kingdom (UK) the Cadbury Report of 1992 imposed greater board independence.

There is a diverse array of approaches to gender diversity reforms. For example, Norway took the lead and mandated publicly listed companies to maintain boards of at least 40 % female members by 2008. Other European countries, such as Italy and Belgium, introduced similar laws in 2011 (Barroso et al., 2024). In 2022, the 'Women on Boards EU Directive' is targeted to warrant a balanced male and female representation of board members of European Union (EU)-listed companies while admitting flexibility for member states that have implemented equally efficient measures. As of November 2022, six of the 27 EU countries mandated gender balance policies (Barroso et al., 2024). Other countries, such as the UK, have adopted voluntary practice through the comply-or-explain principle to achieve analogous levels of board member representation. Although this approach is non-binding, companies are under normative pressures to provide greater female representation to meet industry standards and stakeholders' prospects (Al-Shaer & Harakeh, 2020).

3. Theoretical framework

Organizations accountable to society and the natural environment have a moral duty to preserve the world's natural resources. Companies can demonstrate their environmental stewardship by employing biodiversity accounting and reporting. Biodiversity reporting is a corporate practice that allows stakeholders to assess the corporate stewardship of the natural environment and encourages companies to adopt actions that prevent the depletion of natural resources and reduce the impact of their activities on natural habitats and species (Gaia & Jones, 2020). Firms' motivation to achieve legitimacy is the key driver in responding to institutional pressures (Ntim & Soobaroyen, 2013). Institutional theory, with its coercive, mimetic, and normative isomorphisms (DiMaggio & Powell, 1983), states that companies tend to comply in order to maintain and improve their corporate image and legitimacy status (Haque & Jones, 2020; Ntim & Soobaroyen, 2013).

DiMaggio and Powell (1983) consider coercive isomorphism to be adherence to direct institutional pressures, such as government rules and regulations, and indirect institutional pressures, such as cultural expectations and societal pressure. Mimetic isomorphism refers to imitating the practices of successful and productive industry peers to improve the business environment. In contrast, normative isomorphism refers to pressures from professional bodies and associations that shape organizational practices. Companies comply with environmental policies and regulations by adopting sustainable strategies and action plans to maintain legitimacy and build a corporate image (Haque & Ntim, 2018). Institutional norms and rules can help explain the impact of the UNGC on corporate biodiversity disclosure.

Firms are offered normative and mimetic isomorphism to implement the best sustainable practices by adherence to professional and regulatory bodies' frameworks. Adherence to the UNGC framework provides a firm with normative and mimetic isomorphism to employ the environmental strategies of professional bodies and industry peers (Haque & Jones, 2020; Perez-Batres et al., 2012). Furthermore, compliance with government rules and laws forms coercive forces for implementing the systems that the government advances (García-Sánchez et al., 2016). Firms' implementation of biodiversity management initiatives is likely driven by institutional pressures and the need to retain a firm's reputation to operate within society (Boiral & Heras-Saizarbitoria, 2017; Haque & Jones, 2020).

There is a vast amount of literature on the role of corporate governance mechanisms in promoting social and environmental engagement, but studies examining the role of internal governance in biodiversity disclosure practices are limited (Carvajal et al., 2022; Haque & Jones, 2020). The board of directors plays a vital role in implementing business strategies that minimize the impact of firms' activities on the environment and society (Carvajal et al., 2022; Ntim & Soobaroyen, 2013). The corporate board is considered one of the most essential internal governance mechanisms that foster resource access to better respond to stakeholders' pressure (Li et al., 2023).

RDT explains the role of corporate boards in resource provision (Hillman & Dalziel, 2003). Previous research has used RDT to justify the role of board attributes in social and environmental engagement and disclosure (e.g., Al-Shaer & Zaman, 2018; Haque & Jones, 2020; Katmon et al., 2019). According to RDT, companies may establish a board structure that comprises independent directors who effectively monitor and help gain access to critical resources and shape firms' strategic goals (Bhattacharyya & Yang, 2019). Moreover, female directors are stakeholder oriented and more likely to consider sustainability related issues in boardroom discussions and can help provide valuable resources that contribute to sustainable development strategies, such as those related to biodiversity practices (Issa & Zaid, 2023; Zaid et al., 2020). Finally, companies with board members affiliated with other corporations have better access to rich resources, including best practices on environmental sustainability (Omer et al., 2020), and can help exchange knowledge and information across board networks (Li et al., 2023). In

this study, we assess the potential drivers of biodiversity disclosure by considering the effect of both internal and external governance mechanisms.

4. Empirical literature review and hypotheses development

4.1. Internal governance and biodiversity disclosure

4.1.1. Board affiliation

RDT explains the resource provision role of the board of directors and its potential effect on biodiversity reporting (Hillman & Dalziel, 2003). Under the lens of RDT, directors affiliated with other corporations are one of the unique capabilities of boards. The skills, background, and knowledge of networked board members are considered valuable firm resources, leading to effective governance (Katmon et al., 2019) and improved decision making related to biodiversity impact (Li et al., 2023). Firms with more affiliated board members can access valuable resources (Macaulay et al., 2018). Affiliated board members provide an effective mechanism for knowledge transfer and information exchange across directors' networks (Li et al., 2023). Affiliated directors have better access to new information, best practices (Omer et al., 2020), and recent challenges, including biodiversity loss and global warming. Thus, companies with affiliated board members with a broad environmental sustainability network, particularly in biodiversity, are more likely to be committed to biodiversity disclosure. Based on the foregoing discussion, we propose the first hypothesis:

H1: Firms with more affiliated directors on the board are more likely to be committed to biodiversity disclosure.

4.1.2. Board independence

Independent directors on boards are expected to be more active in controlling managers' behavior, which leads to a decrease in information asymmetry (Al-Shaer et al., 2022). Although corporate governance approaches to reform differ across countries, most reforms emphasize board-related practices, such as enforcing greater board independence (i.e. the UK's Cadbury Report). Independent directors exercise an effective monitoring and governing role over management activities and are more likely to be efficient in directing strategic goals (Bhattacharyya & Yang, 2019) and improving the transparency of social and environmental disclosures (Al-Shaer et al., 2017; Jizi et al., 2014). They can focus on long term goals, such as sustainability related goals, rather than on short term financial goals because their remuneration is usually not dependent on their firms' financial performance (Bhattacharyya & Yang, 2019). Thus, firms with a high proportion of independent directors on their boards are likely to be committed to biodiversity disclosure. Based on the foregoing discussion, we propose the second hypothesis:

H2: Firms with more independent directors on the board are more likely to be committed to biodiversity disclosure.

4.1.3. Board gender diversity

According to RDT, female directors on corporate boards can positively influence environmental performance because of their diverse skills, experience, networks, and perspectives (Issa & Zaid, 2023; Issa et al., 2021). The richness of resources that female directors bring to the board can contribute to developing corporate environmental strategies and policies (Issa & Zaid, 2023). Given the vast amount of literature showing the positive impact of board gender diversity on corporate performance, corporate governance reforms have required changes in board structure, including board gender diversity (Poletti-Hughes & Dimungu-Hewage, 2023). Some countries have followed a voluntary approach to gender diverse boards, while others have established binding legal quotas. These countries have chosen gender policies and recommendations in their institutional isomorphism (i.e. coercive, mimetic, and normative). Female directors can improve boardroom discussions and information sharing thereby helping to address and promote environmental-related issues, such as biodiversity conservation (Haque & Jones, 2020; Issa & Zaid, 2023; Zaid et al., 2020). Female directors are more socially oriented and more inclined to actively engage with stakeholders and respond to their concerns, such as biodiversity risks (Haque & Jones, 2020; Issa & Zaid, 2023). Issa and Zaid (2023) see the resources endowed by female directors as essential in responding to environmental sustainability matters and eventually supporting biodiversity practices. Consequently, companies with a high presence of female directors on boards are likely to be committed to biodiversity disclosure. Based on the foregoing discussion, we propose the third hypothesis:

H3: Firms with more female directors on the board are more likely to be committed to biodiversity disclosure.

4.2. External governance factors and biodiversity disclosure

4.2.1. UNGC signatory status and biodiversity disclosure

Companies disclose information related to biodiversity practices in their annual and sustainability reports (Issa & Zaid, 2023). Firms following specific guidelines and initiatives, such as the GRI and UNGC, refine biodiversity reporting practices (Boiral, 2016; Issa & Zaid, 2023). Previous literature indicates that standards of environmental reporting improve how environmental performance is measured and help provide evidence of compliance (Kimbro & Cao, 2011; Haque & Jones, 2020; Voegtlin & Pless, 2014). The UNGC has developed standards for corporate management to implement and disclose biodiversity practices (Haque & Jones, 2020) and established strategies to integrate biodiversity matters into corporate accounting and reporting practices (Gaia & Jones, 2020).

Adherence to the UNGC framework provides firms with normative and mimetic isomorphism to adopt the sustainable strategies and practices of industry peers and global organizations (Haque & Jones, 2020). Corporate adoption of UNGC principles and standards can enhance dialogue between firms and interested stakeholders, including civil society, governments, and environmental groups, and improve CSR engagement (Voegtlin & Pless, 2014). The UNGC global governance initiative provides companies with exposure to UNGC principles and increases their corporate social and environmental performance visibility (Voegtlin & Pless, 2014). Following UNGC principles can increase a firm's need to disclose information about social and environmental practices, which enhances its transparency and corporate responsibility (Ortas et al., 2015; Voegtlin & Pless, 2014) and reduces tension with stakeholder groups and institutions (Haque & Jones, 2020). It follows that the UNGC helps promote corporate social and environmental responsibility by serving as a guide towards greater transparency and accountability (Ortas et al., 2015). Thus, we argue that corporate commitment to biodiversity disclosure practices is positively associated with the adoption of UNGC standards. Based on the foregoing discussion, we propose the fourth hypothesis:

H4: Firms that sign UNGC standards are more likely to be committed to biodiversity disclosure.

4.2.2. Public governance and biodiversity disclosure

The various governance structures, policies, and regulations countries have created are due to the different institutional environments among countries (Jacoby et al., 2019). According to institutional theory, companies operating in different institutional contexts face various pressures that impact corporate behavior and decision making (García-Sánchez et al., 2016). The institutional frameworks in which companies are rooted can impact corporate engagement in sustainable practices (Kuzey et al., 2023). Existing research evidence highlights an association between public governance, measured by Worldwide Governance Indicators (WGIs) (Kaufmann et al., 2011), and sustainability reporting. For example, Leal Filho et al. (2016) argue that a country's governance structure likely impacts the corporate implementation of broadly accepted sustainability practices. Citizens of a country can shape their

governments and put pressure on companies to become more responsible and transparent in their social and environmental efforts (Cahan et al., 2016). Moreover, a country's political stability can be a driver of greater transparency in sustainability reporting practices (García-Sánchez et al., 2013; Uyar, Karmani, et al., 2022). The effectiveness of a country's public and civil services, the quality of laws and rules, and the credibility of governments' devotion to these acts are likely to affect corporate engagement in responsible practices, including social and environmental practices (Kuzey et al., 2023). Furthermore, countries with a low degree of corruption enjoy sound governance systems based on ethical principles and greater accountability and transparency (Farazmand, 2017). By contrast, countries with higher levels of corruption lack legitimacy and institutionalization due to weak governance structures (Uyar, Karmani, et al., 2022). Consequently, the transparency of sustainability reporting, including the reporting on biodiversity, is likely to be significantly affected by the strength of a country's public governance. Based on the foregoing discussion, we propose the fifth hypothesis:

H5: Firms domiciled in stronger public governance environments are more likely to be committed to biodiversity disclosure.

4.3. The role of internal governance and external pressure in biodiversity disclosure

Due to the voluntary nature of biodiversity disclosure, companies are not mandated to follow biodiversity initiatives, such as the UNGC and GRI guidelines (Haque & Jones, 2020). Firms can use impression management to defend their social legitimacy and corporate image without adopting comprehensive and substantial biodiversity practices (Boiral, 2016; Haque & Ntim 2018). They can adhere to UNGC principles to boost their image and legitimacy, and thereby divert attention from actual engagement in responsible biodiversity practices (Sun & Lange, 2023; Voegtlin & Pless, 2014). Ecologically irresponsible companies may choose to join the UNGC because of its low entry barrier without actually following the UNGC framework (Voegtlin & Pless, 2014). Thus, such irresponsible behavior requires effective internal governance and monitoring. Moreover, countries with weak public governance structures can ease the pressure on companies that engage in irresponsible behavior (Jacoby et al., 2019). Poor-quality rules and laws reduce monitoring capacity and can maximize any social and environmental harm caused by irresponsible corporate behavior (Tatoglu et al., 2014). Moreover, a flawed public governance environment leads to a higher degree of corruption, which impedes legitimacy and transparency, including CSR transparency (Windsor, 2014).

Such cases require an effective internal governance system that substitutes for widespread external governance failings to promote companies' responsible behavior. From an agency perspective, a higher proportion of independent directors on the board ensures the monitoring of managerial activities and reduces information asymmetry, which can affect the transparency of sustainability reporting (Al-Shaer et al., 2022). Furthermore, heterogeneous boards are likely to generate more sustainable choices and emphasize environmental issues in board decisions, which may significantly influence the extent of biodiversity related disclosures (Issa & Zaid, 2023). This will likely reduce the possibility of displaying selective biodiversity data without demonstrating actual ecological performance. When companies join the UNGC for social legitimacy without actual engagement in responsible biodiversity practices, and when they operate in countries with weak public governance structures, internal governance mechanisms can substitute for the role of external governance in promoting environmental responsibility and guiding firms towards greater transparency and accountability.

From a different perspective, academic scholars argue that conventional agency theory fails to capture the effect of the institutional environment on the agency relationship between managers and companies' owners (Jacoby et al., 2019). Previous studies have suggested that institutional theory can support agency theory in explaining how institutional pressure helps firms obtain legitimacy and accountability by developing sustainability practices (Aguilera et al., 2007). Differences in corporate governance structures are likely to be embedded in different public governance environments (Shleifer & Vishny, 1997). Thus, the effectiveness of a public governance environment can complement the internal governance pressure on companies to engage in sustainability practices, including biodiversity reporting. Moreover, firms will likely face pressure from external governance mechanisms, such as UNGC initiatives, to report and manage their influence on biodiversity. The UNGC stresses the significant role of corporate boards in addressing social and environmental concerns, such as biodiversity risks and the depletion of natural resources (Haque & Jones, 2020). Issa and Zaid (2023) argue that female directors have the potential to improve the diversity of skills, experiences, and backgrounds, ultimately supporting biodiversity initiatives. Female directors are likely to be proactive in supporting UNGC biodiversity principles by providing diverse perspectives and critical opinions to enhance biodiversity disclosure (Haque & Jones, 2020; Issa & Zaid, 2023).

Firms committed to biodiversity strategic plans and initiatives gain a social license to operate (Carvajal et al., 2022). It follows that the top management teams, particularly the board of directors, must show their commitment towards biodiversity because such commitment forms a crucial facet of sustainable development (Boiral & Heras-Saizarbitoria, 2017; Carvajal et al., 2022). Firms with affiliated board members have an advantage in transmitting knowledge, ideas, and information (Li et al., 2023). As a result, these companies are likely to build long-term relationships with stakeholders and collaborate with international organizations, such as the United Nations, to minimize the effect of their operations on biodiversity. Based on the foregoing discussion proposing both substitutive and complementary effects between internal governance and external pressure, we propose the sixth hypothesis in a non-directional manner:

H6: The interaction effect of internal governance and external pressure on biodiversity disclosure is significant.

5. Research design

5.1. Variables

5.1.1. Dependent variable

We measure biodiversity disclosure (*BIODIVERSITY*) with a binary variable coded 1 for firms reporting their impact on biodiversity to mitigate their impact on the species, native ecosystems, and preserved and sensitive areas, and 0 otherwise (Carvajal et al., 2022; Haque & Jones, 2020). To measure *BIODIVERSITY*, we use the London Stock Exchange Group (LSEG) Workspace data source (formerly known Thomson Reuters Eikon/Refinitiv database), which captures this metric with the question, "Does the company report on its impact on biodiversity or on activities to reduce its impact on the native ecosystems and species, as well as the biodiversity of protected and sensitive areas?". Studies that use a continuous variable for *BIODIVERSITY* measurement develop their own scale by manually checking the existence of some related items (Bhattacharyya & Yang, 2019; Mahyuddin et al., 2022). Although this is feasible for small-scale and context-bounded studies (Bhattacharyya & Yang, 2019; Mahyuddin et al., 2022), it is not feasible for large-scale studies like our study, which includes 46,564 observations. Thus, we use a binary variable for *BIODIVERSITY*.

5.1.2. Independent variables

We use two types of independent variables: internal and external governance mechanisms. We measure the internal governance attributes with board affiliation (*BD_AFFILIATION*), board independence (*BD_INDEPEND*), and board gender diversity (*BD_GENDER_DIV*). *BD_AFFILIATION* indicates board members' average number of affiliations with other corporations, and *BD_INDEPEND* and *BD_GENDER_DIV* show the percentage of independent and female directors on boards, respectively

(Kuzey et al., 2022; Uyar et al., 2023).

For external governance characteristics, we use a firm's UNGC signatory commitment and public governance strength. The UNGC signatory status variable is *UNGC,* proxied by a binary variable coded 1 if the company signed the UNGC, and 0 otherwise (Van der Waal & Thijssens, 2020).[5] The UNGC is a non-binding pact to stimulate sustainable business practices worldwide and to report on such implementations. The public governance strength of the countries with which firms are affiliated is *WGI*, proxied by the WGI (Uyar, Kuzey, et al., 2022). The WGI includes political stability and absence of violence/terrorism, control of corruption, voice and accountability, government effectiveness, rule of law, and regulatory quality (values range between −2.5 and 2.5).

5.1.3. Control variables

We control *BDSIZE* and *CEODUALITY*, as they affect the decision-making efficiency of the management regarding corporate policies, including biodiversity disclosure. Board size (*BDSIZE*) is proxied by the number of directors on the board, and CEO duality (*CEODUALITY*) is proxied with a binary variable coded 1 if the CEO simultaneously chairs the board, and 0 otherwise (Carvajal et al., 2022; Haque & Jones, 2020). Financial characteristics are among the predictors of environmental engagement and reporting, as they facilitate or constrain firms' abilities for stakeholder engagement. Hence, we control a battery of firm financial attributes, such as firm size (*FIRMSIZE*) (proxied by the natural logarithm of total assets), *PROFITABILITY* (proxied by income before tax over total assets), *LEVERAGE* (proxied by total debt over total assets), current ratio (*CRATIO*) (proxied by current assets over current liabilities), firm investment (*CAPEXPEND*)(proxied by capital expenditures over total assets), and firm innovativeness (*RD*)(proxied by the research and development expenditures over total assets) (Carvajal et al., 2022; Uyar et al., 2023). For instance, larger, more profitable, and more innovative firms are more visible and have more resources to deploy to care for biodiversity and disclose related information, whereas capital expenditures and indebtedness might restrain firms' biodiversity commitment and disclosure. Finally, we control for the ownership structure using the free float percentage of shares tradable by shareholders (*FFLOAT*) (Kuzey et al., 2022; Uyar et al., 2023), as owners are the primary stakeholders closely following and impacting firms' stakeholder relations. Variable definitions in Appendix A. The data for all firm-level variables and UNGC adoption are retrieved from the London Stock Exchange Group (LSEG) Workspace database (formerly known Thomson Reuters Eikon/Refinitiv database), and the WGI data are obtained from the World Bank.

5.2. Research sample

From an initial sample of 75,065 observations obtained from the intersections of the London Stock Exchange Group (LSEG) Workspace database and the World Bank database, we excluded 12,023 records from the financial sector to focus on the non-financial sectors, 10,894 records with missing observations of *BIODIVERSITY* to ensure data completeness, 419 records from countries with fewer than 10 unique firms to maintain adequate country level representation, 5,142 records with case wise missing observations of *BIODIVERSITY* and control variables to avoid bias from incomplete data, and 23 multivariate outliers to minimize the effect of extreme values on the results. The research sample excludes the case wise missing observations of *BIODIVERSITY*, testing variables, and the control variables. After the exclusion of the missing observations based on these sampling constraints, *BD_AFFILIATION* and *UNGC* still have 3.17 % and 4.78 % missing observations, respectively. Missing observations of less than 5 % can be inconsequential, and fewer than 10 % of missing observations are unlikely to cause any estimation biases during the analyses. We do not impute the missing values for BD_AFFILIATION and UNGC, as both variables have fewer than 5 % missing observations. Instead, we retain these variables in the analysis and exclude only the specific observations with missing data on these variables. Following these exclusions, the final research sample comprises 46,564 observations (Table 1, Panel A). We winsorize *BSIZE*, *PROFITABILITY*, *LEVERAGE*, *CRATIO*, *CAPEXPEND* at the 1st and 99th percentiles to reduce the impact of extreme values (Tukey, 1962).

Regarding the industry level distributions, the ratios of the sample range between 5.18 % (real estate) and 18.68 % (industrials) (Table 1, Panel B). Moreover, year level sample distributions reveal ratios ranging between 0.73 % for the year 2002 and 10.47 % for the year 2019 (Table 1, Panel B). Finally, the country level sample distributions show that 47 countries include 6,956 unique firms and 46,564 data points. All the countries have at least 10 or more unique firms (see Appendix B for country distribution).

Table 1
Sample distribution.

Panel A			
Initial sample			75,065
(−) Financials			12,023
(−) Missing observations of *BIODIVERSITY*			10,894
(−) Countries with less than ten firms			419
(−) Case- wise missing observations of dependent variable (*BIODIVERSITY*) and the controls			5,142
(−) Multivariate outliers			23
Final sample			*46,564*
Panel B			
Variable	Categories	Frequency	Percent
Sector	Basic Materials	6,090	13.08
	Consumer Cyclicals	7,880	16.92
	Consumer Non-Cyclicals	4,442	9.54
	Energy	3,746	8.04
	Healthcare	4,660	10.01
	Industrials	8,700	18.68
	Real Estate	2,414	5.18
	Technology	5,909	12.69
	Utilities	2,723	5.85
	Total	*46,564*	*100.00*
Year	2002	338	0.73
	2003	358	0.77
	2004	693	1.49
	2005	977	2.10
	2006	1,012	2.17
	2007	1,179	2.53
	2008	1,509	3.24
	2009	1,838	3.95
	2010	2,342	5.03
	2011	2,488	5.34
	2012	2,583	5.55
	2013	2,677	5.75
	2014	2,772	5.95
	2015	3,230	6.94
	2016	3,309	7.11
	2017	4,009	8.61
	2018	4,516	9.70
	2019	4,873	10.47
	2020	4,538	9.75
	2021	1,323	2.84
	Total	*46,564*	*100.00*

5.3. Research models

We employ country, industry, and year fixed effects (FE) logistic regression analysis to test our hypotheses. Using the country, industry, and year FE regression approach can mitigate potential time invariant

[5] Please see a more detailed description of the UNGC signatory adoption in Appendix A.

Table 2
Descriptive statistics.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
BIODIVERSITY	46,564	0.28	0.45	0.00	1.00
BD_AFFILIATION	45,089	1.04	0.91	0.00	19.33
BD_INDEPEND	46,564	73.94	21.33	0.00	100.00
BD_GENDER_DIV	46,564	14.65	13.13	0.00	100.00
UNGC	44,337	0.18	0.38	0.00	1.00
BSIZE	46,564	9.87	3.27	4.00	21.00
CEODUALITY	46,564	0.39	0.49	0.00	1.00
FIRMSIZE	46,564	22.01	1.70	10.65	27.41
PROFITABILITY	46,564	0.05	0.14	−0.67	0.36
LEVERAGE	46,564	0.25	0.18	0.00	0.84
CRATIO	46,564	2.16	2.26	0.23	17.66
CAPEXPEND	46,564	0.05	0.05	0.00	0.25
RD	46,564	0.02	0.06	0.00	0.37
FFLOAT	46,564	76.83	25.00	0.00	100.00
WGI	46,564	1.10	0.58	−0.79	1.95

Note: All variables are defined in Appendix A.

endogeneity threats (Rjiba et al., 2020). The baseline research hypotheses incorporate linear and moderation models. We present the formulation of the research models below.

5.3.1. Linear models

We formulate the linear logistic research models using Equation (1).

$$(Y)_{i,t,c} = \beta_0 + \beta_1(X)_{i,t,c} + \beta_2(Controls)_{i,t,c} + \beta_3 \sum (Country)_c + \beta_4 \sum (Industry)_i + \beta_5 \sum (Year)_t + \varepsilon_{i,t,c} \quad (1)$$

The dependent variable ($Y_{i,t,c}$) is *BIODIVERSITY*, a binary categorical variable. In addition, the independent variables of interest ($X_{i,t,c}$) are internal governance (*BD_AFFILIATION*, *BD_INDEPEND*, and *BD_GENDER_DIV*) and external governance mechanisms (*UNGC* and *WGI*). The control variables in Equation (1) are *BSIZE*, *CEODUALITY*, *FIRMSIZE*, *PROFITABILITY*, *LEVERAGE*, *CRATIO*, *CAPEXPEND*, *RD*, *FFLOAT*, and *WGI*. The *WGI* is a control variable when not employed as a test variable. Specifically, we constructed five research models. In the initial four models, *WGI* is utilized as a control variable, whereas it is employed as the test variable in the final (fifth) model.

5.3.2. Moderating effect

The second part of the baseline research examines models with the moderating effect of the UNGC signatory status and the WGI on the relationship between internal governance and biodiversity disclosure. Our proposed model with moderating effect is provided in Equation (2).

$$(Y)_{i,t,c} = \beta_0 + \beta_1(X)_{i,t,c} + \beta_2(M)_{i,t,c} + \beta_3(X \times M)_{i,t,c} + \beta_4(Controls)_{i,t,c} + \beta_5 \sum (Country)_c + \beta_6 \sum (Industry)_i + \beta_7 \sum (Year)_t + \varepsilon_{i,t,c} \quad (2)$$

The dependent variable ($Y_{i,t,c}$) is biodiversity disclosure (*BIODIVERSITY*). The testing variables of interest ($X_{i,t,c}$) are the internal governance measures (*BD_AFFILIATION*, *BD_INDEPEND,* and *BD_GENDER_DIV*). The moderating variables ($M_{i,t,c}$) are the firms' UNGC signatory status and WGI as the external governance proxies. The control variables are the same as in the linear models. The *i, t,* and *c* subscripts in the above equations represent the firm, year, and country variables, respectively.

The proposed model with interaction terms addresses the complementary or substitutive effects between internal governance and external pressure. Our model incorporates interaction terms of board attributes (*BD_AFFILIATION*, *BD_INDEPEND*, and *BD_GENDER_DIV*) and institutions (*UNGC* and *WGI*) in pairs, with one being the variable of

Table 3
Pearson correlation analysis.

	Variables	1	2	3	4	5	6	7	8
1	BIODIVERSITY	1							
2	BD_AFFILIATION	0.079*	1						
3	BD_INDEPEND	0.019*	0.173*	1					
4	BD_GENDER_DIV	0.108*	−0.007	0.339*	1				
5	UNGC	0.367*	0.088*	0.058*	0.129*	1			
6	BSIZE	0.221*	0.087*	−0.060*	0.005	0.258*	1		
7	CEODUALITY	−0.064*	−0.019*	−0.024*	−0.011*	−0.031*	0.062*	1	
8	FIRMSIZE	0.354*	0.240*	−0.010*	0.036*	0.334*	0.527*	0.095*	1
9	PROFITABILITY	0.034*	0.051*	−0.024*	0.003	0.058*	0.117*	0.042*	0.270*
10	LEVERAGE	0.106*	0.026*	0.073*	0.058*	0.043*	0.133*	0.009	0.256*
11	CRATIO	−0.128*	−0.064*	−0.014*	−0.059*	−0.122*	−0.201*	0.001	−0.356*
12	CAPEXPEND	0.079*	0.012*	0.011*	−0.089*	−0.009*	−0.017*	−0.009*	−0.017*
13	RD	−0.146*	−0.030*	0.048*	0.006	−0.075*	−0.161*	0.020*	−0.345*
14	FFLOAT	−0.113*	0.015*	0.074*	0.111*	−0.058*	−0.051*	0.114*	0.008
15	WGI	−0.132*	−0.007	0.049*	0.104*	−0.029*	−0.138*	0.010*	−0.092*
	Variables	9	10	11	12	13	14	15	
9	PROFITABILITY	1							
10	LEVERAGE	−0.110*	1						
11	CRATIO	−0.187*	−0.331*	1					
12	CAPEXPEND	0.074*	0.018*	−0.087*	1				
13	RD	−0.507*	−0.180*	0.344*	−0.112*	1			
14	FFLOAT	−0.045*	−0.009	0.033*	−0.051*	0.116*	1		
15	WGI	−0.057*	−0.070*	0.047*	−0.018*	0.071*	0.414*	1	

Notes: All variables are defined in Appendix A. *$p < 0.05$.

Table 4
Board structure, UNGC, and biodiversity disclosure.

	(1)	(2)	(3)	(4)	(5)	(6)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
BD_AFFILIATION	0.076***(4.35)					0.057***(3.03)
BD_INDEPEND		0.0086***(8.06)				0.0067***(5.58)
BD_GENDER_DIV			0.0080***(6.07)			0.0062***(4.25)
UNGC				1.10***(29.96)		1.10***(29.37)
WGI	1.25***(7.04)	1.29***(7.49)	1.47***(8.57)	0.94***(4.92)	1.41***(8.20)	0.75***(3.73)
BSIZE	0.0085*(1.66)	0.0099**(2.01)	0.011**(2.12)	0.0071(1.34)	0.011**(2.22)	0.0015(0.27)
CEODUALITY	−0.0046(−0.15)	0.010(0.33)	−0.014(−0.47)	−0.018(−0.55)	−0.013(−0.43)	0.0042(0.12)
FIRMSIZE	0.76***(59.60)	0.76***(61.50)	0.76***(61.64)	0.70***(52.45)	0.77***(62.61)	0.69***(49.01)
PROFITABILITY	−0.15(−1.02)	−0.11(−0.79)	−0.16(−1.09)	−0.16(−1.07)	−0.11(−0.75)	−0.26*(−1.68)
LEVERAGE	−0.54***(−5.94)	−0.56***(−6.17)	−0.55***(−6.10)	−0.58***(−5.91)	−0.57***(−6.27)	−0.54***(−5.47)
CRATIO	−0.0091(−1.04)	−0.0029(−0.34)	−0.0012(−0.14)	0.0067(0.73)	−0.0043(−0.50)	0.0050(0.53)
CAPEXPEND	4.37***(14.39)	4.20***(14.00)	4.28***(14.26)	4.18***(13.11)	4.21***(14.06)	4.43***(13.65)
RD	1.38***(2.71)	1.39***(2.74)	1.36***(2.68)	0.97*(1.73)	1.36***(2.68)	1.06*(1.87)
FFLOAT	−0.000041(−0.06)	−0.00011(−0.16)	−0.00015(−0.23)	−0.00037(−0.52)	0.00014(0.21)	−0.00090(−1.23)
Constant	−17.9***(−43.10)	−18.3***(−45.90)	−17.6***(−44.40)	−16.8***(−39.00)	−17.9***(−45.29)	−17.1***(−37.17)
Country, industry, & year FE	Included	Included	Included	Included	Included	Included
N	45,061	46,536	46,536	44,309	46,536	42,837
Pseudo R^2	0.328	0.328	0.327	0.329	0.327	0.334
χ^2-stat.	17548.68***	17954.60***	17925.86***	16066.57***	17889.16***	15857.26***

Notes: WGI serves as a test variable in column #5, whereas it functions as a control variable in the remaining columns. All variables are defined in Appendix A. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

interest and the other serving as the moderating variable ($X \times M$). We provide detailed results of these complementary or substitutive effects through moderation analyses in the forthcoming sections. Additionally, we implement a complementarity or substitutability test using a simple one-tailed *t*-test. As suggested by Carree et al. (2011), this test examines the null hypothesis that $\beta_3 = 0$ for the interaction term of the two variables ($X \times M$). By examining these interactions, this study aims to understand how board attributes and institutions jointly influence biodiversity reporting practices. We report the robust standard errors clustered by the countries in the results of the regression analyses for controlling for the potential risk of heteroscedasticity (Wooldridge, 2020).

6. Empirical results and discussion

6.1. Summary statistics

Table 2 presents the descriptive statistics of the research variables. The results show that 28 % of firms report their impact on biodiversity (*BIODIVERSITY*). The mean number of other corporate affiliations for board members (*BD_AFFILIATION*) is 1.04, the mean ratio of non-executive directors (*BD_INDEPEND*) is 73.94 %, and the mean ratio of female directors (*BD_GENDER_DIV*) is 14.65 %. Additionally, 18 % of firms have signed the *UNGC*, and the mean *WGI* is 1.10.

6.2. Correlation analysis

Table 3 reports the Pearson correlation coefficients. Board attributes (*BD_AFFILIATION*, *BD_INDEPEND*, *BD_GENDER_DIV*) and *UNGC* signatory status show significant positive correlations with biodiversity disclosure (*BIODIVERSITY*) ($p < 0.05$), while the *WGI* exhibits a significant negative correlation with *BIODIVERSITY* ($p < 0.05$).

We assess multicollinearity by calculating the variance inflation factors (VIFs) for the independent variables. The VIF values range from 1.02 to 1.96. This is well below the recommended threshold of 10 (Hair et al., 2019), indicating that multicollinearity is not a concern in the research models.

6.3. Baseline analyses

6.3.1. Linear models

The baseline research models are analyzed using country, industry, and year FE logistic regression (Table 4). The results indicate that the three internal governance proxies (*BD_AFFILIATION*, *BD_INDEPEND*, and *BD_GENDER_DIV*) have a significantly positive relationship with biodiversity disclosure ($p < 0.01$). The findings validate H1, H2, and H3 regarding the role of internal governance in stimulating firms' biodiversity disclosure. The results reinforce the principles of RDT, emphasizing the critical role of internal governance mechanisms in securing and managing resources to respond effectively to stakeholder pressures. According to RDT, the composition and structure of a firm's board are pivotal in determining how well it can navigate complex external environments and access the resources necessary to achieve its strategic objectives (Al-Shaer & Zaman, 2018; Hillman & Dalziel, 2003; Li et al., 2023). In line with RDT, the findings imply that independent, female, and affiliated directors on boards are critical in fostering connections with external social and environmental stakeholders. By leveraging these connections, firms can enhance their capabilities in biodiversity disclosure and overall environmental performance.

The results also indicate *UNGC* and *WGI* have a significantly positive relationship with biodiversity disclosure ($p < 0.01$). Thus, we accept H4 and H5, which propose that firms signing the UNGC and domiciled in stronger public governance environments measure by WGI are more likely to be committed to biodiversity disclosure. The outcome of *UNGC* confirms the role of normative pressure in biodiversity disclosure such that the UNGC signatory commitment by firm serves as a global framework that promotes sustainability and corporate responsibility (Hyatt & Berente, 2017). Additionally, the positive relationship between stronger public governance environments, as indicated by the WGI, and biodiversity disclosure provides strong support for coercive isomorphism within institutional theory (DiMaggio & Powell, 1983). The findings confirm that firms operating in countries with high levels of political stability, effective public and civil services, strong legal frameworks, and low levels of corruption are more likely to engage in biodiversity disclosure.

6.3.2. Moderating effects

We perform country, industry, and year FE logistic regression to examine the moderating effects of *UNGC* and *WGI* on the relationship between internal governance and biodiversity disclosure (Tables 5 and 6). The interaction terms *BD_AFFILIATION* × *UNGC*, *BD_INDEPEND* × *UNGC*, and *BD_GENDER_DIV* × *UNGC* show a significantly negative relationship with *BIODIVERSITY* ($p < 0.01$) (Table 5). This finding confirms that internal governance mechanisms (i.e., board affiliation,

Table 5
Interaction effect of board structure and UNGC on biodiversity disclosure.

	(1)	(2)	(3)
Independent variables	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
BD_AFFILIATION	0.11***		
	(5.33)		
UNGC	1.30***	1.83***	1.22***
	(23.52)	(15.93)	(22.99)
BD_AFFILIATION*UNGC	−0.16***		
	(−4.52)		
BD_INDEPEND		0.0086***	
		(7.20)	
BD_INDEPEND*UNGC		−0.010***	
		(−6.79)	
BD_GENDER_DIV			0.0087***
			(5.50)
BD_GENDER_DIV*UNGC			−0.0075***
			(−3.15)
BSIZE	0.0030	0.0088	0.0067
	(0.55)	(1.64)	(1.27)
CEODUALITY	−0.0088	−0.0034	−0.019
	(−0.26)	(−0.10)	(−0.57)
FIRMSIZE	0.70***	0.70***	0.70***
	(50.17)	(51.84)	(51.75)
PROFITABILITY	−0.22	−0.16	−0.20
	(−1.39)	(−1.06)	(−1.31)
LEVERAGE	−0.56***	−0.58***	−0.57***
	(−5.69)	(−5.94)	(−5.82)
CRATIO	0.0017	0.0074	0.0095
	(0.18)	(0.81)	(1.03)
CAPEXPEND	4.38***	4.17***	4.27***
	(13.53)	(13.05)	(13.33)
RD	1.02*	0.99*	0.95*
	(1.81)	(1.77)	(1.70)
FFLOAT	−0.00045	−0.00056	−0.00057
	(−0.62)	(−0.79)	(−0.79)
WGI	0.80***	0.78***	0.97***
	(4.00)	(4.06)	(5.06)
Constant	−17.0***	−17.4***	−16.7***
	(−37.65)	(−39.70)	(−38.38)
Country, industry, & year FE	Included	Included	Included
N	42,837	44,309	44,309
Pseudo R2	0.333	0.331	0.330
χ2-stat.	15823.13***	16146.85***	16097.67***

Notes: All variables are defined in Appendix A. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. **Complementarity or Substitutability tests results from a Simple One-Tailed T-Test.** H_0: β_*BD_AFFILIATION*UNGC* = 0 (χ^2: 20.40; df: 1; p-value: 0.000). H_0: β_*BD_INDEPEND*UNGC* = 0 (χ^2: 46.14; df: 1; p-value: 0.000). H_0: β_*BD_GENDER_DIV*UNGC* = 0 (χ^2: 9.95; df: 1; p-value: 0.002).

board independence, and board gender diversity) and external governance (UNGC signatory status) are substitutes for spurring biodiversity disclosure, confirming H6.

However, the moderating influence of the *WGI* between boards of directors and biodiversity disclosure is not uniform. Whereas the interaction term *BD_AFFILIATION* × *WGI* exhibits a significantly negative relationship with *BIODIVERSITY* ($p < 0.05$), the interaction term *BD_INDEPEND* × *WGI* demonstrates a significantly positive relationship with *BIODIVERSITY* ($p < 0.01$), and the coefficient of the interaction term *BD_GENDER_DIV* × *WGI* is not significant (Table 6). Hence, the *WGI*'s mixed moderation effects support H6 for the interaction of *WGI* with board affiliation and independence but not for the interaction of *WGI* with board gender diversity.

The evidence supporting the interaction effect between internal governance mechanisms and the UNGC on biodiversity disclosure provides strong support for the substitutive effect of these two governance frameworks, and aligns with Zhang et al. (2021). This means that firms can either rely on robust internal governance structures or external governance mechanisms, such as the UNGC, to achieve similar outcomes in terms of biodiversity disclosure. Nevertheless, the WGI's differing interaction effects for distinct board characteristics are also supported by prior studies, with evidence of both substitution and complementary relationships between different governance bundles. For example, Kuzey et al. (2023) find that corporate governance and public governance are supplements in inciting firms for sustainability engagement in an international sample, and Tenakwah et al. (2024) find that these two governance mechanisms are complements in provoking firms for greater sustainability engagement in Ghana. In summary, the varying interaction effects of WGI on board characteristics reflect the complex and context dependent nature of governance relationships.

Moreover, we tested for the complementarity or substitutability of the interaction terms in our moderating models. Specifically, we use a simple one-tailed *t*-test to examine the null hypothesis that the coefficients for the pairwise interaction terms (β3 = 0) of board attributes (*BD_AFFILIATION*, *BD_INDEPEND*, and *BD_GENDER_DIV*) and institutions (*UNGC* and *WGI*) are equal to zero. The findings reveal that the coefficients of five pairwise interaction terms, including *BD_AFFILIATION* × *UNGC*, *BD_INDEPEND* × *UNGC*, *BD_GENDER_DIV* × *UNGC*, *BD_AFFILIATION* × *WGI*, and *BD_INDEPEND* × *WGI*, are statistically significantly different from zero, whereas the coefficient of the interaction term *BD_GENDER_DIV* × *WGI* is not statistically significant.[6]

6.4. Robustness tests

To ensure the robustness of the baseline results, we conducted various tests and report their outcomes in the following paragraphs.

6.4.1. Lagged models

Following prior studies, we used a contemporaneous regression model in the baseline analyses (Carvajal et al., 2022; Haque & Jones, 2020). In addition, we run a robustness test with the lagged model, assuming the possibility of a time lag between board attributes and their repercussions on biodiversity disclosure. To mitigate potential endogeneity threats, we incorporated a one-year lag of the testing variables of interest (*BD_AFFILIATION*, *BD_INDEPEND*, *BD_GENDER_DIV*, *UNGC*, and *WGI*) in the linear and moderating models (Lehoucq & Perez-Linan, 2014). This approach enhances causal inference and addresses reverse causality concerns (Steinberg & Malhotra, 2014). The results reported in Table 7 (Panels A, B, and C) align with the initial baseline analysis results.

6.4.2. Endogeneity

We address endogeneity by conducting IVPROBIT regression, entropy balancing, and propensity score matching (PSM) analyses, with results shown in Table 8, Panels A, B, and C.

First, we apply the IVPROBIT model with endogenous regressors to address potential endogeneity. IVPROBIT is suitable for our binary dependent variable (*BIODIVERSITY*), using minimum chi-square two-step estimation. The instrumental variables are *GOVCOMMITTEE*, the one-year lag of *UNGC*, and *WGI*.[7] Konadu et al. (2022) use *GOVCOMMITTEE* as the instrumental variable for shaping board gender diversity,

[6] **Complementarity or Substitutability tests results from a Simple One-Tailed T-Test.**H0: β_BD_AFFILIATION × UNGC = 0 (χ^2: 20.40; df: 1; p-value: 0.000)H0: β_BD_INDEPEND × UNGC = 0 (χ^2: 46.14; df: 1; p-value: 0.000)H0: β_BD_GENDER_DIV × UNGC = 0 (χ^2: 9.95; df: 1; p-value: 0.002)H0: β_BD_AFFILIATION × WGI = 0 (χ^2: 4.52; df: 1; p-value: 0.0336)H0: β_BD_INDEPEND × WGI = 0 (χ^2: 8.07; df: 1; p-value: 0.0045)H0: β_BD_GENDER_DIV × WGI= 0 (χ^2: 0.15; df: 1; p-value: 0.69712).

[7] IVs: *GOVCOMMITTEE* is used as the instrumental variable for the models with *BD_AFFILIATION*, *BD_INDEPEND*, and *BD_GENDER_DIV* testing variables (Columns 2, 4, and 6). *GOVCOMMITTEE* is the binary variable showing the existence of a corporate governance committee. *GOVCOMMITTEE* (47.15% exist). $UNGC_{(t-1)}$ was used as the instrumental variable for the model with the UNGC testing variable (Column 8). $WGI_{(t-1)}$ was used as the instrumental variable for the model with the WGI testing variable (Column10).

Table 6
Interaction effect of board structure and WGI on biodiversity disclosure.

	(1)	(2)	(3)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
BD_AFFILIATION	0.13***(4.27)		
WGI	1.30***(7.25)	0.94***(4.48)	1.48***(8.57)
BD_AFFILIATION*WGI	−0.051**(−2.13)		
BD_INDEPEND		0.0041**(2.16)	
BD_INDEPEND*WGI		0.0046***(2.84)	
BD_GENDER_DIV			0.0089***(3.48)
BD_GENDER_DIV*WGI			−0.00079(−0.39)
BSIZE	0.0083(1.63)	0.011**(2.18)	0.010**(2.12)
CEODUALITY	−0.0060(−0.19)	0.0073(0.24)	−0.015(−0.48)
FIRMSIZE	0.76***(59.57)	0.76***(61.27)	0.76***(61.43)
PROFITABILITY	−0.15(−1.05)	−0.12(−0.82)	−0.16(−1.08)
LEVERAGE	−0.55***(−5.99)	−0.56***(−6.18)	−0.55***(−6.10)
CRATIO	−0.0091(−1.05)	−0.0028(−0.33)	−0.0013(−0.14)
CAPEXPEND	4.36***(14.36)	4.22***(14.06)	4.28***(14.24)
RD	1.40***(2.74)	1.40***(2.75)	1.37***(2.69)
FFLOAT	−0.000032(−0.05)	−0.00012(−0.17)	−0.00015(−0.22)
Constant	−17.9***(−43.03)	−17.9***(−42.68)	−17.6***(−44.18)
Country, industry, & year FE	Included	Included	Included
N	45,061	46,536	46,536
Pseudo R^2	0.328	0.328	0.327
χ^2-stat.	17553.25***	17962.66***	17926.01***

Notes: All variables are defined in Appendix A. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. **Complementarity or Substitutability tests results from a Simple One-Tailed T-Test.** H_0: $\beta\_BD\_AFFILIATION*WGI = 0$ (χ^2: 4.52; df: 1; p-value: 0.0336). H_0: $\beta\_BD\_INDEPEND*WGI = 0$ (χ^2: 8.07; df: 1; p-value: 0.0045). H_0: $\beta\_BD\_GENDER\_DIV*WGI = 0$ (χ^2: 0.15; df: 1; p-value: 0.69712).

which we follow in choosing this instrument for our board proxies. We posit that the corporate governance committee plays a direct role in shaping board structure but not in biodiversity disclosure, as the main function of this committee is to configure monitoring mechanisms but not disclosure. Furthermore, although the reverse causality possibility (from biodiversity disclosure to the *UNGC* and the *WGI*) is weak, we run the IVPROBIT model with the lag of *UNGC* and *WGI* as the instrumental variables.[8] The lags in testing variables as instrumental variables are widely used in the literature (Murcia et al., 2021; Usman et al., 2018).

The findings are presented in Table 8 (Panel A). The first-stage results show that the instrumental variables are statistically significant, confirming their relevance. The Wald test of exogeneity supports the absence of endogeneity, validating IVPROBIT as appropriate. The second-stage results align with the baseline analysis, with significant positive coefficients for board attributes, *UNGC*, and *WGI*.

Second, we use entropy balancing (Hainmueller, 2012) to address potential self-selection bias based on observable characteristics. We create binary variables *BD_AFFILIATION_QUAR*, *BD_INDEPEND_QUAR*, *BD_GENDER_DIV-QUAR* and *WGI_QUAR* coded 1 (treatment group) for the top quartiles of board governance, *BD_AFFILIATION*, *BD_INDEPEND*, *BD_GENDER_DIV*, and *WGI*, respectively, and the rest coded 0 as a control group. Moreover, *UNGC* is a binary variable, with observations coded as 1 representing the treatment group and observations coded as 0 representing the control group. The re-run linear models (Table 8, Panel B) align with the baseline results, showing significant positive coefficients. Lastly, we apply PSM (Rosenbaum & Rubin, 1983) using the same treatment and control groups. The results (Table 8, Panel C) confirm the baseline findings, with significant positive coefficients for board governance, *UNGC*, and *WGI*.

6.4.3. Heckman's selection

We apply Heckman's (1979) two-stage selection method to address potential non-random sampling bias. In the first stage, we generate binary dependent variables of *BD_AFFILIATION_BIN, BD_INDEPEND_BIN, BD_GENDER_DIV_BIN,* and *WGI_BIN* coded 1 if equal to or above the medians of *BD_AFFILIATION*, *BD_INDEPEND*, *BD_GENDER_DIV*, and *WGI*, respectively, along with the binary *UNGC* variable. Probit regression is used, with *GOVCOMMITTEE*, $UNGC_{t-1}$, and WGI_{t-1} as instrumental variables. We calculate inverse Mills ratios (IMRs) to correct for sample selection bias, incorporating them in the second-stage equation. The results, presented in Table 9, fully align with the initial analysis.

6.4.4. Alternative estimation method

We use PROBIT regression as an alternative estimation method, and the results remain consistent with the initial baseline analysis.[9]

6.4.5. Firm and year FE

To address unobserved heterogeneity, we apply firm and year FE regression analysis (Wooldridge, 2010). The findings are consistent with the baseline results.

6.4.6. Alternative sample

Since the USA is the most dominant country in the sample, we generate an alternative sample by excluding the USA firms and re-run the models using the alternative sample. The results align with the baseline, except *BD_GENDER_DIV* becomes non-significant, suggesting women directors may have less influence on biodiversity disclosure outside the USA. The moderation models yield similar results, except for *BD_INDEPEND* × *WGI*, which becomes non-significant.

6.4.7. Alternative control variables

We include alternative controls (*FIRMSIZE_Alt*, *PROFITABILITY_Alt*, *LEVERAGE_Alt*, *CAPEXPEND_Alt*, and *RD_Alt*) in the baseline models, and the results remain consistent.[10]

Collectively, the results confirm the robustness of the baseline analysis after testing with alternative samples, methods, and addressing endogeneity concerns.

[8] The *UNGC* and the *WGI* are external mechanisms, but biodiversity disclosure is an internal engagement.

[9] The results of robustness tests and further tests from this point forward are not tabulated due to the page constraint.

[10] Please see Appendix A for the definitions of alternative control variables.

Table 7
Lagged testing variables.

Panel A: Board structure, UNCG, and biodiversity disclosure

	(1)	(2)	(3)	(4)	(5)	(6)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
$BD\_AFFILIATION_{(t-1)}$	0.057***(3.19)					0.032(1.63)
$BD\_INDEPEND_{(t-1)}$		0.0084***(7.62)				0.0065***(5.17)
$BD\_GENDER\_DIV_{(t-1)}$			0.0081***(5.74)			0.0068***(4.44)
$UNGC_{(t-1)}$				0.97***(24.81)		0.96***(23.94)
$WGI_{(t-1)}$					1.86***(9.49)	1.53***(6.54)
Controls	Included	Included	Included	Included	Included	Included
Country, industry, & year FE	Included	Included	Included	Included	Included	Included
N	39,353	40,443	40,817	38,464	41,088	36,340
Pseudo R^2	0.324	0.323	0.322	0.331	0.321	0.336
χ^2-stat.	15608.97	15914.98	15994.14	15117.43	16051.52	14676.45

Panel B: Interaction effect of board structure and UNGC on biodiversity disclosure

	(1)	(2)	(3)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
$BD\_AFFILIATION_{(t-1)}$	0.082***(4.02)		
$UNGC_{(t-1)}$	1.16***(20.00)	1.68***(13.94)	1.12***(20.24)
$BD\_AFFILIATION_{(t-1)}$*$UNGC_{(t-1)}$	−0.16***(−4.36)		
$BD\_INDEPEND_{(t-1)}$		0.0080***(6.58)	
$BD\_INDEPEND_{(t-1)}$*$UNGC_{(t-1)}$		−0.0099***(−6.39)	
$BD\_GENDER\_DIV_{(t-1)}$			0.0099***(6.02)
$BD\_GENDER\_DIV_{(t-1)}$*$UNGC_{(t-1)}$			−0.010***(−4.07)
Controls	Included	Included	Included
Country, industry, & year FE	Included	Included	Included
N	36,736	37,821	38,194
Pseudo R^2	0.335	0.333	0.332
χ^2-stat.	14744.93***	15017.45***	15090.46***

Panel C: Interaction effect of board structure and WGI on biodiversity disclosure

	(1)	(2)	(3)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
$BD\_AFFILIATION_{(t-1)}$	0.095***(3.00)		
$WGI_{(t-1)}$	1.63***(7.81)	1.43***(6.03)	1.94***(9.76)
$BD\_AFFILIATION_{(t-1)}$*$WGI_{(t-1)}$	−0.039*(−1.73)		
$BD\_INDEPEND_{(t-1)}$		0.0051**(2.52)	
$BD\_INDEPEND_{(t-1)}$*$WGI_{(t-1)}$		0.0031*(1.81)	
$BD\_GENDER\_DIV_{(t-1)}$			0.0064**(2.26)
$BD\_GENDER\_DIV_{(t-1)}$*$WGI_{(t-1)}$			0.0017(0.76)
Controls	Included	Included	Included
Country, industry, & year FE	Included	Included	Included
N	39,353	40,443	40,817
Pseudo R^2	0.324	0.323	0.322
χ^2-stat.	15631.99***	15935.83***	16020.20***

Notes: All variables are defined in Appendix A, except for the lagged variables, which are regular variable denoted with a subscript of *t-1*. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.5. Further tests

We conduct several additional non-tabulated tests by adopting alternative samples to provide deeper insights into the outcomes. First, we derive five alternative test variables: the *USA* (observations involving USA-based firms), *EU* (observations from countries within the European Union), *EUROPE* (observations from countries in Europe), *EMERGING MARKETS* (observations from countries classified as emerging markets), and *POLLUTING SECTORS* (observations from polluting sectors such as basic materials, energy, industrials, and utilities). In these tests, we aim to explore how institutional environments (national and sectoral affiliations) predict biodiversity disclosure. The findings indicate that the *USA*, *EU*, and *EUROPE* exhibit a significantly negative association with *BIODIVERSITY*, whereas *EMERGING MARKETS* and *POLLUTING SECTORS* demonstrate a significantly positive association with *BIODIVERSITY*.

Second, we test the association between internal and external governance mechanisms and biodiversity disclosure in polluting and non-polluting sectors. In both samples, the coefficients of the testing variables are predominantly significantly positive, in line with the baseline analysis, except for *BD_AFFILIATION*. Whereas *BD_AFFILIATION* is significantly positive for the non-polluting sectors, it is not significant for the polluting sectors; all other results are consistent.

Third, we re-run the main model for the *USA*, *EUROPE*, and *EMERGING MARKETS* sub-samples. In the USA sub-sample, the findings align with the initial results confirming the significant role of internal and external governance mechanisms in biodiversity disclosure. In the European sub-sample, *BD_AFFILIATION* and *WGI* negatively influence *BIODIVERSITY*, while only *BD_GENDER_DIV* and *UNGC* positively affect *BIODIVERSITY*. In the emerging market sub-sample, *BD_AFFILIATION* and *UNGC* exhibit significant influences on *BIODIVERSITY*. Overall, while boards of directors are more influential in the USA sample than in other samples in provoking biodiversity disclosure, the UNGC commitment is influential in all samples. Thus, European and emerging market firms should assume a greater role in environmental sustainability, including biodiversity disclosure. Finally, considering EU Directive 95/2014 (European Directive, 2014), we run an additional analysis, given that the EU Directive obliges large companies of member states to disclose environmental and social issues starting from the fiscal year of 2017 (Doni et al., 2020). Hence, we split the sample into 2002–2016 and

Table 8
Addressing endogeneity (IVPROBIT, Entropy, & PSM).

Panel A: Instrumental Variable PROBIT (IVPROBIT) regression analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	BD_AFFILIATION	BIODIVERSITY	BD_INDEPEND	BIODIVERSITY	BD_GENDER_DIV	BIODIVERSITY	UNGC	BIODIVERSITY	WGI	BIODIVERSITY
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
GOVCOMMITTEE	0.043***(3.704)		3.608***(19.097)		1.106***(7.054)					
$UNGC_{(t-1)}$							0.887***(327.997)			
$WGI_{(t-1)}$									0.868***(260.585)	
BD_AFFILIATION		2.459***(2.838)								
BD_INDEPEND				0.030***(4.366)						
BD_GENDER_DIV						0.098***(3.825)				
UNGC								0.729***(28.036)		
WGI	0.160***(3.272)	0.361*(1.751)	14.244***(18.467)	0.410***(2.930)	−8.316***(−12.994)	1.645***(6.787)	−0.016(−1.215)	0.663***(5.462)		1.290***(9.892)
Controls	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Country, industry, & year FE	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Wald test of exogeneity		18.00***		13.94***		18.04***		47.75***		23.73***
N	45,017	44,989	46,492	46,464	46,492	46,464	37,360	37,343	41,106	41,088
F-stat.	267.115***		1127.320***		370.280***		2130.772***		81324.662***	
χ^2-stat.		6594.849***		11438.815***		9671.612***		9360.847***		10679.695***

Panel B: Entropy balancing

	(1)	(2)	(3)	(4)	(5)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
BD_AFFILIATION_QUAR	0.083***(3.63)				
BD_INDEPEND_QUAR		0.011***(4.12)			
BD_GENDER_DIV_QUAR			0.011***(4.75)		
UNGC				0.96***(21.17)	
WGI	0.70***(2.71)	1.89***(4.85)	2.64***(5.73)	0.84***(2.79)	0.80***(2.73)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Included	Included	Included	Included	Included
N	45,061	46,536	46,536	44,309	44,309
Pseudo R^2	0.332	0.340	0.360	0.264	0.236
χ^2-stat.	4354.94***	4183.30***	5087.96***	3447.54***	2874.55***

Panel C: Propensity Score Matching (PSM)

	(1)	(2)	(3)	(4)	(5)
	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY	BIODIVERSITY
BD_AFFILIATION	0.071***(3.42)				
BD_INDEPEND		0.0089***(3.72)			
BD_GENDER_DIV			0.012***(6.48)		
UNGC				1.09***(22.94)	
WGI	0.39(1.45)	0.86***(2.76)	1.66***(5.22)	1.05***(3.43)	0.97***(3.27)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Included	Included	Included	Included	Included
N	17,590	16,626	20,296	12,214	12,214
Pseudo R^2	0.337	0.324	0.366	0.266	0.233
χ^2-stat.	7571.03	6750.11	9193.61	4493.36	3941.49

Notes: All variables are defined in Appendix A, except for the following. Lagged variables are regular variables denoted with a subscript of *t-1*. *BD_AFFILIATION_QUAR, BD_INDEPEND_QUAR, BD_GENDER_DIV-QUAR* and *WGI_QUAR* coded 1 (treatment group) for the top quartiles of *BD_AFFILIATION, BD_INDEPEND, BD_GENDER_DIV,* and *WGI,* respectively, as treatment groups, and the rest coded 0 as a control group. In Panel A, the IVs are: *GOVCOMMITTEE* is used as the Instrumental variables for the models with *BD_AFFILIATION*, *BD_INDEPEND*, and *BD_GENDER_DIV* testing variables (Column #2, #4, and #6). *GOVCOMMITTEE* (47.15 % exist) is the binary variable showing the existence of corporate governance committee. $UNGC_{(t-1)}$ used as the instrumental variable for the model with *UNGC* testing variable (Column #8). $WGI_{(t-1)}$ used as the instrumental variable for the model with *WGI* testing variable (Column #10). *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9
Heckman's selection.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	BD_AFFILIATION_BIN	BIODIVERSITY	BD_INDEPEND_BIN	BIODIVERSITY	BD_GENDER_DIV_BIN	BIODIVERSITY	UNGC	BIODIVERSITY	WGI_BIN	BIODIVERSITY
	Selection equation 1st stage	Outcome equation 2nd stage	Selection equation 1st stage	Outcome equation 2nd stage	Selection equation 1st stage	Outcome equation 2nd stage	Selection equation 1st stage	Outcome equation 2nd stage	Selection equation 1st stage	Outcome equation 2nd stage
BD_AFFILIATION		0.075***(4.27)								
BD_INDEPEND				0.0086***(8.08)						
BD_GENDER_DIV						0.011***(7.99)				
UNGC								0.57***(7.74)		
WGI	−0.11(−1.32)	1.22***(6.86)	0.40***(4.23)	1.25***(7.16)	−0.46***(−4.92)	1.23***(7.07)	−0.17(−0.85)	1.18***(5.51)		1.80***(3.45)
GOVCOMMITTEE	0.11***(5.09)		0.37***(17.01)		0.13***(6.14)					
$UNGC_{(t-1)}$							3.38***(93.41)			
$WGI_{(t-1)}$									45.6***(38.67)	
IMR1		−0.38**(−2.15)								
IMR2				0.0093(0.07)						
IMR3						−2.25***(−15.08)				
IMR4								−0.32***(−8.45)		
IMR5										−0.077***(−4.39)
Controls	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Country, industry, & year FE	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
N	46,492	44,989	46,492	46,464	46,403	46,403	37,343	37,343	19,354	19,354
Pseudo R^2	0.203	0.327	0.316	0.327	0.285	0.331	0.765	0.328	0.786	0.348
χ^2-stat.	13086.27***	17436.90***	20343.15***	17835.49***	16492.65***	18020.68***	28634.55***	14025.89***	20328.94***	7421.62***

Note: All variables are defined in Appendix A, except the following. Lagged variables are regular variable denoted with a subscript of *t-1*. *BD_AFFILIATION*, *BD_INDEPEND*, *BD_GENDER_DIV*, and *WGI* become the binary dependent variables *BD_AFFILIATION_BIN*, *BD_INDEPEND_BIN*, *BD_GENDER_DIV_BIN*, and *WGI_BIN* coded 1 when equal to or greater than the median of the variable of interest, and 0 otherwise. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. IMR: Inverse Mill's Ratios are calculated for each model separately. Heckman's first stage: Probit model is used by incorporating *UNGC* and the five converted binary variables. Heckman's first stage: GOVCOMMITTEE, $UNGC_{(t-1)}$, and $WGI_{(t-1)}$ are used as instrumental variable for the selection equation.

2017–2021 (i.e. pre- and post-EU Directive) and re-run the models. The coefficients are significantly positive, consistent with the initial findings, for both the pre- and post-EU Directive periods.

7. Summary and conclusion

Despite the growing tendency towards environmental disclosure in the literature, biodiversity disclosure has yet to receive the research attention it deserves. Biodiversity is declining at an alarming rate for many reasons, including land, water, and air pollution. Thus, many stakeholders expect firms to engage with cleaner operational processes to preserve biodiversity and share undertaken practices with biodiversity disclosure. To foster biodiversity engagement and disclosure, we adopt two important mechanisms: internal governance (i.e. board structure) and external governance mechanisms (i.e. UNGC signatory commitment and WGI). Our initial empirical analysis assesses the association between two governance mechanisms and biodiversity disclosure, with a subsequent assessment of the substitutive or complementary role of the two governance mechanisms in spurring biodiversity disclosure.

We find that internal governance (i.e. affiliated, independent, and female directors) and external governance (i.e. the UNGC signatory status and the WGI) spur biodiversity disclosure in firms. Moreover, the UNGC signatory status and board structure are substitutes for driving biodiversity disclosure, whereas public governance and board structure are substitutes or complements or neither in driving biodiversity disclosure, depending on the board attribute type. Further tests reveal that firms affiliated with emerging countries and polluting sectors are positively associated with biodiversity disclosure, while firms domiciled in the USA and Europe are negatively associated with biodiversity disclosure. However, boards of directors in the USA have a stronger positive association with biodiversity disclosure than their counterparts in Europe and emerging markets. Lastly, board attributes are positively associated with biodiversity disclosure in pre- and post-EU Directive 95/2014 sub-samples.

Our observations corroborate the extant literature in many ways. First, the evidence supporting the positive impact of being a UNGC signatory on biodiversity disclosure aligns with the concept of normative isomorphism within institutional theory. Second, the findings regarding the influence of the WGI confirm the role of coercive isomorphism within institutional theory. We note that the findings indicate mixed results confirming either complementary or substitutional role of coercive forces on biodiversity disclosure when interacting with board attributes. Third, the study's findings regarding the role of board characteristics in influencing biodiversity disclosure validate resource dependence theory. The presence of board members with environmental expertise or a strong commitment to sustainability enables firms to better navigate the complexities of biodiversity issues and ensures that they have the necessary knowledge and resources to disclose relevant information. Finally, the interaction effects observed in the study highlight the interplay between resource dependence theory and institutional theory. The interaction between internal governance structures and external institutional pressures, such as the UNGC and WGI, suggests that firms' biodiversity disclosure practices are shaped by a complex dynamic between their internal resource needs and the external pressures.

Our findings have several practical implications. Importantly, we find that both internal governance mechanisms and external pressure encourage firms to care more about their impact on biodiversity, and motivate them to mitigate their impact on the species, native ecosystems, and biodiversity of preserved and sensitive areas. The currently low level of biodiversity disclosure can be improved through the voluntary commitment to the UNGC principles, which advise firms to take a precautionary approach to ecological challenges, undertake greater eco-friendly initiatives, and adopt more eco-friendly technologies. Another way is that affiliated, independent, and female directors might stimulate knowledge spillover across firms, which may help in the transfer of best practices of sustainability disclosure practices. Concerning the interplay between internal governance and UNGC, the findings imply the sufficiency of either reinforcing the internal governance structure or signing UNGC principles in augmenting biodiversity disclosure. Nevertheless, although public governance quality per se encourages firms to undertake biodiversity disclosure, its interaction with director characteristics is not uniform, which suggests researchers should take care when drawing inferences related to the influence of directors.

Our contextual analysis reveals that firms operating in emerging markets and sectors with high environmental impact, such as mining, manufacturing, and energy, show a stronger motivation to engage in biodiversity disclosure. This trend likely stems from legitimacy concerns, as these firms face greater scrutiny from local and global stakeholders regarding their environmental impacts. The contextual analysis underscores the importance of a tailored approach to biodiversity disclosure, in which firms strategically consider their national and sectoral affiliations. Doing so allows them to address legitimacy concerns and capitalize on opportunities to strengthen their sustainability credentials and foster stakeholder trust, ultimately driving long-term value creation.

One limitation of this study lies in the unbalanced nature of the sample, primarily due to the limited availability of comprehensive biodiversity data. Another significant limitation pertains to the binary classification of biodiversity disclosure and UNGC signatory status, stemming from the lack of continuous data in our data sources. Despite these limitations, the study's generalizability is enhanced by using an extensive international sample spanning various sectors and countries. The binary nature of the data for biodiversity disclosure and UNGC signatory status could be addressed in future research through more granular data collection methods, such as manual analysis of sustainability reports within smaller, more focused samples.

Given that biodiversity disclosure remains an emerging area within sustainability reporting, future research could explore how various governance, ownership, and contextual factors, such as national, regional, and sectoral characteristics, influence the likelihood and extent of biodiversity disclosure. Moreover, future research could also investigate the potential effects of biodiversity disclosure on key firm outcomes, such as market performance, accounting performance, and the ability to secure external funding. Such studies would provide critical insights into whether and how biodiversity disclosure translates into tangible benefits for firms, shedding light on how stakeholders, ranging from shareholders and customers to creditors, respond to a company's commitment to biodiversity. Finally, beyond the focus on the private sector, public and non-profit sectorial studies might help capture different facets of the topic and provide insights for better preservation of our planet's biodiversity.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Variables

Dependent variable:		
BIODIVERSITY	Biodiversity disclosure is a binary variable coded 1 for firms reporting their impact on biodiversity to mitigate their impact on the species, native ecosystems, and preserved and sensitive areas, and 0 otherwise.	LSEG*
Independent variables:		
BD_AFFILIATION	Average number of other corporate affiliations for the board members	LSEG
BD_INDEPEND	Percentage of non-executive directors on board	LSEG
BD_GENDER_DIV	Percentage of female directors on board	LSEG
UNGC	A binary variable coded 1 if the company has signed the UNGC, and otherwise 0. The UNGC is a non-binding pact to stimulate sustainable business practices worldwide and to report on such implementations. The UNGC's 7th, 8th, and 9th principles are specifically dedicated to environmental responsibility (UNGC, 2023). Principle 7: Businesses should support a precautionary approach to environmental challenges; Principle 8: undertake initiatives to promote greater environmental responsibility; and Principle 9: encourage the development and diffusion of environmentally friendly technologies.	LSEG
WGI	Worldwide Governance Indicators' average of political stability and absence of violence/terrorism, control of corruption, voice and accountability, government effectiveness, rule of law, and regulatory quality. (Values range from −2.5 to 2.5).	The World Bank
Control variables:		
BSIZE	Number of directors on board	LSEG
CEODUALITY	A binary variable coded 1 if the CEO simultaneously chairs the board, and 0 otherwise.	LSEG
FIRMSIZE	Natural logarithm of total assets	
PROFITABILITY	Income before tax over total assets.	
LEVERAGE	Total debt over total assets	
CRATIO	Current assets over current liabilities	
CAPEXPEND	Capital expenditures over total assets	
RD	Research and development expenditures over total assets	
FFLOAT	Free float percentage of shares tradable by shareholders	LSEG
Alternative control variables:		
FIRMSIZE_Alt	Natural logarithm of the market capitalization	
PROFITABILITY_Alt	Income before interest and tax over total assets	
LEVERAGE_Alt	Total liabilities over total assets	
CAPEXPEND_Alt	Capital expenditures over net sales	
RD_Alt	Research and development expenditures over net sales	
Instrumental variable:		
GOVCOMMITTEE	A binary variable coded 1 if firm has a corporate governance committee, and 0 otherwise.	LSEG

*The London Stock Exchange Group (LSEG) Workspace database (formerly known Thomson Reuters Eikon/Refinitiv database).

Appendix B. . Country level sample distribution

	Country	Unique firms	Percent	Data points	Percent
1	Argentina	45	0.65	120	0.26
2	Australia	318	4.57	2,442	5.24
3	Austria	26	0.37	173	0.37
4	Belgium	40	0.58	267	0.57
5	Bermuda	28	0.40	64	0.14
6	Brazil	93	1.34	651	1.40
7	Canada	351	5.05	2,488	5.34
8	Chile	35	0.50	250	0.54
9	China	466	6.70	1,641	3.52
10	Colombia	14	0.20	83	0.18
11	Denmark	44	0.63	363	0.78
12	Finland	49	0.70	386	0.83
13	France	146	2.10	1,250	2.68
14	Germany	166	2.39	1,083	2.33
15	Greece	22	0.32	163	0.35
16	Hong Kong	126	1.81	1,096	2.35
17	India	128	1.84	883	1.90
18	Indonesia	40	0.58	268	0.58
19	Ireland, Republic of	45	0.65	427	0.92
20	Israel	30	0.43	139	0.30
21	Italy	69	0.99	386	0.83
22	Japan	412	5.92	4,760	10.22
23	Korea, Republic (S. Korea)	129	1.85	939	2.02
24	Luxembourg	31	0.45	111	0.24
25	Malaysia	54	0.78	427	0.92
26	Mexico	43	0.62	322	0.69
27	Netherlands	58	0.83	458	0.98
28	New Zealand	50	0.72	299	0.64
29	Norway	55	0.79	285	0.61
30	Peru	26	0.37	112	0.24
31	Philippines	23	0.33	179	0.38
32	Poland	25	0.36	176	0.38
33	Portugal	13	0.19	96	0.21
34	Qatar	13	0.19	28	0.06

(continued on next page)

(*continued*)

	Country	Unique firms	Percent	Data points	Percent
35	Russia	36	0.52	332	0.71
36	Saudi Arabia	19	0.27	61	0.13
37	Singapore	61	0.88	451	0.97
38	South Africa	99	1.42	770	1.65
39	Spain	63	0.91	541	1.16
40	Sweden	148	2.13	718	1.54
41	Switzerland	127	1.83	869	1.87
42	Taiwan	131	1.88	1,028	2.21
43	Thailand	75	1.08	309	0.66
44	Turkey	48	0.69	208	0.45
45	United Arab Emirates	10	0.14	29	0.06
46	United Kingdom	383	5.51	3,444	7.40
47	United States of America	2,543	36.56	14,989	32.19
	Total	*6,956*	*100.00*	*46,564*	*100.00*

Data availability

The authors do not have permission to share data.

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