emerald PUBLISHING

ISSN 2754-1312
eISSN: 2754-1320
Volume 00 Number 00 2021

Journal of
Accounting Literature

# Understanding the relation between climate change risks and biodiversity disclosures: An international analysis

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| Journal: | *Journal of Accounting Literature* |
| Manuscript ID | JAL-04-2024-0072.R1 |

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| Manuscript Type: | Research Paper |
| Keywords: | Biodiversity disclosures, Climate change risks, Carbon emissions, Waste generation, Sustainable development, Cross-country |
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# Understanding the relation between climate change risks and biodiversity disclosures: An international analysis


## Abstract

### Purpose

This study explores the relation between firm-level climate change risks, measured by carbon emissions and waste generation, and the level of biodiversity disclosures.

### Design/methodology/approach

Drawing on an international sample from 2009 to 2021, our study employs panel regression models to assess the effects of climate change risks on biodiversity disclosures. We also conduct a range of sensitivity analyses, including additional proxies, endogeneity tests, and alternative samples to examine the robustness of our inferences.

### Findings

We find that firms with higher carbon emissions and waste generation levels tend to disclose extensive biodiversity information. Furthermore, we provide evidence that the disaggregated components of carbon (Scope 1 and 2) emissions and waste (hazardous and non-hazardous) generation volumes are positively associated with biodiversity disclosures. Our results also reveal that the effects of climate change risks on biodiversity disclosures are stronger for firms from environmentally sensitive industries. Finally, our results show that climate and biodiversity protection regulations appear to be effective in limiting legitimation efforts.

### Originality/value

Consistent with legitimacy theory, our findings suggest that high carbon and waste emitting firms tend to utilize increased biodiversity disclosures as a legitimizing tool to conform to societal expectations and protect their legitimacy.


**Keywords:** Biodiversity disclosures; Climate change risks; Carbon emissions; Waste generation, Sustainable development, Cross-country

## 1. Introduction

Along with global warming and climate change, biodiversity loss has been recognized as the most challenging and rapidly increasing threat to the planet, which is currently experiencing the sixth wave of mass species extinction (Adler *et al.*, 2018; Atkins and Maroun, 2018; Roberts *et al.*, 2021). Given that modern businesses and biodiversity systems have reciprocal relationships, including the impacts of business activities on biodiversity and the subsequent effects of deteriorating biodiversity on corporate sustainability (Boiral and Heras-Saizarbitoria, 2017; Hassan *et al.*, 2020), preserving biodiversity and ecosystems enables businesses to identify ecological risks/threats, enhance stakeholder relationships, and improve sustainability (Haque and Jones, 2020; Treepongkaruna, 2024). Therefore, global organizations whose survival and sustainability are dependent on critical ecosystems' services should treat biodiversity and species as their primary stakeholders (Roberts *et al.*, 2021).

There is a growing interest in an emerging body of biodiversity research, especially with regard to corporate accountability towards biodiversity conservation and reporting (Atkins and Maroun, 2018; Gaia and Jones, 2017). However, the majority of prior studies have been mostly qualitative and mainly focused on assessing biodiversity models (Siddiqui, 2013), analyzing biodiversity management (Boiral and Heras-Saizarbitoria, 2017), and exploring changes in biodiversity (Atkins and Maroun, 2020). Few empirical studies have explored whether biodiversity partnerships (Adler *et al*., 2018; Hassan *et al*., 2020), environmental NGOs (Gaia and Jones, 2020), and board gender diversity (Carvajal *et al.*, 2022; Haque and Jones, 2020) influence biodiversity reporting. While past research (Ding *et al.*, 2023; Giannarakis *et al.*, 2017) has explored the impacts of corporate carbon/environmental performance on other forms of environmental disclosures, it is still unclear how firm-level climate change risks (CCRs) influence biodiversity disclosures (BIODSL). This study, therefore, examines the effects of CCRs on BIODSL.

Meanwhile growing concerns over the rapidly increasing biodiversity crisis have led the global regulators and policymakers to undertake environmental initiatives/reforms aiming to protect biodiversity and ecosystems (Adler *et al.*, 2018; Gaia and Jones, 2017). For example, the United Nations (UN) introduced the Paris Agreement in 2015 to prevent the global temperature increase and achieve carbon neutrality worldwide by 2050 (Bilal *et al.*, 2024; Luo and Tang, 2021). In addition, the UN adopted the Convention on Biological Diversity (CBD) in 1992 at the Rio Earth

Summit. Ratified by all UN members except the USA, the CBD is considered one of the main global efforts to combat climate change, halt biodiversity loss, and restore ecosystems (CBD, 2020). Although corporate environmental disclosures are a function of global climate change initiatives and environmental regulatory frameworks of the country in which a firm operates (Luo, 2019; Tauringana and Chithambo, 2015), the efficacy of such initiatives in improving corporate accountability with regard to biodiversity preservation and associated disclosures has not been adequately undertaken in previous studies.

Past research (Bui *et al.*, 2020; Ding *et al.*, 2023; Giannarakis *et al.*, 2017; Luo, 2019) examining the link between climate change performance and disclosures has offered two opposing viewpoints. From the legitimacy theory perspective, one stream of literature (Cho and Patten, 2007; Luo, 2019) suggests that firms with inferior carbon/environmental performance are exposed to increased stakeholder demands/pressures, and therefore issue more environmental disclosures to protect reputation/legitimacy. Consistent with signaling theory, another stream of literature (Bui *et al.*, 2020; Giannarakis *et al.*, 2017) argues that firms with better carbon/environmental performance provide extensive environmental information to signal their superior performance. However, these/past studies have primarily focused on the environmental performance–disclosures link, and there are no systematic studies within the biodiversity accounting literature that may explain the impacts of *CCRs* on *BIODSL*. Moreover, few related studies (Gaia and Jones, 2020; Haque and Jones, 2020) assessing biodiversity reporting practices have mainly focused on particular countries (e.g., the UK) or regions (e.g., Europe).

Therefore, drawing on global firms over the period 2009-2021, our study explores the effects of *CCRs* in terms of excessive carbon emissions and waste production volumes on the levels of *BIODSL* in a multi-country setting. Consistent with legitimacy theory, we find that firms with higher *CCRs* tend to issue more *BIODSL*. We also reveal that the disaggregated components of carbon (Scope 1 and 2) emissions and waste (hazardous and non-hazardous) levels increase *BIODSL*. Our analysis further shows that the positive effects of *CCRs* on *BIODSL* are stronger for firms from environmentally sensitive industries. Finally, our results demonstrate the effectiveness of global climate and biodiversity protection initiatives, such as the Paris Agreement and the CBD, in limiting corporate engagement in legitimation practices.

Our study contributes to the existing literature in a number of ways. First, our study extends the climate and biodiversity accounting literature (Carvajal *et al.*, 2022; Ding *et al.*, 2023; Haque and Jones, 2020) by examining whether *CCRs* influence *BIODSL*. Unlike past studies, which have mainly focused on process-based environmental scores, our study employs actual volumes of both carbon emissions and waste generation, which are comprehensive and relevant proxies for *CCRs*. Although corporate carbon is an important dimension of climate change performance (Luo, 2019), waste generation is another unique dimension and objective reflection of *CCRs* (Gull *et al.*, 2024). As noted by Gull *et al.* (2024), broad environmental performance indicators used in prior research have limitations due to subjective measurements and different estimation methods. We also construct the unique *BIODSL* index based on comprehensive biodiversity protection reporting indicators. Using objective and relevant proxies, we thus provide novel evidence on the *CCRs*–*BIODSL* link from a multi-country perspective. Our findings suggest that firms with increased carbon emissions and waste generation levels disclose extensive biodiversity-related information to protect their legitimacy/reputation.

Second, our study contributes to the biodiversity accounting literature (Carvajal *et al.*, 2022; Haque and Jones, 2020; Treepongkaruna, 2024) by analyzing the moderating effect of environmentally sensitive industries on the *CCRs*–*BIODSL* nexus. Prior literature (Luo, 2019; Orazalin *et al.*, 2024) argues that carbon/environmental performance may influence voluntary disclosures depending on institutional factors and regulatory contexts. Our findings offer new evidence that firms from environmentally sensitive industries disclose more biodiversity-related disclosures to respond to increased stakeholder pressures/demands for environmental accountability and protect legitimacy.

Finally, our study complements past research (Ding *et al.*, 2023; Orazalin *et al.*, 2024) by exploring how climate and biodiversity protection regulations, such as the Paris Agreement and the CBD, affect *CCRs* and *BIODSL*. While prior investigations (Freedman and Jaggi, 2011; Orazalin *et al.*, 2024) have mainly focused on specific environmental initiatives (e.g., the Kyoto Protocol), empirical evidence on the effects of the Paris Agreement and the *CBD* on corporate accountability and practices associated with biodiversity conservation is almost non-existent. Our findings suggest that both the Paris Agreement and the CBD are effective in limiting legitimation efforts, thus supporting the view that global environmental regulations may enhance corporate accountability towards climate mitigation (Haque and Ntim, 2020; Tauringana and Chithambo, 2015).

## 2. Literature review and hypothesis development

Prior empirical studies (Bui *et al.*, 2020; Cho and Patten, 2007; Clarkson *et al.*, 2008; Ding *et al.*, 2023; Giannarakis *et al.*, 2017; Luo, 2019; Siddique *et al.*, 2021) on the environmental performance–disclosure link have predominantly applied signaling and legitimacy theories. Signaling theory posits that businesses are likely to differentiate themselves by disclosing more information about their qualities and strengths in order to reduce information asymmetry and achieve a competitive advantage (Bui *et al.*, 2020; Del Gesso and Lodhi, 2024). Under this perspective, firms with superior climate change performance may use extensive environmental disclosures to signal to the market about their climate mitigation activities/practices and performance (Giannarakis *et al.*, 2017; Siddique *et al.*, 2021). Therefore, signaling theory predicts a negative association between *CCRs* and *BIODSL*, suggesting that firms with lower levels of carbon and waste are likely to disclose more information on their efforts to protect biodiversity.

By contrast, legitimacy theory (Deegan, 2002; Suchman, 1995) suggests that firms exposed to heightened stakeholder pressures/demands tend to issue extensive environmental information to protect reputation/legitimacy. High-polluting firms without effective climate mitigation activities/initiatives are generally perceived as socially irresponsible, and therefore face more rigorous environmental regulations, greater stakeholder pressures, and higher legitimacy risks (Bilal *et al.*, 2024; Luo, 2019). To protect legitimacy, such firms may engage in responsive strategies/reforms to show that they operate within the bounds of appropriate social behavior (Deegan and Rankin, 1997) and their activities are proper, desirable, and useful (Suchman, 1995). In this regard, extensive environmental disclosures may help high-polluting firms maintain legitimacy, protect reputation, and mitigate business risks (Cho and Patten, 2007; Ding *et al.*, 2023). Nevertheless, such increased disclosures are viewed as a means of protecting image and legitimacy, and therefore, do not reflect actual sustainability performance (Soobaroyen and Ntim, 2013). Thus, in light of biodiversity crisis, legitimacy theory predicts a positive association between *CCRs* and *BIODSL*, indicating that firms with higher levels of carbon and waste disclose more biodiversity-related information to protect/maintain legitimacy.

Empirical studies exploring the association between environmental/carbon performance and disclosures have yielded mixed results (Bui *et al.*, 2020; Clarkson *et al.*, 2008; Dawkins and Fraas, 2011; Giannarakis *et al.*, 2017; Luo and Tang, 2014; Qian and Schaltegger, 2017; Siddique *et al.*, 2021). For example, among others, Bui *et al*. (2020) report a negative nexus between carbon emissions and disclosures, thus supporting the notion that firms disclose more carbon-related information to highlight their superior performance and differentiate themselves in the market, consistent with signaling theory. In contrast, Ding *et al.* (2023) document that high-polluting firms facing stakeholder pressures increase carbon disclosures to manage stakeholders' expectations and ultimately mitigate legitimacy risks. Other studies (Cho and Patten, 2007; Luo, 2019) have also revealed that poor climate change performance drives carbon/environmental disclosures, in line with legitimacy theory. However, and indicated before, none of the previous studies has examined the effects of *CCRs* on *BIODSL*. Thus, based on legitimacy and signaling theories, as well as the conflicting findings of past studies, we propose the following two contradictory hypotheses:

***H1a***: Carbon emissions and waste generation levels are negatively associated with the level of biodiversity disclosures, consistent with signaling theory.

***H1b***: Carbon emissions and waste generation levels are positively associated with the level of biodiversity disclosures, consistent with legitimacy theory.

## 3. Data and methodology

### *3.1. Sample and data*

Our study focuses on all global firms with necessary data to construct the *BIODSL* index. Unlike previous biodiversity-related studies (Adler *et al.*, 2018; Carvajal *et al.*, 2022; Haque and Jones, 2020), our work seeks to analyze a relatively large sample of firms originating from multiple industries and countries. We collected data from several sources. First, we obtained data on biodiversity indicators, carbon emissions, waste generation levels, and internal governance from ASSET4 ESG. Second, we collected data on accounting and financial controls from the

Worldscope database. Finally, we downloaded macroeconomic statistics, including GDP and inflation rates from the World Bank's database (World Bank, 2022).

The initial sample consisted of 13,933 firm-years from 45 countries from 2009 to 2021.[1] The sample was reduced by 5,809 firm-years without carbon, waste, and biodiversity data. Then, 498 firm-years were removed due to missing data on the control variables. Hence, our final sample consists of 7,626 firm-years from 892 firms operating in 10 industries and 44 countries from 2009 to 2021.[2] Appendix A reports the sample distributions by country (Panel A) and industry (Panel B). As shown in Panel A, the United States and the United Kingdom are the most represented countries, accounting for 17.22% (1,313 firm-years) and 13.59% (1,036 firm-years) of the sample, respectively. The remaining 5,277 firm-years (69.19%) are represented by other countries. Further, Panel B shows that the sample is based on 10 different industries, with the industrials representing the largest proportion of the sample (24.10%), followed by consumer discretionary (15.47%) and consumer staples (10.65%).

### *3.2. Measurement of biodiversity disclosures*

We developed the *BIODSL* index based on environmental data from Asset4 ESG, following three main steps. First, we reviewed related studies (Adler *et al.*, 2018; Haque and Jones, 2020; Maroun and Atkins, 2018) to source relevant biodiversity disclosures. Second, we referred to the *GRI* reporting guidelines to determine pertinent biodiversity protection indicators. Third, we performed an in-depth analysis of all environmental categories provided by ASSET4 ESG to identify biodiversity-related reporting indicators. Consequently, we detected nine specific biodiversity-related indicators. They are biodiversity loss reduction, sulfur and nitrogen oxides emissions reduction, waste reduction, e-waste reduction, toxic chemicals and substances reduction, environmental restoration, eco-designed products/processes, environmental innovation/product impacts minimization, and land environmental impact reduction. Related research (Atkins and Maroun, 2018; Haque and Jones, 2020) suggests that firms should disclose the impacts of their

[1]The dataset starts from 2009 because the majority of firms did not disclose biodiversity-related information prior to this year.
[2]To mitigate the effects of potential outliers, we winsorized all the continuous variables at the 1st and 99th percentiles.

business activities at the ecosystem and planet levels by performing a broader assessment of local and global ecosystems. Therefore, we used these reporting indicators to develop the *BIODSL* index because they better reflect firms' impacts on biodiversity and threatened species, along with other corporate initiatives/actions aimed at enhancing the positive impacts and mitigating the adverse effects of their business operations on the environment. A value of one was assigned if an indicator is disclosed and zero was assigned if that indicator is not disclosed. We then added all the indicators to obtain the overall disclosure score. This measurement approach is similar to previous studies assessing voluntary disclosures (Orazalin *et al.*, 2024).[3] Finally, we calculated the *BIODSL* index for each firm by comparing its reporting items to those of other firms from the same industry. Therefore, the index adjusted within each industry ranges between 0% and 100%, where larger values indicate higher levels of *BIODSL*.

### *3.3. Measurement of climate change risks*

Corporate carbon emissions and waste generation levels are the major and most significant causes of climate change, and therefore their actual levels are recognized as objective and relevant proxies for assessing corporate climate-related risks (Gull *et al.*, 2024; Luo, 2019; Luo and Tang, 2021). Thus, we measure *CCRs* based on corporate carbon and waste generation data from Asset4 ESG. Consistent with related research (Orazalin *et al.*, 2024; Uyar *et al.*, 2023), we evaluate firm-level carbon emissions (*CARBON*) as the natural logarithm of total carbon (both Scope 1 and 2) emissions[4] and assess waste generation (*WASTE*) as the natural logarithm of total waste (both hazardous and non-hazardous) production. These proxies reflect a firm's climate risks and its actual environmental impacts in the form of carbon emissions and waste levels and enable to assess whether a firm has managed to reduce its carbon and waste levels compared to its past outcomes and industry peers (Luo and Tang, 2021). As such, lower values of *CARBON* and *WASTE* indicate

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[3]To ensure the internal consistency of the score, we estimated the Cronbach's alpha. The estimated value is higher than the minimum threshold value of 0.700, thus confirming the reliability and validity of the score.

[4]Scope 1 emissions are direct emissions from sources controlled/owned by a firm, whereas Scope 2 emissions are indirect ones from sources not controlled/owned by a firm. Since Scope 3 emissions (another form of indirect emissions) are missing for the majority of firms, we did not include them in our study.

lower climate risks and better climate change performance relative to the firm's prior years and its industry benchmarks in a current year.

*3.4. Control variables*

Prior empirical studies (Bui *et al.*, 2020; Carvajal *et al.*, 2022; Clarkson *et al.*, 2008; Ding *et al.*, 2023; Giannarakis *et al.*, 2017; Haque and Jones, 2020; Hassan *et al.*, 2020; Luo, 2019; Orazalin and Mahmood, 2018; Tauringana and Chithambo, 2015; Treepongkaruna, 2024) have shown that there are certain firm-specific and country-level characteristics that may affect environmental disclosures. In particular, we control firm-specific characteristics, including corporate governance (*CGOVR*), firm size (*FSIZE*), profitability (*FPROF*), financial risk (*FLVRG*), slack (*FSLACK*), and capital intensity (*CAPEX*) as potential drivers of biodiversity information. In addition, we control the country-level variables, such as inflation rates (*INFLN*) and *GDP* growth (*GDPGR*). The descriptions/measurements of the variables are summarized in Appendix B.

*3.5. Empirical model*

We employ the following models to test the impacts of *CCRs* on *BIODSL*:

$$BIODSL=\beta_0+\beta_1 CARBON+\beta_2 Controls+country,\ industry,\ and\ year\ fixed\ effects+\ \varepsilon \quad (1)$$

$$BIODSL=\beta_0+\beta_1 WASTE+\beta_2 Controls+country,\ industry,\ and\ year\ fixed\ effects+\ \varepsilon \quad (2)$$

where, *BIODSL* represents biodiversity disclosures, *CARBON* represents carbon emissions, *WASTE* represents waste generation, *Controls* represent the firm and country-level variables discussed above, and ε represents the error term. To account for systematic variations in the main variables across periods, industries, and countries, we also included year, industry, and country fixed effects.

## 4. Results and discussion

### *4.1. Descriptive analysis*

Table 1 reports the descriptive statistics of the variables for the whole sample period spanning from 2009 to 2021. The *BIODSL* index has a mean of 50.00% and varies between 0.11% and 99.92%. The mean *CARBON* and *WASTE* are 13.03 and 11.17, respectively and these values are generally consistent with those of past research (Gull *et al.*, 2024; Orazalin *et al.*, 2024). Regarding the corporate governance variable, *CGOVQ* has a mean of 62.89. Finally, the mean values of *FSIZE*, *FPROF*, *FLVRG*, *FSLCK*, *CAPEX*, *INFLN*, and *GDPRG* are 16.18, 7.75%, 29.07%, 0.03, 0.05, 1.94%, and 1.63%, respectively.

Table 2 presents correlation measures among the variables. The coefficients show that *CARBON* and *WASTE* are positively correlated with *BIODSL*, thus providing preliminary evidence that firms with higher levels of carbon emissions and waste are more likely to issue extensive biodiversity information. The matrix also shows that the coefficients among the independent variables do not exceed a maximum threshold value of 0.80, indicating that serious multicollinearity is not expected.[5]

### *4.2. Regression results*

Table 3 reports the regression results of the effects of *CARBON* and *WASTE* on *BIODSL*. As shown in Column (1), *CARBON* is significantly and positively related to *BIODSL*, supporting *H1b*. This evidence indicates that high-polluting firms issue extensive biodiversity-related information, consistent with the legitimacy viewpoint. Similarly, Column (2) specifies that the coefficient of *WASTE* is significant and positive, implying that higher waste levels may lead to more biodiversity-related information. This evidence validates *H1b* and suggests that firms with increased levels of waste tend to issue extensive biodiversity-related information. It is evident from the coefficients that a one-unit increase in *CARBON* leads to a 1.523 percentage point increase in

[5]The last column (*VIF*) of the matrix also shows that none of the variance inflation factors exceeds 3.00, thus verifying the absence of multicollinearity.

*BIODSL*, whereas a one-unit increase in *WASTE* leads to a 1.714 percentage point increase. More specifically, an increase in one standard deviation of carbon emissions (in Table 1) increases the level of biodiversity disclosures by about 12.58% [(*CARBON*)2.34*1.523/(*BIODSL*)28.31], while an increase in one standard deviation of waste generation increases disclosures by 16.59% [(*WASTE*)2.74*1.714/(*BIODSL*)28.31], thus indicating that the results are also economically significant. Overall, the results in Table 3 support the notion that poor environmental performers have incentives to increase climate-related disclosures in order to protect their legitimacy and maintain support from stakeholders (Cho and Patten, 2007; Luo, 2019). These findings are also consistent with recent research (Ding *et al.*, 2023; Orazalin *et al.*, 2024) that poor climate change performance drives environmental initiatives and disclosures. Theoretically, these results are in line with legitimacy theory (Deegan, 2002; Deegan and Rankin, 1997; Suchman, 1995) and suggest that firms exposed to greater *CCRs* are likely to utilize increased *BIODSL* as a tool of legitimacy to conform to societal expectations, protect reputation, and enhance/maintain legitimacy.

To test the effects of specific components of *CCRs*, we further utilize the disaggregated components of carbon emissions in terms of Scope 1 (*CARB_SC1*) and Scope 2 (*CARB_SC2*) and the disaggregated components of waste generation in terms of hazardous (*WAST_HAZ*) and non-hazardous (*WAST_NHAZ*) waste. To measure these variables, we take the natural logarithm of the disaggregated components, consistent with our *CARBON* and *WASTE* measures. Table 4 shows that *CARB_SC1* and *CARB_SC2* are positively connected to *BIOSCL*, implying that both Scope 1 and 2 emissions drive biodiversity-related information. Similarly, the coefficients of *WAST_HAZ* and *WAST_NHAZ* are positive and significant, indicating that firms generating higher levels of both hazardous and non-hazardous waste issue more biodiversity-related information. Overall, the results in Table 4 support legitimacy theory and verify that firms with higher *CCRs*, i.e., those with higher levels of emissions and waste disclose extensive biodiversity-related information.

For the control variables, *CGOVR* is positively associated with *BIODSL*, thus indicating that improved corporate governance leads to extensive biodiversity disclosures. Further, *FSIZE* is statistically positive with *BIODSL*, supporting the argument that large firms facing greater stakeholder pressures/demands for environmental transparency disclose more environmental information (Haque and Jones, 2020). Similarly, the coefficients of *FSLCK* and *CAPEX* are positive, verifying that increased financial slack and capital expenditures may lead to extensive environmental information. Finally, *FLVRG* is negatively associated with *BIODSL*, supporting the argument that highly leveraged firms are less likely to demonstrate greater commitment to climate change initiatives and environmental reporting practices due to their focus on operating activities and short-terms debts (Haque and Jones, 2020). The coefficients for other control variables are insignificant.

### *4.3. Robustness tests*

We conduct a range of sensitivity analyses to examine the robustness of our inferences. First, we employ alternative proxies for *BIODSL*, *CARBON*, and *WASTE*. In particular, following related research (Issa and Zaid, 2023; Treepongkaruna, 2024), we use the ASSET4 ESG's biodiversity protection disclosure score (*BIOSCR*), which reflects a firm's biodiversity reporting practices to protect biodiversity and species and reduce its impacts on the ecosystems. Further, we utilize two carbon intensity variables, measured as the ratio of total carbon emissions to total assets (*CARAST*) and the ratio of total carbon emissions to revenues (*CARREV*). Using the same approach, we estimate two measures of waste generation, calculated as the ratio of total waste production volumes to total assets (*WASAST*) and the ratio of total waste to revenues (*WASREV*).[6] As reported in Table 5, *CARBON* and *WASTE* have a positive association with *BIOSCR*, while *CARAST*, *CARREV*, *WASAST*, and *WASREV* are positively related to *BIODSL*, thus verifying that corporate climate risks increase biodiversity-related information.

Second, to address potential endogeneity that may arise from omitted variables, we use a two-stage least squares (*2SLS*) approach. Following past research (Gull *et al.*, 2024; Orazalin *et al.*, 2024), we utilize two instrumental variables: (1) the median values of *CCRs* (*CARBON_HEAD* and *WASTE_HEAD*) at the firm's headquarters and (2) their mean values (*CARBON_IND* and *WASTE_IND*) within the industry. While these instruments are likely to influence *CCRs*, they are less likely to correlate with *BIODSL*.[7] As reported in Table 6, the coefficients of *CARBON* and

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[6]These alternative proxies have been widely utilized in past investigations (Gull *et al.*, 2024; Uyar *et al.*, 2023).

[7]The first-stage results, Cragg-Donald Wald F-statistics, Kleibergen-Paap rk LM statistics, and Stock-Yogo critical values demonstrate the relevance and validity of our instrumental variables.

*WASTE* are significant and positive, indicating that the original models and main results do not suffer from omitted variables bias.

Third, we conduct a two-stage Heckman (Heckman, 1979) procedure to address potential sample selection issues. Since this analysis requires the identification of a proper exclusion restriction in the first stage, we use the industry averages of *CARBON* (*CARBON_IND*) and *WASTE* (*WASTE_IND*) as exclusion restrictions. In the first stages, the dependent variables are *CAR_DUM* and *WAS_DUM*, which are coded one if the *CARBON* and *WASTE* variables exceed the median values, and zero otherwise. Further, the Mills ratios are estimated based on the parameters in the first stages and then included as additional variables in the second stage regressions. The results in Table 7 are generally consistent with the main results, confirming that the inferences are robust to sample selection bias.

Fourth, we regress *BIODSL* on the first and second lagged explanatory variables. Although carbon emissions and waste generation are likely to affect biodiversity reporting, it is possible that firms with increased *BIODSL* may have higher *CCRs*, causing a reverse causality in this nexus. Using the lagged independent variables mitigates serious reverse causality problems in the baseline model (Uyar *et al.*, 2023), as *CCRs* in the preceding year are unlikely to be affected by *BIODSL* of the current year. As shown in Table 8, the first and second lag values of *CARBON* ($CARBON_{t-1}$, and $CARBON_{t-2}$) exhibit a positive association with *BIODSL*. Similarly, the first and second lags of *WASTE* ($WASTE_{t-1}$, and $WASTE_{t-2}$) are positively related to *BIODSL*. Overall, these estimates verify that the main findings are less likely to be determined by reverse causality concerns.

Finally, we re-estimate our analysis by excluding US and UK firm-years from the sample. Appendix A shows that the US accounts for 17.22% of the firm-years, while the UK accounts for 13.59%. Because these two dominant economies may drive our results, we generate separate sub-samples and repeat our analysis. As shown in Table 9, we first exclude US firms in Columns (1-2), then UK firms in Columns (3-4), and then both US and UK firms in Columns (5-6). The results demonstrate that the effects of *CARBON* and *WASTE* on *BIODSL* are still significant and positive. Overall, this analysis suggests that our main findings are not affected by the alternative samples.

*4.4. Additional analyses*

In this section, we conduct additional analyses to explore the effects of industry and regulatory factors on *CCRs* and *BIODSL*. In particular, we assess whether the link between *CCRs* and *BIODSL* differs between environmentally sensitive and non-sensitive firms. Available research (Boiral and Heras-Saizarbitoria, 2017; Orazalin et al., 2024) argues that firms in sensitive industries face more stringent regulations and higher stakeholder pressures due to their negative impacts on the environment, and therefore differ from those in non-sensitive industries in terms of their responses to climate change and reporting behavior. Thus, following Shrestha et al. (2023), we classify the energy, materials, and utilities industries as environmentally sensitive and all other industries as non-sensitive industries. We then test the moderating effect of the sensitive industries (*INDUM*), which equals to one if a firm is from an environmental sensitive industry, and zero otherwise. As reported in Columns (1) and (2) of Table 10, the interaction terms *CARBON*INDUM* and *WASTE*INDUM* are significantly positive with *BIODSL*. These results align with the legitimacy view and suggest that firms from sensitive industries disclose more biodiversity-related information to respond to increased stakeholder pressures/demands and protect legitimacy.

Further, we examine how the Paris Agreement influences the link between *CCRs* and *BIODSL*. Prior literature (Luo, 2019; Shrestha *et al.*, 2023) suggests that environmental disclosures are a function of global environmental initiatives/reforms and regulations of the country in which a firm operates. Specifically, firms facing rigorous climate regulations reflect their reactions through environmental disclosures (Tauringana and Chithambo, 2015). Thus, we create the *PARIS* variable, which equals to one if a firm-year is from 2016 and onwards, and zero otherwise. Columns (3) and (4) of Table 10 display that the interactions *CARBON*PARIS* and *WASTE*PARIS* are significant and negative, indicating that the effects of *CARBON* and *WASTE* are weaker after the introduction of the Agreement. These results support the viewpoint that global climate regulations are effective in restricting legitimation efforts (Luo, 2019).

Finally, we test the moderating effect of the *CBD* on the *CCRs–BIODSL* link. As mentioned before, the USA is the only country that declined to ratify the *CBD*. Arguably, this is an interesting context to test whether the effects of *CCRs* on *BIODSL* differ between ratifying and non-ratifying nations. Thus, we introduce the *CBD* variable, which equals to one if firm-years belong to the UN members that ratified the *CBD*, and zero otherwise. Columns (5) and (6) of Table 10 show that although the interaction *WASTE*CBD* is negative and insignificant, the coefficient of *CARBON*CBD* is negatively significant, indicating that the effects of *CCRs* on *BIODSL* are weaker for firms from the ratifying countries. These results indicate that firms with higher *CCRs* from the ratifying nations are less inclined to utilize increased *BIODSL* as a legitimizing tool, thus demonstrating the effectiveness of global environmental regulations, such as the *CBD*, in limiting corporate engagement in symbolic efforts/practices.

## 5. Conclusion

This study examines whether climate change risks in terms of increased carbon emissions and waste generation levels influence biodiversity disclosures. Focusing on global firms over the period from 2009 to 2021, our results support legitimacy theory (Deegan, 2002; Suchman, 1995) and suggest that firms with higher levels of carbon and waste disclose extensive biodiversity information. Furthermore, the disaggregated components of carbon (Scope 1 and 2 emissions) and waste (hazardous and non-hazardous waste) also drive biodiversity disclosures. The results also demonstrate that the effects of climate risks on biodiversity disclosure are stronger for firms from environmentally sensitive industries, suggesting that industry-related factors/regulations have an impact on corporate incentives to utilize extensive biodiversity reporting as a legitimizing tool to conform to societal expectations and protect reputation/legitimacy (Ding *et al.*, 2023; Luo, 2019; Orazalin *et al.*, 2024). Finally, the results reveal that global biodiversity protection initiatives, namely the Paris agreement and the CBD, appear to be more effective in limiting corporate engagement in utilizing increased biodiversity disclosures as a legitimizing tool. Overall, our findings offer economically significant evidence that firms' climate change risks in terms of excessive carbon emissions and waste production lead to higher biodiversity disclosure levels.

This work offers a number of important theoretical, policy, and practical implications. In particular, our results verify the legitimacy theory's (Deegan, 2002; Suchman, 1995) proposition that firms facing increased stakeholder pressure/demands disclose more environmental information in order to achieve social recognition and protect reputation/legitimacy. Although past studies (Cho and Patten, 2007; Ding *et al.*, 2023; Luo, 2019) have applied this theoretical approach to explore the environmental performance–disclosure link, our study provides novel evidence that high carbon and waste emitting firms may utilize extensive biodiversity disclosures as a legitimizing tool to maintain legitimacy, protect reputation, and mitigate business risks. With regard to policy implications, our results further suggest that regulators should design explicit initiatives and guidelines to monitor, regulate, and rate firm-level climate change risks and disclosure practices and report to all stakeholders accordingly. Furthermore, policymakers and regulators can promote biodiversity reporting by enhancing alignment among climate-related reforms, reporting guidelines, and environmental policies for sustainable development, and biodiversity conservation initiatives at the national and global levels. Policymakers also need to enact enforceable regulations with verifiable targets for carbon emissions, waste generation, and biodiversity conservation, especially in weakly regulated environmental settings. Our findings also suggest that financial analysts and investors should assess not only environmental transparency, but also corporate climate risks to make informed investment decisions. Finally, board members and managers should refrain from issuing biodiversity disclosures that do not reflect actual and verifiable corporate efforts/practices and performance.

Our study is subject to some limitations. For example, we focus on large firms, and as such, the observed relationships cannot be generalized to small and medium-sized firms. Hence, future research could extend our study by analyzing smaller firms. Furthermore, we explore the effects of carbon emissions and waste production on biodiversity disclosures. Future research, therefore, could consider other firm-specific and external factors that may influence disclosures. In addition, the indicators for measuring biodiversity disclosures, although used in prior research (Haque and Jones, 2020), assess the quantity rather than the quality of disclosures. Therefore, future research could shed further light on biodiversity transparency by employing alternative proxies. Nevertheless, despite these limitations, our work offers new insights into the relation between climate change risks and biodiversity disclosures.

**Declaration of interest:**

The authors declare that they have no conflict of interest.

**References**

Adler, R., Mansi, M. and Pandey, R. (2018), “Biodiversity and threatened species reporting by the top Fortune Global companies”, *Accounting, Auditing and Accountability Journal*, Vol. 31 No. 3, pp. 787–825, doi: 10.1108/AAAJ-03-2016-2490.

Atkins, J. and Maroun, W. (2018), “Integrated extinction accounting and accountability: building an ark”, *Accounting, Auditing and Accountability Journal*, Vol. 31 No. 3, pp. 750–786, doi: 10.1108/AAAJ-06-2017-2957.

Atkins, J. and Maroun, W. (2020), “The Naturalist’s Journals of Gilbert White: exploring the roots of accounting for biodiversity and extinction accounting”, *Accounting, Auditing and Accountability Journal*, Vol. 33 No. 8, pp. 1835–1870, doi: 10.1108/AAAJ-03-2016-2450.

Bilal, Gerged, A.M., Arslan, H.M., Abbas, A., Chen, S. and Manzoor, S. (2024), “A bibliometric review of corporate environmental disclosure literature”, *Journal of Accounting Literature*, Vol. 46 No. 2, pp. 214–237, doi: 10.1108/jal-01-2022-0006.

Boiral, O. and Heras-Saizarbitoria, I. (2017), “Managing biodiversity through stakeholder involvement: Why, who, and for what initiatives?”, *Journal of Business Ethics*, Vol. 140 No. 3, pp. 403–421, doi: 10.1007/s10551-015-2668-3.

Bui, B., Houqe, M.N. and Zaman, M. (2020), “Climate governance effects on carbon disclosure and performance”, *British Accounting Review*, Vol. 52 No. 2, p. 100880, doi: 10.1016/j.bar.2019.100880.

Carvajal, M., Nadeem, M. and Zaman, R. (2022), “Biodiversity disclosure, sustainable development and environmental initiatives: Does board gender diversity matter?”, *Business Strategy and the Environment*, Vol. 31 No. 3, pp. 969–987, doi: https://doi.org/10.1002/bse.2929.

CBD. (2020), *Global Biodiversity Outlook 5*, Convention on Biological Diversity.

Cho, C.H. and Patten, D.M. (2007), “The role of environmental disclosures as tools of legitimacy: A research note”, *Accounting, Organizations and Society*, Vol. 32 No. 7–8, pp. 639–647, doi: 10.1016/j.aos.2006.09.009.

Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. (2008), “Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis”, *Accounting, Organizations and Society*, Vol. 33 No. 4, pp. 303–327, doi: 10.1016/j.aos.2007.05.003.

Dawkins, C. and Fraas, J.W. (2011), “Coming Clean: The Impact of Environmental Performance and Visibility on Corporate Climate Change Disclosure”, *Journal of Business Ethics*, Vol. 100 No. 2, pp. 303–322, doi: 10.1007/s10551-010-0681-0.

Deegan, C. (2002), “The legitimising effect of social and environmental disclosures – a theoretical foundation”, *Accounting, Auditing & Accountability Journal*, Vol. 15 No. 3, pp. 282–311, doi: 10.1108/09513570210435852.

Deegan, C. and Rankin, M. (1997), “The materiality of environmental information to users of annual reports”, *Accounting, Auditing & Accountability Journal*, Vol. 10 No. 4, pp. 562–583, doi: 10.1108/09513579710367485.

Ding, D., Liu, B. and Chang, M. (2023), “Carbon Emissions and TCFD Aligned Climate-Related Information Disclosures”, *Journal of Business Ethics*, Vol. 182 No. 4, pp. 967–1001, doi: 10.1007/s10551-022-05292-x.

Freedman, M. and Jaggi, B. (2011), “Global warming disclosures: Impact of Kyoto protocol across countries”, *Journal of International Financial Management and Accounting*, Vol. 22

No. 1, pp. 46–90, doi: 10.1111/j.1467-646X.2010.01045.x.

Gaia, S. and Jones, M.J. (2017), “UK local councils reporting of biodiversity values: A stakeholder perspective”, *Accounting, Auditing and Accountability Journal*, Vol. 30 No. 7, pp. 1614–1638, doi: 10.1108/AAAJ-12-2015-2367.

Gaia, S. and Jones, M.J. (2020), “Biodiversity reporting for governmental organisations: Evidence from English local councils”, *Accounting, Auditing and Accountability Journal*, Vol. 33 No. 1, pp. 1–31, doi: 10.1108/AAAJ-05-2018-3472.

Del Gesso, C. and Lodhi, R.N. (2024), “Theories underlying environmental, social and governance (ESG) disclosure: a systematic review of accounting studies”, *Journal of Accounting Literature*, doi: 10.1108/jal-08-2023-0143.

Giannarakis, G., Zafeiriou, E. and Sariannidis, N. (2017), “The Impact of Carbon Performance on Climate Change Disclosure”, *Business Strategy and the Environment*, Vol. 26 No. 8, pp. 1078–1094, doi: 10.1002/bse.1962.

Gull, A.A., Luong, H. and Nadeem, M. (2024), “Board co-option and corporate environmental orientation: New insights from the waste management perspective”, *Corporate Governance: An International Review*, doi: 10.1111/corg.12567.

Haque, F. and Jones, M.J. (2020), “European firms’ corporate biodiversity disclosures and board gender diversity from 2002 to 2016”, *British Accounting Review*, Vol. 52 No. 2, p. 100893, doi: 10.1016/j.bar.2020.100893.

Haque, F. and Ntim, C.G. (2020), “Executive compensation, sustainable compensation policy, carbon performance and market value”, *British Journal of Management*, Vol. 31 No. 3, pp. 525–546, doi: 10.1111/1467-8551.12395.

Hassan, A.M., Roberts, L. and Atkins, J. (2020), “Exploring factors relating to extinction disclosures: What motivates companies to report on biodiversity and species protection?”, *Business Strategy and the Environment*, Vol. 29 No. 3, pp. 1419–1436, doi: 10.1002/bse.2442.

Heckman, J.J. (1979), “Sample selection bias as a specification Error”, *Econometrica*, Vol. 47 No. 1, pp. 153–161.

Issa, A. and Zaid, M.A.A. (2023), “Firm’s biodiversity initiatives disclosure and board gender diversity: A multi-country analysis of corporations operating in Europe”, *Business Strategy and the Environment*, Vol. 32 No. 7, pp. 4991–5007, doi: 10.1002/bse.3404.

Luo, L. (2019), “The influence of institutional contexts on the relationship between voluntary carbon disclosure and carbon emission performance”, *Accounting and Finance*, Vol. 59 No. 2, pp. 1235–1264, doi: 10.1111/acfi.12267.

Luo, L. and Tang, Q. (2014), “Does voluntary carbon disclosure reflect underlying carbon performance?”, *Journal of Contemporary Accounting and Economics*, Vol. 10 No. 3, pp. 191–205, doi: 10.1016/j.jcae.2014.08.003.

Luo, L. and Tang, Q. (2021), “Corporate governance and carbon performance: role of carbon strategy and awareness of climate risk”, *Accounting and Finance*, Vol. 61 No. 2, pp. 2891–2934, doi: 10.1111/acfi.12687.

Maroun, W. and Atkins, J. (2018), “The emancipatory potential of extinction accounting: Exploring current practice in integrated reports”, *Accounting Forum*, Vol. 42 No. 1, pp. 102–118, doi: 10.1016/j.accfor.2017.12.001.

Orazalin, N. and Mahmood, M. (2018), “Economic, environmental, and social performance indicators of sustainability reporting: Evidence from the Russian oil and gas industry”, *Energy Policy*, Vol. 121, pp. 70–79, doi: https://doi.org/10.1016/j.enpol.2018.06.015.

Orazalin, N., Ntim, C. and Malagila, J. (2024), "Board sustainability committees, climate change initiatives, carbon performance, and market value", *British Journal of Management*, Vol. 35 No. 1, pp. 295–320, doi: 10.1111/1467-8551.12715.

Qian, W. and Schaltegger, S. (2017), "Revisiting carbon disclosure and performance: Legitimacy and management views", *British Accounting Review*, Vol. 49 No. 4, pp. 365–379, doi: 10.1016/j.bar.2017.05.005.

Roberts, L., Hassan, A., Elamer, A. and Nandy, M. (2021), "Biodiversity and extinction accounting for sustainable development: A systematic literature review and future research directions", *Business Strategy and the Environment*, Vol. 30 No. 1, pp. 705–720, doi: 10.1002/bse.2649.

Shrestha, P., Choi, B. and Luo, L. (2023), "Carbon Management System Quality and Corporate Financial Performance", *International Journal of Accounting*, Vol. 58 No. 1, p. 2350001, doi: 10.1142/S1094406023500014.

Siddique, M.A., Akhtaruzzaman, M., Rashid, A. and Hammami, H. (2021), "Carbon disclosure, carbon performance and financial performance: International evidence", *International Review of Financial Analysis*, Vol. 75, p. 101734, doi: 10.1016/j.irfa.2021.101734.

Siddiqui, J. (2013), "Mainstreaming biodiversity accounting: Potential implications for a developing economy", *Accounting, Auditing and Accountability Journal*, Vol. 26 No. 5, pp. 779–805, doi: 10.1108/AAAJ-03-2013-1242.

Soobaroyen, T. and Ntim, C.G. (2013), "Social and environmental accounting as symbolic and substantive means of legitimation: The case of HIV/AIDS reporting in South Africa", *Accounting Forum*, Vol. 37 No. 2, pp. 92–109, doi: 10.1016/j.accfor.2013.04.002.

Suchman, M.C. (1995), "Managing Legitimacy: Strategic and Institutional Approaches", *Academy of Management Review*, Vol. 20 No. 3, pp. 571–610, doi: 10.5465/amr.1995.9508080331.

Tauringana, V. and Chithambo, L. (2015), "The effect of DEFRA guidance on greenhouse gas disclosure", *British Accounting Review*, Vol. 47 No. 4, pp. 425–444, doi: 10.1016/j.bar.2014.07.002.

Treepongkaruna, S. (2024), "Corporate sustainability and biodiversity reporting: A proactive business strategy to mitigate litigation and reputational risks", *Business Strategy and the Environment*, pp. 1–12, doi: 10.1002/bse.3840.

Uyar, A., Al-Shaer, H., Kuzey, C. and Karaman, A.S. (2023), "Do foreign directors reinforce better waste management? The moderating role of eco-innovation", *Business Strategy and the Environment*, pp. 1–26, doi: 10.1002/bse.3589.

World Bank. (2022), "The World Bank Open Data", *World Bank Open Data*, available at: https://data.worldbank.org/ (accessed 18 February 2022).

**Table 1. Descriptive Statistics**

| Variable | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| BIODSL (%) | 7626 | 50.00 | 28.31 | 0.11 | 99.92 |
| CARBON (ln) | 7626 | 13.03 | 2.34 | 7.25 | 18.18 |
| WASTE (ln) | 6018 | 11.17 | 2.74 | 4.94 | 20.36 |
| CGOVR (%) | 7626 | 62.89 | 20.00 | 0.41 | 99.41 |
| FSIZE (ln) | 7626 | 16.18 | 1.38 | 12.98 | 19.24 |
| FPROF (%) | 7626 | 7.75 | 7.43 | -16.95 | 32.79 |
| FLVRG (%) | 7626 | 29.07 | 15.91 | 0.00 | 73.80 |
| FSLCK (ratio) | 7626 | 0.03 | 0.03 | 0.00 | 0.17 |
| CAPEX (ratio) | 7626 | 0.05 | 0.04 | 0.00 | 0.20 |
| INFLN (%) | 7626 | 1.94 | 1.95 | -4.48 | 19.60 |
| GDPGR (%) | 7626 | 1.63 | 3.21 | -11.17 | 24.48 |

Notes: The descriptions/measurements of the variables are summarized in Appendix B.
**Source(s):** Authors' own work

**Table 2. Pairwise correlations**

| Variables | BIODSL | CARBON | WASTE | CGOVR | FSIZE | FPROF | FLVRG | FSLCK | CAPEX | INFLN | GDPGR | VIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BIODSL | 1.00 | | | | | | | | | | | |
| CARBON | 0.31*** | 1.00 | | | | | | | | | | 2.32 |
| WASTE | 0.25*** | 0.60*** | 1.00 | | | | | | | | | 1.65 |
| CGOVR | 0.16*** | 0.20*** | 0.17*** | 1.00 | | | | | | | | 1.07 |
| FSIZE | 0.41*** | 0.63*** | 0.43*** | 0.23*** | 1.00 | | | | | | | 1.78 |
| FPROF | -0.05*** | -0.11*** | -0.10*** | 0.00 | -0.13*** | 1.00 | | | | | | 1.59 |
| FLVRG | -0.02* | 0.10*** | -0.06*** | 0.00 | 0.14*** | -0.15*** | 1.00 | | | | | 1.11 |
| FSLCK | -0.08*** | -0.13*** | -0.12*** | 0.02* | -0.16*** | 0.59*** | -0.06*** | 1.00 | | | | 1.53 |
| CAPEX | 0.03*** | 0.27*** | 0.09*** | 0.05*** | 0.03** | 0.12*** | 0.03*** | 0.10*** | 1.00 | | | 1.13 |
| INFLN | -0.11*** | -0.05*** | -0.01 | -0.03** | -0.18*** | 0.11*** | 0.07*** | 0.05*** | 0.05*** | 1.00 | | 1.11 |
| GDPGR | -0.03** | 0.00 | -0.02* | -0.01 | -0.03*** | 0.15*** | -0.05*** | 0.06*** | 0.04*** | 0.20*** | 1.00 | 1.07 |

Notes: ***, **, and * correlation is significant at the 0.01, 0.05, and 0.10 levels (2-tailed), respectively.

**Source(s):** Authors' own work

**Table 3. The association between climate change risks and biodiversity disclosures**

| | (1) BIODSL | (2) BIODSL |
|---|---|---|
| CARBON | 1.523*** | |
| | (0.212) | |
| WASTE | | 1.714*** |
| | | (0.163) |
| CGOVR | 0.098*** | 0.086*** |
| | (0.015) | (0.016) |
| FSIZE | 6.383*** | 5.437*** |
| | (0.328) | (0.321) |
| FPROF | 0.017 | 0.044 |
| | (0.047) | (0.053) |
| FLVRG | -0.098*** | -0.080*** |
| | (0.019) | (0.022) |
| FSLCK | 35.259*** | 25.300* |
| | (11.481) | (13.182) |
| CAPEX | 21.337** | 31.481*** |
| | (8.609) | (9.429) |
| INFLN | -0.270 | -0.139 |
| | (0.294) | (0.318) |
| GDPGR | -0.232 | -0.020 |
| | (0.160) | (0.167) |
| Constant | -86.19*** | -73.07*** |
| | (4.753) | (5.348) |
| Country fixed effects | Yes | Yes |
| Industry fixed effects | Yes | Yes |
| Year fixed effects | Yes | Yes |
| Observations | 7626 | 6018 |
| Adj. $R^2$ | 0.308 | 0.285 |

Notes: This table presents the results from regressing biodiversity disclosures (BIODSL) on corporate carbon emissions (CARBON), waste levels (WASTE), and other covariates. Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.

**Source(s):** Authors' own work

**Table 4. Disaggregated components of climate change risks and biodiversity disclosures**

| | (1) BIODSL | (2) BIODSL | (3) BIODSL | (4) BIODSL |
|---|---|---|---|---|
| CARB_SC1 | 1.132*** | | | |
| | (0.165) | | | |
| CARB_SC2 | | 1.713*** | | |
| | | (0.204) | | |
| WAST_HAZ | | | 1.439*** | |
| | | | (0.167) | |
| WAST_NHAZ | | | | 1.870*** |
| | | | | (0.176) |
| CGOVR | 0.102*** | 0.092*** | 0.051*** | 0.056*** |
| | (0.015) | (0.015) | (0.020) | (0.019) |
| FSIZE | 6.632*** | 6.353*** | 5.557*** | 5.025*** |
| | (0.311) | (0.307) | (0.360) | (0.359) |
| FPROF | 0.016 | 0.005 | -0.079 | 0.010 |
| | (0.047) | (0.047) | (0.062) | (0.061) |
| FLVRG | -0.095*** | -0.082*** | -0.079*** | -0.085*** |
| | (0.019) | (0.019) | (0.026) | (0.027) |
| FSLCK | 36.070*** | 26.478** | 50.094*** | 33.113** |
| | (11.478) | (11.538) | (14.991) | (14.915) |
| CAPEX | 24.103*** | 31.432*** | 27.797** | 34.811*** |
| | (8.601) | (8.294) | (11.552) | (10.953) |
| INFLN | -0.286 | -0.276 | -0.683* | -0.555 |
| | (0.294) | (0.294) | (0.355) | (0.351) |
| GDPGR | -0.242 | -0.223 | -0.258 | -0.273 |
| | (0.160) | (0.160) | (0.195) | (0.190) |
| Constant | -83.85*** | -86.83*** | -69.06*** | -73.17*** |
| | (4.826) | (4.716) | (6.372) | (6.229) |
| Country fixed effects | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Observations | 7626 | 7626 | 3975 | 4105 |
| Adj. $R^2$ | 0.308 | 0.310 | 0.309 | 0.305 |

Notes: This table presents the results from regressing biodiversity disclosures (BIODSL) on disaggregated corporate carbon emissions in terms of Scope 1 (CARB_SC1) and Scope 2 (CARB_SC2) components, disaggregated waste levels in terms of hazardous (WAST_HAZ) and non-hazardous (WAST_NHAZ) components, and other covariates. Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.

**Source(s):** Authors' own work

**Table 5. Robustness test: alternative measures**

| | (1) BIOSCR | (2) BIOSCR | (3) BIODSL | (4) BIODSL | (5) BIODSL | (6) BIODSL |
|---|---|---|---|---|---|---|
| CARBON | 1.282*** | | | | | |
| | (0.335) | | | | | |
| WASTE | | 2.494*** | | | | |
| | | (0.241) | | | | |
| CARAST | | | 4.291*** | | | |
| | | | (0.934) | | | |
| WASAST | | | | 1.009*** | | |
| | | | | (0.119) | | |
| CARREV | | | | | 3.177*** | |
| | | | | | (0.444) | |
| WASREV | | | | | | 0.334*** |
| | | | | | | (0.045) |
| CGOVR | 0.060** | 0.043 | 0.101*** | 0.092*** | 0.098*** | 0.090*** |
| | (0.023) | (0.026) | (0.015) | (0.016) | (0.015) | (0.016) |
| FSIZE | 6.789*** | 4.569*** | 7.953*** | 7.042*** | 7.952*** | 7.093*** |
| | (0.516) | (0.514) | (0.237) | (0.267) | (0.236) | (0.267) |
| FPROF | -0.187*** | -0.127 | 0.009 | 0.024 | 0.023 | 0.029 |
| | (0.071) | (0.079) | (0.047) | (0.053) | (0.047) | (0.053) |
| FLVRG | -0.007 | 0.012 | -0.091*** | -0.088*** | -0.095*** | -0.089*** |
| | (0.030) | (0.035) | (0.019) | (0.022) | (0.019) | (0.022) |
| FSLCK | 21.782 | 17.620 | 35.714*** | 26.000** | 37.293*** | 24.820* |
| | (17.399) | (20.319) | (11.547) | (13.217) | (11.514) | (13.221) |
| CAPEX | 73.801*** | 86.790*** | 33.872*** | 38.812*** | 31.442*** | 40.283*** |
| | (14.314) | (15.869) | (8.452) | (9.486) | (8.409) | (9.499) |
| INFLN | 0.054 | 0.251 | -0.265 | -0.110 | -0.249 | -0.106 |
| | (0.459) | (0.501) | (0.295) | (0.322) | (0.295) | (0.322) |
| GDPGR | -0.482** | -0.384 | -0.265 | -0.046 | -0.268* | -0.043 |
| | (0.245) | (0.268) | (0.162) | (0.168) | (0.161) | (0.168) |
| Constant | -69.98*** | -54.53*** | -91.77*** | -78.47*** | -91.92*** | -78.52*** |
| | (7.625) | (8.682) | (4.720) | (5.349) | (4.717) | (5.364) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 7626 | 6018 | 7626 | 6018 | 7626 | 6018 |
| Adj. $R^2$ | 0.232 | 0.220 | 0.305 | 0.279 | 0.308 | 0.277 |

Notes: This table presents the results from regressing biodiversity disclosures (BIODSL) on climate change risks using the alternative proxies for carbon emissions (CARAST and CARREV) and waste levels (WASAST and WASREV) and the alternative measure of biodiversity disclosure (BIOSCR). Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.

**Source(s):** Authors' own work

**Table 6. Robustness test: two-stage least squares (2SLS)**

| | First stage | Second stage | First stage | Second stage |
|---|---|---|---|---|
| | **(1) CARBON** | **(2) BIODSL** | **(3) WASTE** | **(4) BIODSL** |
| CARBON_HEAD | 0.545*** | | | |
| | (0.044) | | | |
| CARBON_IND | 0.234*** | | | |
| | (0.083) | | | |
| CARBON | | 3.563** | | |
| | | (1.387) | | |
| WASTE_HEAD | | | 0.576*** | |
| | | | (0.056) | |
| WASTE_IND | | | 0.816*** | |
| | | | (0.137) | |
| WASTE | | | | 3.767*** |
| | | | | (1.042) |
| CGOVR | 0.005*** | 0.089*** | 0.004*** | 0.078*** |
| | (0.001) | (0.016) | (0.001) | (0.017) |
| FSIZE | 1.011*** | 4.282*** | 1.019*** | 3.297*** |
| | (0.013) | (1.449) | (0.023) | (1.128) |
| FPROF | -0.013*** | 0.038 | -0.024*** | 0.093 |
| | (0.003) | (0.050) | (0.005) | (0.059) |
| FLVRG | 0.008*** | -0.113*** | -0.015*** | -0.049* |
| | (0.001) | (0.022) | (0.002) | (0.027) |
| FSLCK | -2.383*** | 40.371*** | 0.526 | 24.021* |
| | (0.681) | (11.976) | (1.113) | (13.386) |
| CAPEX | 12.983*** | -5.246 | 8.030*** | 15.049 |
| | (0.580) | (19.996) | (0.886) | (12.593) |
| INFLN | 0.008 | -0.248 | 0.022 | -0.195 |
| | (0.018) | (0.295) | (0.027) | (0.321) |
| GDPGR | -0.004 | -0.185 | 0.007 | 0.000 |
| | (0.010) | (0.160) | (0.014) | (0.168) |
| Constant | -13.44*** | -80.80*** | -21.31*** | -67.91*** |
| | (1.390) | (6.004) | (2.196) | (5.987) |
| Country fixed effects | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Observations | 7626 | 7626 | 6018 | 6018 |
| Cragg-Donald Wald F-stat. | 67.692 | | 87.525 | |
| Kleibergen-Paap rk LM statistic | 101.401 | | 137.836 | |
| Stock-Yogo critical value | 19.93 | | 19.93 | |
| Adj. $R^2$ | 0.705 | 0.299 | 0.525 | 0.264 |

This table reports the 2SLS results from regressing biodiversity disclosures (BIODSL) on climate change climate change risks and other covariates. Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.

**Source(s):** Authors' own work

**Table 7. Robustness test: a two-stage Heckman model**

| | First stage | Second stage | First stage | Second stage |
|---|---|---|---|---|
| | **(1) CAR_DUM** | **(2) BIODSL** | **(3) WAS_DUM** | **(4) BIODSL** |
| CARBON_IND | 0.410*** | | | |
| | (0.129) | | | |
| CARBON | | 0.836* | | |
| | | (0.430) | | |
| WASTE_IND | | | 0.394*** | |
| | | | (0.099) | |
| WASTE | | | | 1.444*** |
| | | | | (0.279) |
| CGOVR | 0.003*** | 0.085*** | 0.005*** | 0.138*** |
| | (0.001) | (0.021) | (0.001) | (0.029) |
| FSIZE | -0.043*** | 6.897*** | 0.000 | 6.184*** |
| | (0.016) | (0.568) | (0.017) | (0.478) |
| FPROF | -0.010*** | -0.027 | -0.006* | 0.013 |
| | (0.003) | (0.062) | (0.003) | (0.079) |
| FLVRG | 0.004*** | -0.158*** | -0.006*** | -0.119*** |
| | (0.001) | (0.028) | (0.001) | (0.038) |
| FSLCK | -2.004** | -7.466 | -1.433* | -14.003 |
| | (0.800) | (17.203) | (0.855) | (20.913) |
| CAPEX | 16.942*** | 23.796 | 4.450*** | 67.401*** |
| | (0.652) | (15.049) | (0.594) | (18.865) |
| INFLN | -0.003 | -0.908** | 0.013 | -0.543 |
| | (0.019) | (0.379) | (0.020) | (0.433) |
| GDPGR | -0.022** | -0.338 | -0.016 | -0.153 |
| | (0.011) | (0.229) | (0.011) | (0.255) |
| Constant | -4.87** | -88.62*** | -5.22*** | -89.50*** |
| | (1.983) | (6.886) | (1.489) | (8.550) |
| Mills ratio | | 3.535* | | 7.610 |
| | | (2.079) | | (5.835) |
| Country fixed effects | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Observations | 7626 | 7626 | 6018 | 6018 |
| Wald chi2 | 0.000*** | 0.000*** | 0.000*** | 0.000*** |

This table reports the two-stage Heckman selection results from regressing biodiversity disclosures (BIODSL) on climate change risks and other covariates. Industry average values of carbon emissions (CARBON_IND) and waste levels (WASTE_IND) are used as exclusion restrictions in the first stage estimations. The Mills ratios are estimated based on the parameters in the first stage and are included in the second stage regressions. Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.
**Source(s):** Authors' own work

**Table 8. Robustness test: lag values of independent variables**

| | (1) BIODSL | (2) BIODSL | (3) BIODSL | (4) BIODSL |
|---|---|---|---|---|
| $CARBON_{t-1}$ | 1.280*** | | | |
| | (0.226) | | | |
| $CARBON_{t-2}$ | | 1.017*** | | |
| | | (0.241) | | |
| $WASTE_{t-1}$ | | | 1.689*** | |
| | | | (0.173) | |
| $WASTE_{t-2}$ | | | | 1.681*** |
| | | | | (0.187) |
| Controls | Included | Included | Included | Included |
| Constant | -83.37*** | -81.49*** | -69.29*** | -64.96*** |
| | (5.011) | (5.299) | (5.645) | (5.986) |
| Country fixed effects | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Observations | 6734 | 5842 | 5278 | 4545 |
| Adj. $R^2$ | 0.311 | 0.317 | 0.287 | 0.294 |

Notes: This table presents the results from regressing biodiversity disclosures (BIODSL) on the first and second lag values of corporate carbon emissions ($CARBON_{t-1}$ and $CARBON_{t-2}$) and waste levels ($WASTE_{t-1}$ and $WASTE_{t-2}$). Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.
**Source(s):** Authors' own work

**Table 9. Robustness test: alternative samples**

| | Excluding US firms | | Excluding UK firms | | Excluding US and UK firms | |
|---|---|---|---|---|---|---|
| | (1) BIODSL | (2) BIODSL | (3) BIODSL | (4) BIODSL | (5) BIODSL | (6) BIODSL |
| CARBON | 1.479*** | | 1.746*** | | 1.790*** | |
| | (0.233) | | (0.228) | | (0.256) | |
| WASTE | | 1.888*** | | 1.561*** | | 1.727*** |
| | | (0.176) | | (0.175) | | (0.191) |
| Controls | Included | Included | Included | Included | Included | Included |
| Constant | -87.55*** | -72.44*** | -84.54*** | -71.42*** | -84.70*** | -69.43*** |
| | (5.292) | (5.814) | (5.214) | (5.872) | (5.976) | (6.529) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 6313 | 5103 | 6590 | 5349 | 5277 | 4434 |
| Adj. $R^2$ | 0.338 | 0.315 | 0.304 | 0.287 | 0.337 | 0.321 |

Notes: This table presents the results from regressing biodiversity disclosures (BIODSL) on corporate carbon emissions (CARBON), waste levels (WASTE), and other covariates excluding US and UK firms. Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.

**Source(s):** Authors' own work

**Table 10. Additional analyses: the effects of regulatory settings**

| | (1) BIODSL | (2) BIODSL | (3) BIODSL | (4) BIODSL | (5) BIODSL | (6) BIODSL |
|---|---|---|---|---|---|---|
| CARBON | 1.251*** | | 1.846*** | | 2.756*** | |
| | (0.231) | | (0.281) | | (0.389) | |
| WASTE | | 1.380*** | | 2.125*** | | 2.049*** |
| | | (0.209) | | (0.226) | | (0.336) |
| CARBON*INDUM | 0.896*** | | | | | |
| | (0.305) | | | | | |
| WASTE*INDUM | | 0.689*** | | | | |
| | | (0.258) | | | | |
| CARBON*PARIS | | | -0.492** | | | |
| | | | (0.250) | | | |
| WASTE*PARIS | | | | -0.623*** | | |
| | | | | (0.230) | | |
| CARBON*CBD | | | | | -1.476*** | |
| | | | | | (0.372) | |
| WASTE*CBD | | | | | | -0.393 |
| | | | | | | (0.345) |
| INDUM | -8.727* | -11.813*** | | | | |
| | (4.470) | (3.525) | | | | |
| PARIS | | | 12.778*** | 11.127*** | | |
| | | | (4.219) | (3.894) | | |
| CBD | | | | | 15.741*** | -1.073 |
| | | | | | (5.396) | (4.503) |
| Controls | Included | Included | Included | Included | Included | Included |
| Constant | -86.70*** | -68.04*** | -90.07*** | -77.51*** | -98.53*** | -71.57*** |
| | (5.285) | (5.892) | (5.126) | (5.596) | (6.472) | (6.487) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 7626 | 6018 | 7626 | 6018 | 7626 | 6018 |
| Adj. $R^2$ | 0.309 | 0.285 | 0.308 | 0.285 | 0.310 | 0.285 |

Notes: This table presents the results from regressing biodiversity disclosures (BIODSL) on corporate carbon emissions (CARBON), waste levels (WASTE), and the moderating effects of environmentally sensitive industries (INDUM), the Paris Agreement (PARIS), and the Convention on Biological Diversity (CBD). Robust standard errors below estimated coefficients are reported in parentheses. *, **, and *** denote significance of the estimated coefficients at the 10%, 5%, and 1% levels, respectively.

**Source(s):** Authors' own work

## Appendix A: Sample breakdown by country and industry

**Panel A: Country-level sampling**

| Country | No. of firms | Percentage | Firm-years | Percentage |
|---|---|---|---|---|
| AUSTRALIA | 27 | 3.03 | 239 | 3.13 |
| AUSTRIA | 4 | 0.45 | 44 | 0.58 |
| BELGIUM | 11 | 1.23 | 88 | 1.15 |
| BRAZIL | 41 | 4.60 | 377 | 4.94 |
| CANADA | 31 | 3.48 | 281 | 3.68 |
| CHILE | 12 | 1.35 | 81 | 1.06 |
| CHINA | 3 | 0.34 | 25 | 0.33 |
| COLOMBIA | 5 | 0.56 | 31 | 0.41 |
| DENMARK | 7 | 0.78 | 64 | 0.84 |
| FINLAND | 14 | 1.57 | 146 | 1.91 |
| FRANCE | 36 | 4.04 | 304 | 3.99 |
| GERMANY | 37 | 4.15 | 324 | 4.25 |
| GREECE | 3 | 0.34 | 26 | 0.34 |
| HONG KONG | 16 | 1.79 | 103 | 1.35 |
| HUNGARY | 2 | 0.22 | 18 | 0.24 |
| INDIA | 7 | 0.78 | 69 | 0.90 |
| IRELAND | 7 | 0.78 | 68 | 0.89 |
| ISRAEL | 1 | 0.11 | 11 | 0.14 |
| ITALY | 18 | 2.02 | 160 | 2.10 |
| JAPAN | 109 | 12.22 | 822 | 10.78 |
| LUXEMBOURG | 2 | 0.22 | 24 | 0.31 |
| MALAYSIA | 9 | 1.01 | 62 | 0.81 |
| MEXICO | 3 | 0.34 | 23 | 0.30 |
| NETHERLANDS | 19 | 2.13 | 168 | 2.20 |
| NEW ZEALAND | 9 | 1.01 | 58 | 0.76 |
| NORWAY | 6 | 0.67 | 56 | 0.73 |
| PHILIPPINES | 8 | 0.90 | 68 | 0.89 |
| PORTUGAL | 6 | 0.67 | 58 | 0.76 |
| RUSSIAN FEDERATION | 3 | 0.34 | 16 | 0.21 |
| SINGAPORE | 8 | 0.90 | 60 | 0.79 |
| SOUTH AFRICA | 40 | 4.48 | 334 | 4.38 |
| SOUTH KOREA | 21 | 2.35 | 201 | 2.64 |
| SPAIN | 17 | 1.91 | 154 | 2.02 |
| SWEDEN | 21 | 2.35 | 175 | 2.29 |
| SWITZERLAND | 26 | 2.91 | 241 | 3.16 |
| TAIWAN | 22 | 2.47 | 179 | 2.35 |
| THAILAND | 8 | 0.90 | 66 | 0.87 |
| TURKEY | 6 | 0.67 | 41 | 0.54 |
| UNITED ARAB EMIRATES | 2 | 0.22 | 12 | 0.16 |
| UNITED KINGDOM | 107 | 12.00 | 1036 | 13.59 |
| UNITED STATES | 158 | 17.71 | 1313 | 17.22 |
| **Total** | **892** | **100.00** | **7626** | **100.00** |

**Panel B: Industry-level sampling**

| Industry | No. of firms | Percentage | Firm-years | Percentage |
|---|---|---|---|---|
| Basic Materials | 95 | 10.65 | 785 | 10.29 |
| Consumer Discretionary | 138 | 15.47 | 1182 | 15.50 |
| Consumer Staples | 81 | 9.08 | 669 | 8.77 |
| Energy | 56 | 6.28 | 464 | 6.08 |
| Health Care | 50 | 5.61 | 445 | 5.84 |
| Industrials | 215 | 24.10 | 1866 | 24.47 |
| Real Estate | 73 | 8.18 | 594 | 7.79 |
| Technology | 50 | 5.61 | 441 | 5.78 |
| Telecommunications | 53 | 5.94 | 504 | 6.61 |
| Utilities | 81 | 9.08 | 676 | 8.86 |
| **Total** | **892** | **100.00** | **7626** | **100.00** |

**Source(s):** Authors' own work

## Appendix B: Variable descriptions

| Variable | Acronym | Description |
|---|---|---|
| Biodiversity disclosure | BIODSL | The index is calculated based on 9 disclosure indicators, which reflect a company's impacts on biodiversity and threatened species, together with corporate initiatives/polices/actions to enhance the positive impacts and mitigate the adverse effects of its business operations on the environment and ecosystems. These indicators include biodiversity loss reduction, sulfur and nitrogen oxides emissions reduction, waste reduction, e-waste reduction, environmental restoration, eco-design products/processes, toxic chemicals and substances reduction, environmental innovation/product impacts minimization, and land environmental impact reduction. Each indicator is assigned a value of one if reported, and zero otherwise. The weighted average index is then calculated within each industry and ranges between 0% and 100%. |
| Carbon emissions | CARBON | Natural logarithm of actual carbon emissions. |
| Waste levels | WASTE | Natural logarithm of actual waste levels |
| Corporate governance | CGOVR | The score assesses the quality of corporate governance related to board structures (diversity, independence, and committees), their functions, roles, responsibilities, and executive compensation. It varies between 0% and 100%. |
| Firm size | FSIZE | Natural logarithm of total assets. |
| Profitability | FPROF | Net earnings divided by total assets*100. |
| Financial risk | FLVRG | Total debts divided by total assets*100. |
| Slack | FSLCK | The ratio of cash and cash equivalents to total assets. |
| Capital intensity | CAPEX | The ratio of capital expenditures to total assets. |
| Inflation rate | INFLN | Percentage change in the retail prices of goods, products and services that can be changed or fixed between two consecutive years. |
| GDP growth | GDPGR | Percentage change in real GDP between two consecutive years. |

**Source(s):** Authors' own work