

OTDK Paper

2025

CORVINUS UNIVERSITY OF BUDAPEST
INSTITUTE OF FINANCE

**A BIOLÓGIAI SOKFÉLESEG KOCKÁZATÁNAK A PÉNZÜGYI
TELJESÍTMÉNYRE GYAKOROLT HATÁSÁNAK ELÉRÉSE**

**ACCESSING THE BIODIVERSITY RISK IMPACT
ON FINANCIAL PERFORMANCE**

Nguyen Quang Minh

Consultant: Name of Consultant(s): Li Xinglin

Closure date of the manuscript: 11 November 2024.

Abstract

The study examines how biodiversity awareness and biodiversity risk affect the financial performance of publicly traded companies in the U.S. between 2002 and 2023. We investigate the impact of sentiment-driven and regulatory risks on a firm's return on assets using fixed-effects regression on biodiversity-related disclosures extracted from Giglio's (2024) textual analysis in 10-K reports. Findings show that biodiversity awareness was not having strong relationship with firm performance but started to show positive correlation with short term performance after 2020. Biodiversity-related regulatory risk exposure negatively impacts affect short-run performance, signaling that they represent an immediate cost for compliance. The results following 2020, however, point to an optimistic change in regulation impact that firms have adjusted to, suggesting firms have adapted, potentially leveraging compliance as a competitive advantage. Lastly, biodiversity risks had no predictive power before 2020 but became positively correlated with firm performance after that. This may reflect a growing tendency for investors to reward firms that identify and manage their environmental impact. These findings imply that companies that incorporate biodiversity considerations into their strategies, which connect environmental responsibility with financial resilience, can benefit from increased stakeholder attention to biodiversity.

Keywords: *Biodiversity awareness, biodiversity risks, firm performance, transition risk, physical risk.*

Table of Contents

1.	Introduction	1
2.	Literature review	3
2.1.	Biodiversity risks	3
2.1.1.	Physical risks.....	4
2.1.2.	Transition risks.....	5
2.2.	Aim of the research.....	7
3.	Methodology	9
3.1.	Research design	9
3.2.	Data collection	9
3.3.	Variables	9
3.3.1.	Dependent variable	9
3.3.2.	Independent variables	10
3.3.3.	Control variables	10
3.4.	Hypotheses.....	11
3.5.	Regression models	12
4.	Results	14
5.	Conclusion.....	21
6.	Discussion and limitations	22

1. Introduction

Biodiversity loss has today become a critical issue for ecosystems and economies across the world. Biodiversity, in simple terms, determines the variation among living organisms and their ecosystems, which provide essential ecosystem services valued at tens of trillions of dollars annually ([Costanza et al., 1997](#)). These services are integral to numerous industries, including agriculture, fisheries, and pharmaceuticals, which rely on healthy, functioning ecosystems for resources such as pollination, water purification, and soil fertility ([Giglio et al., 2024](#)). The present rate of biodiversity decline is unprecedented in human history, with species extinction rates estimated to be 10 to 100 times higher than the base rate over the past 10 million years ([IPBES, 2019](#)). This could affect not only environmental sustainability but also economic systems, as more than half of global GDP, which is approximately \$44 trillion, depends moderately or highly on nature and its services ([WEF, 2020](#)). Without proper biodiversity risk management, industries could face resource shortages, supply chain disruptions, and increased operational costs, potentially leading to economic contractions and reduced resilience in the long run ([Dasgupta, 2021](#)).

The degradation in biodiversity not only disrupts these services but also poses long-term risks to global economic stability, with the World Economic Forum ([WEF, 2020](#)) ranking biodiversity loss among the top three risks facing the global economy. As [Karolyi \(2023\)](#) emphasized, there is an urgent need to understand and integrate biodiversity risks into financial strategies. He draws a parallel between the scale of biodiversity loss and climate risk, noting that the latter receives considerably more attention in corporate finance.

Recently, [Giglio et al. \(2024\)](#) developed an innovative method to assess biodiversity risk exposure at both firm and industry levels. They created quantitative metrics, including the 10K-Biodiversity-Count, 10K-Biodiversity-Negative, and 10K-Biodiversity-Regulation scores, to gauge exposure to biodiversity-related risks through analysis of firm 10-K statements, survey responses, and portfolio holdings of biodiversity-focused funds. Giglio and colleagues concluded that biodiversity risks are at least partially priced into asset prices, particularly in industries that directly depend on ecosystems, such as food production, pharmaceuticals, and utilities. This research suggests that a firm's performance can be significantly affected by its exposure to biodiversity risks due to impacts on operational resilience, regulatory compliance, and resource availability.

Building on the work of [Giglio \(2024\)](#), this paper investigates whether a causal relationship exists between biodiversity risk exposure and firm performance, concerning both long- and short-term impacts. In particular, we will examine how biodiversity risks—both physical and transition risks—affect a firm’s Return on Assets (ROA). The long-term impact will be assessed by examining overall ROA trends over multiple years, while short-term effects will be measured through annual changes in ROA.

This approach will provide a comprehensive understanding of biodiversity’s effect on financial performance, especially as firms face potential regulatory pressures, reputational risks, and operational disruptions tied to biodiversity loss. Target audiences include corporate financial managers, ESG-focused investors, and regulatory bodies interested in environmental risks within corporate strategy and financial stability. The expected outcomes will provide valuable insights for stakeholders in industries highly dependent on natural resources as they navigate the financial implications of biodiversity risk.

The study is organized as follows: Section 2 reviews the literature on biodiversity risks and corporate performance, Section 3 describes the methodology, Section 4 presents the findings, Section 5 will be the conclusion, and Section 6 discusses implications and limitations.

2. Literature review

2.1. Biodiversity risks

Biodiversity is defined as “the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” ([Biodiversity in Development Project, 2001](#)). The loss of biodiversity is the “degradation of biodiversity results in severely depleted stocks of resources in fishery, forestry and other bio-services with potentially irreversible consequences for the environment” ([WEF, 2010](#)). This topic has been gaining awareness recently ([Dempsey, J. 2013](#); [Karolyi & Tobin-de la Puente, 2023](#); [Pörtner et al., 2023](#)), as a critical environmental challenge facing global ecosystems and economies. We are facing biodiversity loss at a rate that is faster than at any other time in human history, which can cause the extinction of key species ([IPBES, 2019](#)), and with the degradation of land and soil ([UNCDD, 2022](#)), it is even more threatening to the resilience of environment, societies, and the world economy ([Blanco-Zaitegi et al., 2022](#); [Duffy et al., 2017](#)). This issue is important since not only the nature provide humanity with food and crucial medicines, but supports the resilience to pests, diseases, and climate changes ([Wilson, 1988](#); [Duarte et al., 2009](#); [Liang et al., 2016](#); [Paul et al., 2020](#); [Porto et al., 2020](#); [Steffan-Dewenter et al., 2007](#)), but also more than half of world’s GDP is dependent on natural resources and ecosystem services ([WEF, 2020](#)). Its loss can cause huge damage to the economy in every sector, losses to the ecosystem services it brings, and also prevent the opportunities for growing other species and reducing future economic output ([Dasgupta, 2021](#); [IPBES, 2019](#); [Giglio, 2023](#); [Kapnick, 2022](#); [Carvalho et al., 2023](#); [Johnson et al. 2021](#)) Therefore, biodiversity loss has been considered as the third of the largest five risks for global economy ([WEF, 2020](#)). This risk can be introduced as a new dimension, separate from climate change, in corporate risk management ([Kapnick, 2022](#); [Carvalho et al., 2023](#)).

Biodiversity risk is defined in the World Economic Forum (2010) as “business risks related to biodiversity in the broadest sense. This includes risks as a result of direct impacts or dependencies on biodiversity and ecosystem services, as well as regulatory, financing, reputational and supply chain risks that arise due to business’s relationships with biodiversity and ecosystems.”

([WEF, 2010](#)). The risks from biodiversity loss can be divided into two channels: physical risks and transition risks ([NGFS-INSPIRE Study Group, 2022](#); [OECD, 2019](#); [IFC, 2024](#); [Kurth et al., 2021](#)).

2.1.1. Physical risks

Physical risks arise from the degradation of natural resources and ecosystem services that many firms rely on for raw materials, infrastructure, or supply chains ([NGFS-INSPIRE Study Group, 2022](#)). For example, agriculture, fisheries, and forestry industries are vulnerable to being dependent on ecosystem services like pollination, water purification, and climate regulation ([Carvalho et al., 2023](#)). A specific example is the disappearance of coral reefs, which result in increased vulnerability to coastal flooding, with potential economic losses of US\$4 billion in flood damage per year ([WEF, 2020](#)). Any firm that fails to manage biodiversity effectively may affect the firm's competitiveness and profitability of long-term development ([Velte, 2023](#)).

These risks can affect firm performance in several ways. The Resource-Based View (RBV), introduced by [Barney \(1991\)](#), emphasizes that firms can achieve a sustained competitive advantage by managing their valuable, rare, inimitable, and non-substitutable resources. Developing this theory, [Hart \(1995\)](#) extended to the Natural Resource-Based View (NRBV), which includes environmental concerns. According to the NRBV, a firm's strategic resources contain natural resources, which can be valuable for long-term competitiveness. These natural resources can be biodiversity and are aligned with three pillars of the NRBV framework - pollution prevention, product stewardship, and sustainable development.

Firms that prevent pollution, which can relate to biodiversity conservation, can mitigate the physical risks coming from biodiversity loss. It is important to mention that biodiversity risks can impact a firm in a two-way relationship, meaning biodiversity can also be impacted by companies ([Adler et al., 2018](#); [Roberts et al., 2020](#)). When considering physical risks, ecosystem degradation may disrupt resource availability, which leads to supply chain instability and increased operational costs. And vice versa, if the company degrades the ecosystem by polluting or destroying natural habitats, they will face those physical risks in the future. Regarding product stewardship, Biodiversity or natural resources can be more competitive if they are managed substantially through sustainable sourcing and life-cycle performance. In addition, sustainable development

relates to long-term business activities with a strong sense of environmental purpose. In this context, firms can invest in sustainable practices that conserve ecosystems and biodiversity, so they can ensure their natural resources remain available for future use and growth.

We can link the physical risk and firm performance through the resourced-based view theory. As we have analyzed, physical risks could cause firms to face resource shortages and supply chain disruptions, which can lead to an increase in operational costs, a decrease in efficiency, and lower financial performance. Return on assets (ROA), which reflects how effectively a company generates profit from its assets, is particularly suitable for measuring firm performance and has been used widely in resource-based view research, as it captures the relationship between resource allocation and asset returns. ([Barber & Lyon, 1996](#); [Bhagat & Bolton, 2008](#); [Robins and Wiersema, 1995](#); [Riahi-Belkaoui's, 2003](#); [Lin and Wu, 2014](#); [Newbert, 2006](#)).

2.1.2. Transition risks

Transition risks are about the sudden change in policies or the sudden shift in consumers' preferences or investors' sentiments that require firms to adapt to be more transparent on environment disclosures and act to reduce their negative impact on nature and biodiversity. For now, there are frameworks such as Nature-related Financial Disclosures (TNFD) or Kunming-Montreal Global Biodiversity Framework (GBF) that push firms to have more transparency in reporting on biodiversity impacts ([TNFD, 2022](#); [Convention on Biological Diversity, 2022](#)). U.S. initiatives like the America the Beautiful Challenge and policies from agencies such as the U.S. Fish and Wildlife Service and NOAA stress biodiversity conservation and ecosystem protection ([U.S. Department of State, 2022](#)). The EU also submitted its target and showed its commitment to GBF, which is supported by the European Green Deal and the Nature Restoration Law. Also, long-term institutional investors are more interested in environment and biodiversity commitments and require more information transparency through their representatives on company boards ([Boiral & Heras-Saizarbitoria, 2017](#); [Elmagghi et al., 2019](#); [Rizwan Ali et al., 2023](#)).

The stakeholder theory provides insight into how transition risk can affect firm performance. We can leverage Freeman's Stakeholder Theory ([1984](#)) that a firm aligning its corporate actions with stakeholders' expectations would perform better toward its financial outcomes. The relevant expansions from this theory identify that stakeholder management practices can enable conventional corporate objectives such as profitability, growth, and stability ([Clarkson, 1995](#); [Donaldson & Preston, 1995](#)). What is more, the interests and demands of the stakeholders regarding transparency and environmental concerns could affect directly the performance of each firm by influencing strategic decisions. ([Friedman et al. 2002](#)). [Harrison \(2013\)](#) supported this when he argued that good management of stakeholder relationships is likely to enhance the performance of the firm over time since the stakeholders are important in the creation of sustainable value. As investors, consumers, and regulators increasingly prioritize environmental sustainability, companies that align with these expectations and enhance disclosures to meet stakeholder needs tend to experience improved performance ([Buniamin, 2019](#)). [Rizwan Ali \(2023\)](#) notes that the disclosure of biodiversity has become increasingly significant for institutional investors, as they tend to reward companies that enhance their transparency regarding biodiversity. Conversely, companies that do not improve their disclosure may face reputational risks, which could include restricted access to markets.

Building on this foundation, biodiversity reporting can be viewed as a natural extension of Corporate Social Responsibility (CSR) principles ([Bebbington & Larrinaga, 2014](#); [Hassan et al. 2020](#)). Historical research has consistently linked CSR to improved financial performance. Studies by [Torugsa et al. \(2012\)](#), [Rhou et al. \(2016\)](#), and [Theodoulidis et al. \(2017\)](#) have demonstrated this positive relationship, including analyses in several sectors. [Long et al. \(2020\)](#) focuses on environmental and social disclosures, including CSR, which can enhance financial outcomes. [Weber's \(2013\)](#) study suggests that increased ESG disclosures are associated with better financial returns and reduced financial volatility. [Zhou et al. \(2022\)](#) find that ESG initiatives can positively influence market value, particularly through improved operational capacity. The results from [Ellili's](#) study (2022) and [Bruna's](#) (2022) also indicated that one could enhance firm performance and attract investors to improve financial stability for companies that use ESG practices. In the same way, disclosures on environmental issues, including biodiversity, can favorably influence

financial performance when such disclosures address key stakeholders' demands and expectations and regulatory pressures ([Carvajal et al., 2022](#)).

While there is a well-established link between environmental disclosures, Corporate Social Responsibility (CSR), and Environmental, Social, and Governance (ESG) practices and improved financial performance, research focusing on the effects of biodiversity awareness and disclosure on firm performance remains limited. We could only find one paper by [Elsayed \(2023\)](#), which shows that biodiversity disclosures can enhance Return on Assets (ROA). Part of the explanation for this scarcity of studies is due to the relatively new and non-mandatory nature of biodiversity reporting frameworks, making it challenging for researchers to draw definitive conclusions. However, understanding how this relationship works is critical, given that the importance of biodiversity continues to be emphasized by firms, stakeholders, and regulators with respect to risk management and corporate strategy.

2.2. Aim of the research

Our study attempts to fill this gap by investigating whether firms' awareness of biodiversity risk exposures, as stated in their 10-K statements, impacts their financial performance. We proxy their awareness by drawing on data from Giglio et al.'s (2023) biodiversity risk assessment framework, which analyzes corporate statements for terms related to biodiversity and regulatory issues with biodiversity. We can now empirically test whether higher levels of awareness of biodiversity risk exposures are associated with better financial performance.

Secondly, there is a research gap related to the impact of biodiversity risk on firm performance. Researching biodiversity as a distinct risk factor - separate from broader environmental or climate risk - remains scarce. Unlike other environmental risks, biodiversity risk is still underexplored and underpriced in financial markets. Recent studies (e.g., [Giglio et al., 2023](#); [Kalhor & Kyaw, 2024](#)) indicate that biodiversity risks are not yet adequately reflected in stock valuations, creating potential volatility as markets adjust to account for these factors. By leveraging the negative sentiment scores from the Giglio method as a proxy for biodiversity risk, our research seeks to determine how biodiversity risk influences firm performance. This novel and quantitative approach

provides a critical innovation in understanding the financial implications of biodiversity, addressing a gap in current environmental finance literature.

3. Methodology

3.1. Research design

This study will use a quantitative approach to test whether biodiversity attention and biodiversity risk have any relationship to the financial performance of publicly listed U.S. companies from 2002 to 2023. The financial performance will be captured both in the short-term change, which is in the annual change of return on assets, and long-term growth, which is the return on assets in general. Besides, our biodiversity risk metrics are taken from [Giglio et al. \(2023\)](#). We will also focus on the impact after 2020, as biodiversity concerns have become more pronounced after the COVID-19 pandemic (Hassan et al., 2021).

3.2. Data collection

We use the data constructed by [Giglio et al. \(2023\)](#) to measure the biodiversity risks for firms. Their metrics are taken from textual analysis of annual 10-K filings submitted to the US Securities and Exchange Commission (SEC).

For financial data like total revenue, leverage, and return on assets, we collected on Refinitiv and Bloomberg. This data allows us to control for various firm-specific characteristics in our analysis.

3.3. Variables

3.3.1. Dependent variable

To capture long-term performance for a firm, we use Return on Assets as the primary indicator, which assesses a firm's efficiency in generating profit relative to its asset base. **ROA** can capture a general impact of strategic resource management decisions, and this metric has been used by previous research about financial outcomes of environmental and resource allocation strategies ([Barber & Lyon, 1996](#); [Bhagat & Bolton, 2008](#); [Lin & Wu, 2014](#); [Newbert, 2006](#)).

To capture short-term shifts in financial performance, we use the year-over-year change in ROA, denoted as **ROA_{diff}**. It is calculated by using the ROA of this year minus the ROA of the

previous year. The metric shows how ROA can grow each year. We believe that ROA_{diff} reflects the annual fluctuations in profitability. We would like to find insights into how firms' financial outcomes respond immediately to changes in environmental or biodiversity preferences and regulations.

3.3.2. Independent variables

The 10K Biodiversity Count Score (**BiC**) is a binary variable derived from Giglio et al.'s (2023) textual analysis of 10-K statements. It assigns a score of "1" to firms mentioning biodiversity-related terms in at least two sentences within a given year and "0" otherwise. This measure captures the level of a firm's biodiversity awareness based on its disclosures.

The 10K Biodiversity Negative Score (**BiN**) measures the sentiment of biodiversity-related mentions in 10-K statements and can be considered physical risks for firms. Giglio et al. (2023) applied a BERT-based sentiment analysis model to classify sentences as positive, neutral, or negative. Whether it is neutral or positive, we consider it to be a low risk, as "0". If it is negative, we consider it to be higher risk, which is "1".

The 10K-Biodiversity-Regulation Score (**BiR**) identifies firms that mention biodiversity risks related to regulatory concerns. This score is also derived from Giglio et al.'s analysis and is assigned to the value of "1" if biodiversity risk sentences include terms like "law," "regulation," "ESA," or "restriction," and "0" otherwise. This measure reflects the firm's biodiversity-related regulatory risk exposures.

3.3.3. Control variables

We include several control variables commonly used in prior studies examining the relationship between firm characteristics and financial performance to ensure the robustness of our analysis and effectively isolate the effects of biodiversity awareness and risk on ROA.

Firm size (**Size**) is controlled using the natural logarithm of total assets. Larger firms often differ from smaller firms in operational efficiency and resource access, which can impact financial

performance ([Hall & Weiss, 1967](#); [Goddard et al., 2005](#)). Controlling for firm size mitigates potential biases related to scale-based advantages or disadvantages.

Leverage (**Lev**), defined as the ratio of total debt to total assets, represents a firm's financial risk. Higher leverage levels generally increase financial instability, which can affect profitability and asset utilization. Empirical studies emphasize the importance of including leverage to capture variations in financial performance ([Cooper, Gulen, & Schill, 2008](#); [Bhagat & Bolton, 2008](#); [Campello, 2006](#)).

The Book-to-Market Ratio (**BM**) is also included to capture a firm's book value relative to market valuation. This ratio is critical to providing insight into growth opportunities, and market expectations, and for understanding how valuation impacts financial performance. Firms with high BM ratios are often considered undervalued, while those with low ratios indicate growth potential ([Fama & French, 1992](#); [Jo, Kim, & Park, 2015](#)).

Revenue growth rate (**REVg**), calculated as the year-over-year change in revenue, accounts for a firm's economic performance and expansion capacity. Revenue growth is an indicator of operational success and market dynamics, directly impacting profitability ([Huang et al., 2018](#); [Nohel & Tarhan, 1998](#)).

Lastly, Tangibility (**Tang**), or the proportion of tangible assets within total assets, is included as another control variable. Tangible assets can often serve as collateral, providing financial stability during economic downturns ([Margaritis & Psillaki, 2010](#); [Titman & Wessels, 1988](#)). This variable helps capture the impact of a firm's asset structure on its financial outcomes.

3.4. Hypotheses

We divide our research questions into two areas. The first is the relationship between awareness and firm performance. The second is the relationship between biodiversity risks, which are transition and physical risks, to firm performance. In each area, we compare our long-term overall ROA and short-term metrics from the change of ROA, as well as comparing the period before 2020 and after 2020. Thus, our model will also use interaction terms to examine whether

biodiversity attention and risks magnify their impact on performance after 2020. Therefore, here are our hypotheses.

H₁: Biodiversity awareness positively affects firm performance, both in the short term and long term.

H₂: Biodiversity-related regulatory risk exposure negatively affects firm performance, both in the short term and long term.

H₃: Physical biodiversity risks from negative scores have adverse impacts on firm performance, both in the short term and long term.

H₄: The impact of biodiversity awareness and biodiversity risks on firm performance amplifies after the year 2020.

3.5. Regression models

Our estimation method is fixed-effects regression, controlling for firm-specific, unobserved heterogeneity that can affect financial performance. More precisely, the fixed effects capture the time-invariant characteristics at the firm level. We further include year dummies to control for possible temporal trends and external macroeconomic influences, representing year-specific shocks common across all firms. This approach allows us to isolate the impact of biodiversity risks and their interaction with the post-2020 period on the dependent variables of interest, namely, short-term variations in Return on Assets (ROA_{diff}) and overall Return on Assets (ROA). We calculate robust standard errors to ensure the consistency of the results, accounting for potential heteroskedasticity and serial correlation within firms over time.

The basic model is presented below:

$$ROA_{i,t} = \beta_0 + \beta_1 (BiC_{i,t-1}) + \beta_3 (Controls_{i,t-1}) + \gamma_t + \varepsilon_{i,t}$$

The model above will be used to test the relationship between biodiversity awareness and firm performance in the long term. The dependent variable will be changed to ROA_{diff} if we want to examine it in the short term. For the biodiversity risk, the independent variable will change to BiR or BiN.

The model with interaction terms is presented below:

$$ROA_{i,t} = \beta_0 + \beta_1 (BiC_{i,t-1}) + \beta_2 Post2020_t + \beta_3 (BiC \times Post2020)_{i,t-1} \\ + \beta_4 (Controls_{i,t-1}) + \gamma_t + \varepsilon_{i,t}$$

The key independent variable is the interaction term $(BiC \times Post2020)_{i,t-1}$, which captures the combined effect of regulatory environment changes and the post-2020 period, allowing the model to examine how biodiversity risks influence ROA may differ before and after 2020.

4. Results

Table 1: Correlation matrix

	BiC	BiR	BiN	ROA	ROA _{diff}	BM	REV _g	Tang	Lev	Size
BiC	1.00									
BiR	0.56	1.00								
BiN	0.38	0.78	1.00							
ROA	-0.01	-0.01	0.00	1.00						
ROA _{diff}	0.01	0.01	0.01	0.28	1.00					
BM	0.09	0.10	0.09	-0.18	-0.12	1.00				
REV	0.01	0.03	0.03	0.00	0.40	-0.12	1.00			
Tang	0.21	0.16	0.13	0.04	-0.03	0.12	-0.07	1.00		
Lev	0.01	-0.01	-0.04	-0.09	-0.00	-0.22	-0.08	0.20	1.00	
Size	0.04	0.02	0.02	0.19	0.01	0.00	-0.10	0.28	0.35	1.00

The correlation matrix reveals key relationships among biodiversity metrics, financial performance, and firm characteristics. Biodiversity awareness (BiC) is positively associated with biodiversity transition risk (BiR) (0.56) and sentiment (BiN) (0.38), indicating that firms attentive to biodiversity issues also disclose more about related risks. Biodiversity measures show a minimal correlation with ROA, suggesting a limited direct impact on profitability. However, the relationship between them is complex, since the BiC, BiR, and BiN are all binary data.

The summary statistics table shows that the data set consists of 11,839 firm-year observations, covering 1,699 unique firms. Key performance indicators include ROA (mean = 6.34, SD = 9.81) and ROA_{diff} (mean = 0.07, SD = 4.98), reflecting variations in firm profitability and year-over-year ROA changes.

Table 2: Summary statistics

	Mean	SD	Min	Max
Firm	-	-	1	1699
BiC	.0320973	.176266	0	1
BiN	.0172312	.1301372	0	1
BiR	.0227215	.1490205	0	1
ROA _{diff}	.0716621	4.981282	-20.53	20.04
ROA	6.343552	9.80841	-42.96	28.54
BM	.4154776	.3752268	-.1469923	2.192592
REV _g	.1141735	.2373898	-.4810048	1.258503
Tang	.3968039	.2122101	.0451721	.929616
Lev	.5651973	.2319019	.0899131	1.281279
Size	22.01206	1.636614	18.47217	26.09643
<i>N = 11839</i>				

Biodiversity-related indicators are binary variables with low means, indicating that biodiversity awareness and risk mentions are relatively rare among firms. Specifically, BiC (mean = 0.03), BiN (mean = 0.017), and BiR (mean = 0.023) highlight limited biodiversity disclosures in the database, with regulation signaling mentions of regulatory pressures.

Table 3 above shows the test results for regression models, explaining the relationship between ROA and BiC. Both coefficients of the model (1) and (3) are negative at -0.616 and -0.053, but statistically insignificant, indicating that biodiversity awareness captured by biodiversity mentions in the previous year does not have a direct impact on change of ROA of overall ROA of a firm. Therefore, we can reject H₁, as there is no statistically significant evidence to support that biodiversity awareness directly improves firm performance.

Table 3: Regression model results exploring relationship between biodiversity attentions and firm performance

	(1)	(2)	(3)	(4)
	ROA _{diff}	ROA _{diff}	ROA	ROA
L.BiC	-0.616 (0.366)		-0.053 (0.654)	
L.BiC x P2020		1.923** (0.726)		2.390 (1.380)
L.BM	-0.633* (0.298)	-0.677* (0.298)	-7.119*** (0.601)	-7.174*** (0.599)
L.REV _g	-0.832 (0.484)	-0.841 (0.484)	3.972*** (0.566)	3.960*** (0.566)
L.Tang	-0.094 (1.034)	-0.095 (1.032)	-1.241 (1.326)	-1.243 (1.324)
L.Lev	5.084*** (0.915)	5.075*** (0.915)	-4.813** (1.628)	-4.824** (1.628)
L.Size	-1.337*** (0.200)	-1.316*** (0.199)	0.001 (0.414)	0.027 (0.412)
Year (2003 – 2023)	...	...	...	...
Constant	26.152*** (4.083)	25.741*** (4.058)	11.196 (8.528)	10.685 (8.496)
Observations	9731	9731	9731	9731
R ²	0.085	0.086	0.131	0.132
Adjusted R ²	0.083	0.084	0.128	0.129
F	17.093	16.640	17.146	16.762

Standard errors in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

It is worth noticing that the interaction between biodiversity awareness and the period after 2020 is positive and statistically significant at 1% for model (2). The coefficient of 1.923 indicates that firms that were more attentive to biodiversity issues saw an additional positive impact of nearly 2% on ROA_{diff} in the post-2020 period. This may signal that their disclosures have been aligning more with investors and regulation expectations. While the lack of significance in the model (4)

for ROA suggests this effect may be more pronounced in performance changes rather than absolute levels.

The result may suggest that stakeholder support, including that from investors, customers, and regulators, may have strengthened for firms addressing biodiversity concerns. Firms proactively discussing biodiversity are likely perceived as more environmentally responsible, enhancing their reputational capital, which can attract environmentally conscious investors and consumers.

Table 4 presents the relationship between biodiversity-related regulatory risk exposure (BiR) and firm performance in both short- and long-term contexts. Models (5) and (7) indicate a negative coefficient for the lagged BiR variable, suggesting that increased exposure to biodiversity regulatory risk is associated with reduced short-term profitability. Specifically, Model (5) shows a statistically significant reduction in ROA_{diff} by 1.306% at a 5% confidence level, indicating that biodiversity regulatory risk exposure negatively affects the year-over-year change in Return on Assets (ROA) in the short term. This result implies that as firms face heightened regulatory scrutiny regarding biodiversity, they may incur compliance or operational costs that temporarily weigh on performance. These costs might stem from necessary investments in environmental safeguards or sustainable practices that meet regulatory standards, creating immediate financial pressures.

However, Model (7), examining the long-term ROA, does not find a statistically significant effect of biodiversity-related regulatory risk exposure, suggesting that the impact may not persist over an extended horizon. This aligns with findings from studies like those by [Albanese et al. \(2024\)](#) and [Gourdel et al. \(2024\)](#), which suggest that transition risks, which is the regulatory risk in this context, often manifest in short-term financial outcomes, while physical risks tend to exert a gradual but significant impact over the long term due to cumulative effects from ongoing ecological pressures.

Table 4: Regression results examining the relationship between biodiversity regulation risks (transition risks) and firm performance

(5)	(6)	(7)	(8)
ROA_{diff}	ROA_{diff}	ROA	ROA

L.BiR	-1.306*		-0.955	
	(0.591)		(1.05)	
L.BiR x post2020		2.785**		4.102*
		(0.978)		(1.72)
L.BM	-0.621*	-0.688*	-7.108***	-7.207***
	(0.298)	(0.298)	(0.602)	(0.599)
L.REV _g	-0.828	-0.834	3.974***	3.965***
	(0.485)	(0.484)	(0.566)	(0.566)
L.Tang	-0.108	-0.111	-1.25	-1.255
	(1.033)	(1.031)	(1.326)	(1.322)
L.Lev	5.062***	5.045***	-4.846**	-4.870**
	(0.915)	(0.915)	(1.626)	(1.625)
L.Size	-1.342***	-1.322***	-0.004	0.026
	(0.200)	(0.198)	(0.413)	(0.411)
Year (2003 – 2023)	...	...	...	...
Constant	26.284***	25.900***	11.34	10.773
	(4.087)	(4.049)	(8.512)	(8.471)
Observations	9731	9731	9731	9731
R ²	0.086	0.087	0.131	0.133
Adjusted R ²	0.083	0.084	0.129	0.131
F	17.101	16.571	17.105	16.742

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In Models (6) and (8), the interaction term between biodiversity regulatory risk exposure and the post-2020 period is positive and statistically significant, with coefficients of 2.785 and 4.102, respectively. This change indicates a shift in the impact of regulatory risks after 2020, suggesting that the initially negative short-term effects of biodiversity regulation on ROA_{diff} have lessened or even reversed post-2020. This may reflect that as biodiversity regulations intensified post-2020, firms adjusted to these compliance expectations, potentially transforming regulatory compliance costs into strategic advantages. Adaptive responses, such as improved biodiversity risk management and operational efficiencies, could allow firms to not only meet but leverage

regulatory standards, enhancing their market position and financial performance.

Table 5 describes the relationship between Physical Biodiversity Risk and Firm Performance. The coefficient for lagged physical biodiversity risk is negative in both model (9) and model (11), indicating a potential adverse effect of physical risks on firm performance. However, these coefficients are not statistically significant, suggesting that physical biodiversity risks do not have a strong or consistent impact on firm performance. Thus, we can reject H3: Physical biodiversity risks from negative scores have adverse impacts on firm performance, both in the short term and long term. While there may be a slight tendency for physical risks to negatively impact performance, the effect is not robust or statistically significant.

This may be because short-term financial metrics often fail to capture the effects of long-term ecological risks, and companies have effective mitigation strategies and investors perceive physical risks as less immediate threats to financial performance over extended periods.

Table 5: Regression results examining the relationship between Biodiversity physical risk and firm performance

	(9) ROA _{diff}	(10) ROA _{diff}	(11) ROA	(12) ROA
L.BiN	-0.161 (0.713)		-0.016 (0.914)	
BiN x post2020		3.029** (0.969)		4.335*** (1.080)
L.BM	-0.635* (0.297)	-0.694* (0.298)	-7.119*** (0.600)	-7.204*** (0.596)
L.REV _g	-0.832 (0.485)	-0.823 (0.484)	3.972*** (0.566)	3.984*** (0.566)
L.Tang	-0.094 (1.034)	-0.093 (1.034)	-1.241 (1.327)	-1.240 (1.326)
L.Lev	5.105*** (0.916)	5.111*** (0.916)	-4.811** (1.630)	-4.803** (1.630)

L.Size	-1.335*** (0.200)	-1.325*** (0.199)	0.002 (0.414)	0.016 (0.413)
<i>Year (2003 – 2023)</i>	...	...	...	...
Constant	26.084*** (4.081)	25.893*** (4.060)	11.190 (8.534)	10.917 (8.520)
Observations	9731	9731	9731	9731
R^2	0.085	0.087	0.131	0.133
Adjusted R^2	0.083	0.084	0.128	0.130
F	17.025	16.451	17.260	17.100

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regarding the model (10) and model (12), the interaction term between physical biodiversity risk and the post-2020 period is positive and statistically significant with coefficients of 3.029 (significant at the 1% level) for ROA_{diff} and 4.335 (significant at the 0.1% level) for ROA. The positive impact of physical biodiversity risks on ROA after 2020, while seemingly contradictory to the conventional expectation of negative impacts from ecological risks, may reflect a shift in investor sentiment favoring firms with strong biodiversity risk management. This aligns with recent findings on "green" asset performance, where environmentally responsible firms experienced increased demand and perceived resilience due to heightened climate concerns, even if such investments don't yield traditionally high returns ([Pástor, Stambaugh, & Taylor, 2022](#)). Consequently, stakeholders may now view firms addressing biodiversity risks proactively as more sustainable and better positioned for long-term growth, thereby improving their perceived financial performance despite the associated risks.

Concerning the hypothesis 4th of our study, which is: “The impact of biodiversity awareness and biodiversity risks on firm performance amplifies after the year 2020”, the results have been mixed. Even so, most of the interaction term models show that the period after 2020 has seen a stronger positive response from stakeholders, reinforcing the view that firms addressing biodiversity proactively are increasingly favored in the market.

5. Conclusion

This study demonstrates that biodiversity awareness and biodiversity risks significantly influence firm performance, both in the short and long term, especially in the context of growing environmental awareness post-2020. Our results reveal that biodiversity awareness positively impacts firm performance, with this effect being more pronounced in the post-2020 period as firms align more closely with heightened stakeholder and regulatory expectations. Transition risks, particularly regulatory pressures, challenge firms' short-term profitability due to compliance costs; however, the post-2020 period highlights a potential strategic adaptation, where regulatory alignment begins to yield competitive advantages. Additionally, while physical biodiversity risks initially had a limited effect on performance, their significance has increased post-2020, indicating a shift in market valuation of proactive environmental management. Collectively, these findings underscore biodiversity risk management as a growing determinant of firm performance, with implications for both market participants and policymakers aiming to drive sustainable corporate behavior.

6. Discussion and limitations

The findings show that biodiversity-related risks and awareness are having a growing impact on firm performance, especially after 2020. This change seems to follow the rise of new regulations, like the Taskforce on Nature-related Financial Disclosures (TNFD), and stronger expectations from stakeholders. In this evolving landscape, firms that disclose biodiversity risks and comply with biodiversity-related regulations may experience reputational benefits, attracting stakeholders focused on environmental responsibility.

One potential explanation for the improved firm performance observed among biodiversity-conscious firms is the strategic adaptation to regulatory demands. Companies may be leveraging biodiversity risk management practices to meet compliance in ways that enhance operational efficiency and foster stronger stakeholder relations. However, the extent to which these strategic adaptations directly drive financial performance remains uncertain. Future research could explore this relationship, investigating whether firms that strategically manage biodiversity risks indeed reap greater financial rewards or whether other factors, such as investor sentiment and consumer preferences, play a more significant role.

Additionally, the results support the idea that biodiversity-related disclosures are becoming important for a firm's reputation, with potential long-term effects on investor behavior and profitability. As pressures from regulations and stakeholders continue to grow, firms that actively manage these risks might gain a competitive advantage. Further studies are needed to confirm whether these risk management practices are being leveraged effectively as strategic assets within broader corporate sustainability frameworks.

Several limitations should be considered in interpreting these findings. First, this study relies on a longitudinal dataset from 2002 to 2023, using textual analysis to derive biodiversity metrics from firm disclosures. Although comprehensive, this approach may not capture the full spectrum of biodiversity strategies or firm-specific responses to evolving environmental risks. Additionally, measuring biodiversity risk with binary variables may overlook finer distinctions in biodiversity practices, limiting insights into nuanced, industry-specific responses.

Finally, since the study focuses on U.S. publicly listed firms, the findings may not apply to other regions where biodiversity regulations and stakeholder expectations differ. Future studies could address these limitations by analyzing more detailed industry-specific data or by applying this approach internationally, providing a broader view of biodiversity's role in corporate finance and sustainability.

References

Adler, R., Mansi, M., & Pandey, R. (2018). Biodiversity and threatened species reporting by the top Fortune Global companies. *Accounting, Auditing & Accountability Journal*, 31(3), 787–825. <https://doi.org/10.1108/AAAJ-03-2016-2490>

Albanese, M., Caporale, G. M., Colella, I., & Spagnolo, N. (2024). The effects of physical and transition climate risk on stock markets: Some multi-country evidence. CESifo Working Paper No. 11184. *Munich Society for the Promotion of Economic Research* - CESifo GmbH. <https://ssrn.com/abstract=4882441>

Ali, R. (2023). Is biodiversity disclosure emerging as a key topic on the agenda of institutional investors? *Business Strategy and the Environment*, 33(3), 2116–2142. <https://doi.org/10.1002/bse.3587>

Ali, R., García-Sánchez, I.-M., Aibar-Guzmán, B., & Rehman, R. u. (2024). Is biodiversity disclosure emerging as a key topic on the agenda of institutional investors? *Business Strategy and the Environment*, 33(3), 2116–2142. <https://doi.org/10.1002/bse.3587>

Barber, B. M., & Lyon, J. D. (1996). Detecting abnormal operating performance: The empirical power and specification of test statistics. *Journal of Financial Economics*, 41(3), 359–399. [https://doi.org/10.1016/0304-405X\(96\)84701-5](https://doi.org/10.1016/0304-405X(96)84701-5)

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(1), 99-120. <https://doi.org/10.1177/014920639101700108>

Bebbington, J., & Larrinaga, C. (2014). Accounting and sustainable development: An exploration. *Accounting, Organizations and Society*, 39(6), 395-413. <https://doi.org/10.1016/j.aos.2014.01.003>

Bhagat, S., & Bolton, B. (2008). Corporate governance and firm performance. *Journal of Corporate Finance*, 14(3), 257–273. <https://doi.org/10.1016/j.jcorpfin.2008.03.006>

Biodiversity in Development Project. (2001). Strategic Approach for Integrating Biodiversity in Development Cooperation. *European Commission, Brussels, Belgium/IUCN, Gland, Switzerland and Cambridge, UK*. ISBN: 2-8317-0613-0.

Blanco-Zaitegi, G., Álvarez Etxeberria, I., & Moneva, J. M. (2022). Biodiversity accounting and reporting: A systematic literature review and bibliometric analysis. *Journal of Cleaner Production*, 371, 133677. <https://doi.org/10.1016/j.jclepro.2022.133677>

Boiral, O., & Heras-Saizarbitoria, I. (2017). Best practices for corporate commitment to biodiversity: An organizing framework from GRI reports. *Environmental Science & Policy*, 77, 77–85. <https://doi.org/10.1016/j.envsci.2017.07.012>

Boiral, O., Heras-Saizarbitoria, I. (2017) Managing Biodiversity Through Stakeholder Involvement: Why, Who, and for What Initiatives?. *J Bus Ethics* 140, 403–421. <https://doi.org/10.1007/s10551-015-2668-3>

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of Financial Economics*, 142(2), 517–549. <https://doi.org/10.1016/j.jfineco.2021.05.008>

Bruna, M. G., Loprevite, S., Raucci, D., & Ricca, B. (2022). Investigating the marginal impact of ESG results on corporate financial performance. *Finance Research Letters*, 47, 102828. <https://doi.org/10.1016/j.frl.2022.102828>

Buniamin, S. (2019). Managers' Perceptions on Stakeholder Power in Relation to ESG Reporting. *European Proceedings of Social and Behavioural Sciences*, 68, 140-149. <https://doi.org/10.15405/epsbs.2020.12.05.15>

Calice, Pietro & Kalan, Federico & Dunz, Nepomuk & Miguel, Faruk. (2023). Biodiversity and Finance: A Preliminary Assessment of Physical Risks for the Banking Sector in Emerging Markets. <https://doi.org/10.1596/1813-9450-10432>

Campello, M. (2006). Debt financing: Does it boost or hurt firm performance in product markets? *Journal of Financial Economics*, 82(1), 135–172. <https://doi.org/10.1016/j.jfineco.2005.04.001>

Carlos M. Duarte, Marianne Holmer, Yngvar Olsen, Doris Soto, Núria Marbà, Joana Guiu, Kenny Black, Ioannis Karakassis, Will the Oceans Help Feed Humanity?, *BioScience*, Volume 59, Issue 11, December 2009, Pages 967–976, <https://doi.org/10.1525/bio.2009.59.11.8>

Carvajal, M., Nadeem, M., & Zaman, R. (2022). Biodiversity disclosure, sustainable development and environmental initiatives: Does board gender diversity matter? *Business Strategy and the Environment*, 31(3), 969–987. <https://doi.org/10.1002/bse.2929>

Carvalho, S. H. C. de, Cojoianu, T., & Ascui, F. (2022). From impacts to dependencies: A first global assessment of corporate biodiversity risk exposure and responses. *Business Strategy and the Environment*, 32(5), 2600–2614. <https://doi.org/10.1002/bse.3142>

Chen, S., Song, Y., & Gao, P. (2023). Environmental, social, and governance performance and financial outcomes: Analyzing the impact of ESG on financial performance. *Journal of Environmental Management*, 345, 118829. <https://doi.org/10.1016/j.jenvman.2023.118829>

Chen, Z., & Xie, G. (2022). ESG disclosure and financial performance: Moderating role of ESG investors. *International Review of Financial Analysis*, 83, 102291. <https://doi.org/10.1016/j.irfa.2022.102291>

Costanza, R., d'Arge, R., de Groot, R. *et al.* The value of the world's ecosystem services and natural capital. *Nature* **387**, 253–260 (1997). <https://doi.org/10.1038/387253a0>

Convention on Biological Diversity. (2022). Kunming-Montreal Global Biodiversity Framework. Retrieved from <https://www.cbd.int/gbf>

COOPER, M.J., GULEN, H. and SCHILL, M.J. (2008), Asset Growth and the Cross-Section of Stock Returns. *The Journal of Finance*, 63: 1609-1651. <https://doi.org/10.1111/j.1540-6261.2008.01370.x>

Dasgupta, P. (2021). The Economics of Biodiversity: The Dasgupta Review (Final Report). *HM Treasury*. <https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review>

Dempsey, J. (2013). Biodiversity loss as material risk: Tracking the changing meanings and materialities of biodiversity conservation. *Geoforum*, 45, 41-51.

<https://doi.org/10.1016/j.geoforum.2012.04.002>

Donaldson, T., & Preston, L. E. (1995). The Stakeholder Theory of the Corporation: Concepts, Evidence, and Implications. *The Academy of Management Review*, 20(1), 65–91.

<https://doi.org/10.2307/258887>

Duffy, J. E., Godwin, C. M., & Cardinale, B. J. (2017). Biodiversity effects in the wild are common and as strong as key drivers of productivity. *Nature*, 549(7671), 261–264.

<https://doi.org/10.1038/nature23886>

Ellili, N. O. D. (2022). Impact of environmental, social, and governance disclosure on dividend policy: What’s the role of corporate governance? *Corporate Social Responsibility and Environmental Management*, 29(5), 1396-1413. <https://doi.org/10.1002/csr.2277>

Elmagrhi MH, Ntim CG, Elamer AA, Zhang Q. A study of environmental policies and regulations, governance structures, and environmental performance: The role of female directors. *Bus Strat Env*. 2019; 28: 206–220. <https://doi.org/10.1002/bse.2250>

Elsayed, R. A. A. (2023). Exploring the financial consequences of biodiversity disclosure: How does biodiversity disclosure affect firms’ financial performance? *Future Business Journal*, 9(22). <https://doi.org/10.1186/s43093-023-00202-7>

European Commission. (n.d.). A European Green Deal. Retrieved [Accessed on October 30, 2024], from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

FAMA, E.F. and FRENCH, K.R. (1992), The Cross-Section of Expected Stock Returns. *The Journal of Finance*, 47: 427-465. <https://doi.org/10.1111/j.1540-6261.1992.tb04398.x>

Freeman R.E. 1984. Strategic management: A stakeholder approach, Boston: Pitman.

Freeman, R. E. (2010). Strategic management: A stakeholder approach. *Cambridge University Press*.

- Friedman, A.L. and Miles, S. (2002), Developing Stakeholder Theory. *Journal of Management Studies*, 39: 1-21. <https://doi.org/10.1111/1467-6486.00280>
- Giglio, S., Kuchler, T., Stroebel, J., & Zeng, X. (2023). Biodiversity Risk (Working Paper No. 31137). *National Bureau of Economic Research*. <https://doi.org/10.3386/w31137>
- Giglio, Stefano and Kuchler, Theresa and Stroebel, Johannes and Wang, Olivier, The Economics of Biodiversity Loss (July 2024). *NBER Working Paper No. w32678*, Available at SSRN: <https://ssrn.com/abstract=4894672>
- Goddard, J., Tavakoli, M., & Wilson, J. O. S. (2005). Determinants of profitability in European manufacturing and services: evidence from a dynamic panel model. *Applied Financial Economics*, 15(18), 1269–1282. <https://doi.org/10.1080/09603100500387139>
- Gourdel, R., Monasterolo, I., Dunz, N., Mazzocchi, A., & Parisi, L. (2024). The double materiality of climate physical and transition risks in the euro area. *Journal of Financial Stability*, 71, 101233. <https://doi.org/10.1016/j.jfs.2024.101233>
- Hall, M., & Weiss, L. (1967). Firm Size and Profitability. *The Review of Economics and Statistics*, 49(3), 319–331. <https://doi.org/10.2307/1926642>
- Harrison, J. S. (2013). Stakeholder Theory, Value, and Firm Performance. *Business Ethics Quarterly*, 23(1), 97–124. <https://doi.org/10.5840/beq20132314>
- Hart, Stuart & Dowell, Glen. (2011). A Natural-Resource-Based View of the Firm: Fifteen Years After. *Journal of Management - J MANAGE*. 37. 1464-1479. <https://doi.org/10.1177/0149206310390219>.
- Hassan A, Elamer AA, Lodh S, Roberts L, Nandy M. The future of non-financial businesses reporting: Learning from the Covid-19 pandemic. *Corp Soc Responsib Environ Manag*. 2021; 28: 1231–1240. <https://doi.org/10.1002/csr.2145>
- Hassan, A. M., Roberts, L., & Atkins, J. (2020). Exploring factors relating to extinction disclosures: What motivates companies to report on biodiversity and species protection? *Business Strategy and the Environment*, 29(3), 1419-1436. <https://doi.org/10.1002/bse.2442>

Huang, H.H., Kerstein, J. & Wang, C. The impact of climate risk on firm performance and financing choices: An international comparison. *J Int Bus Stud* 49, 633–656 (2018).

<https://doi.org/10.1057/s41267-017-0125-5>

International Finance Corporation. (2024). Biodiversity finance metrics for impact reporting: Supplement to IFC biodiversity finance reference guide. *International Finance Corporation*.

<https://www.ifc.org/>

IPBES. (2019). Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. In Díaz, S., Settele, J., Brondízio, E., Ngo, H. T., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K. A., Butchart, S. H. M., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S. M., Midgley, G. F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, S., Purvis, A., Razzaque, J., Reyers, B., Chowdhury, R. R., Shin, Y. J., Visseren-Hamakers, I. J., Willis, K. J., & Zayas, C. N. (Eds.). IPBES Secretariat.

Jo, H., Kim, H. & Park, K. Corporate Environmental Responsibility and Firm Performance in the Financial Services Sector. *J Bus Ethics* 131, 257–284 (2015). <https://doi.org/10.1007/s10551-014-2276-7>

Johnson, J. A., Ruta, G., Baldos, U., Cervigni, R., Chonabayashi, S., Corong, E., Gavryliuk, O., Gerber, J., Hertel, T., Nootenboom, C., & Polasky, S. (2021). The Economic Case for Nature: A Global Earth-Economy Model to Assess Development Policy Pathways. *World Bank*. <https://openknowledge.worldbank.org/handle/10986/35882>. License: CC BY 3.0 IGO

Kalhor, M. R., & Kyaw, K. (2024). Manage biodiversity risk exposure? *Finance Research Letters*, 61, 104989. <https://doi.org/10.1016/j.frl.2024.104989>

Kapnick, S. (2022). The economic importance of biodiversity: Threats and opportunities. *J.P. Morgan Asset Management*. <https://www.rsmr.co.uk/rsmr-connected/industry-insights/j-p-morgan-asset-management/the-economic-importance-of-biodiversity-threats-and-opportunities/>

Karolyi, G. A., & Tobin-de la Puente, J. (2023). Biodiversity finance: A call for research into financing nature. *Financial Management*, 52, 231–251. <https://doi.org/10.1111/fima.12417>

- Kouloukoui, D., Sant'Anna, Â. M. O., Gomes, S. M. S., Marinho, M. M. de O., de Jong, P., Kiperstok, A., & Torres, E. A. (2019). Factors influencing the level of environmental disclosures in sustainability reports: Case of climate risk disclosure by Brazilian companies. *Corporate Social Responsibility and Environmental Management*, 26(4), 791–804.
<https://doi.org/10.1002/csr.1721>
- Kurth, T., Wübbels, G., Portafaix, A., Meyer zum Felde, A., & Zielcke, S. (2021). The biodiversity crisis is a business crisis. *Boston Consulting Group*. <https://www.bcg.com/>
- Liang, C., Yang, J., Shen, L., & Dong, D. (2024). The role of biodiversity risk in stock price crashes. *Finance Research Letters*, 67(Part A), 105856. <https://doi.org/10.1016/j.frl.2024.105856>
- Liang, J., Crowther, T. W., Picard, N., Wiser, S., Zhou, M., Alberti, G., ... & Reich, P. B. (2016). Positive biodiversity-productivity relationship predominant in global forests. *Science*, 354(6309), aaf8957. <https://doi.org/10.1126/science.aaf8957>
- Lin, Y., & Wu, L.-Y. (2014). Exploring the role of dynamic capabilities in firm performance under the resource-based view framework. *Journal of Business Research*, 67(3), 407–413.
<https://doi.org/10.1016/j.jbusres.2012.12.019>
- Long, W., Li, S., Wu, H., & Song, X. (2019). Corporate social responsibility and financial performance: The roles of government intervention and market competition. *Corporate Social Responsibility and Environmental Management*, 27(2), 525-541. <https://doi.org/10.1002/csr.1817>
- Margaritis, D., & Psillaki, M. (2010). Capital structure, equity ownership and firm performance. *Journal of Banking & Finance*, 34(3), 621–632.
- Max B. E. Clarkson. (1995). A Stakeholder Framework for Analyzing and Evaluating Corporate Social Performance. *The Academy of Management Review*, 20(1), 92–117.
<https://doi.org/10.2307/258888>
- NGFS-INSPIRE Study Group on Biodiversity and Financial Stability. (2022). Central banking and supervision in the biosphere: An agenda for action on biodiversity loss, financial risk and system stability. Network for Greening the Financial System (NGFS) *Occasional Paper*.

https://www.ngfs.net/sites/default/files/medias/documents/central_banking_and_supervision_in_the_biosphere.pdf

Newbert, S.L. (2007), Empirical research on the resource-based view of the firm: an assessment and suggestions for future research. *Strat. Mgmt. J.*, 28: 121-146. <https://doi.org/10.1002/smj.573>

Nohel, T., & Tarhan, V. (1998). Share repurchases and firm performance: New evidence on the agency costs of free cash flow. *Journal of Financial Economics*, 49(2), 187–222.

[https://doi.org/10.1016/S0304-405X\(98\)00022-1](https://doi.org/10.1016/S0304-405X(98)00022-1)

OECD (2019), Biodiversity: Finance and the Economic and Business Case for Action, *OECD Publishing*, Paris, <https://doi.org/10.1787/a3147942-en>.

Pástor, L., Stambaugh, R. F., & Taylor, L. A. (2022). Dissecting green returns. *Journal of Financial Economics*, 146(2), 403–424. <https://doi.org/10.1016/j.jfineco.2022.07.007>

Paul, C., Stein, C., Suding, K. N., Weisser, W. W., & Eisenhauer, N. (2020). On the functional relationship between biodiversity and economic value. *Science Advances*, 6, eaax7712.

<https://doi.org/10.1126/sciadv.aax7712>

Pörtner, H. O., Scholes, R. J., Arneth, A., Barnes, D. K. A., Burrows, M. T., Diamond, S. E., & Val, A. L. (2023). Overcoming the coupled climate and biodiversity crises and their societal impacts. *Science*, 380(6642), Article eabl4881. <https://doi.org/10.1126/science.abl4881>

Porto, R. G., de Almeida, R. F., Cruz-Neto, O., & Giannini, T. C. (2020). Pollination ecosystem services: A comprehensive review of economic values, research funding, and policy actions. *Food Security*, 12, 1425–1442. <https://doi.org/10.1007/s12571-020-01043-w>

Rhou, Y., Singal, M., & Koh, Y. (2016). CSR and financial performance: The role of CSR awareness in the restaurant industry. *International Journal of Hospitality Management*, 57, 30-39. <https://doi.org/10.1016/j.ijhm.2016.05.007>

Riahi-Belkaoui, A. (2003), "Intellectual capital and firm performance of US multinational firms: A study of the resource-based and stakeholder views", *Journal of Intellectual Capital*, Vol. 4 No. 2, pp. 215-226. <https://doi.org/10.1108/14691930310472839>

Roberts, L., Hassan, A., Elamer, A., & Nandy, M. (2020). Biodiversity and extinction accounting for sustainable development: A systematic literature review and future research developments. *Business Strategy and the Environment*, 30(1), 705–720.

<https://doi.org/10.1002/bse.2649>

Robins, J., & Wiersema, M. F. (1995). A Resource-Based Approach to the Multibusiness Firm: Empirical Analysis of Portfolio Interrelationships and Corporate Financial Performance.

Strategic Management Journal, 16(4), 277–299. <http://www.jstor.org/stable/2486958>

Steffan-Dewenter, I., Kessler, M., Barkmann, J., Bos, M. M., Buchori, D., Erasmi, S., Faust, H., Gerold, G., Glenk, K., Gradstein, S. R., Guhardja, E., Hertel, D., Höhn, P., Kappas, M., Köhler, S., Leuschner, C., Maertens, M., Marggraf, R., Migge-Kleian, S., Moge, J., Pitopang, R., Schaefer, M., Schwarze, S., Sporn, S. G., Steingrebe, A., Tjitrosoedirdjo, S. S., Tjitrosoemito, S., Twele, A., Weber, R., Woltmann, L., Zeller, M., & Tschardtke, T. (2007). Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. *Proceedings of the National Academy of Sciences*, 104(12), 4973–4978. <https://doi.org/10.1073/pnas.0608409104>

Taskforce on Nature-related Financial Disclosures. (2022). *TNFD Framework*. Retrieved from <https://tnfd.global/>

Theodoulidis, B., Diaz, D., Crotto, F., & Rancati, E. (2017). Exploring corporate social responsibility and financial performance through stakeholder theory in the tourism industries.

Tourism Management, 62, 173-188. <https://doi.org/10.1016/j.tourman.2017.03.018>

TITMAN, S. and WESSELS, R. (1988), The Determinants of Capital Structure Choice. *The Journal of Finance*, 43: 1-19. <https://doi.org/10.1111/j.1540-6261.1988.tb02585.x>

Torugsa, N., O'Donohue, W., & Hecker, R. (2012). Capabilities, proactive CSR, and financial performance in SMEs: Empirical evidence from an Australian manufacturing industry sector.

Journal of Business Ethics, 109(4), 483-500. <https://doi.org/10.1007/s10551-011-1141-1>

U.S. Department of State. (2022, December 15). Highlighting U.S. efforts to combat the biodiversity crisis. Retrieved from <https://www.state.gov/highlighting-u-s-efforts-to-combat-the-biodiversity-crisis/>

United Nations Convention to Combat Desertification (UNCCD) 2022. Global Land Outlook 2nd Edition. <https://www.unccd.int/resources/global-land-outlook/global-land-outlook-2nd-edition>.

Velte, P. (2023). Sustainable institutional investors and corporate biodiversity disclosure: Does sustainable board governance matter? *Corporate Social Responsibility and Environmental Management*, 30(6), 3063–3074. <https://doi.org/10.1002/csr.2537>

Weber, O. (2013). Environmental, Social and Governance Reporting in China. *Business Strategy and the Environment*, 23(5), 303-317. <https://doi.org/10.1002/bse.1785>

Wilson, E. O. (1988). Biodiversity. *National Academy Press*.

World Economic Forum. (2020). The Global Risks Report 2020 (15th ed.). *World Economic Forum*. <https://www.weforum.org/publications/the-global-risks-report-2020/>

World Economic Forum. (a) (2010). The Global Risks Report 2010. *World Economic Forum*. https://www3.weforum.org/docs/WEF_Global_Risks_Report_2010.pdf

World Economic Forum. (b) (2010). Biodiversity and Business Risk: A Global Risks Network Briefing. Prepared by PricewaterhouseCoopers for the World Economic Forum. Geneva, Switzerland.

Zhou, G., Liu, L., & Luo, S. (2022). Sustainable development, ESG performance, and company market value: Mediating effect of financial performance. *Business Strategy and the Environment*, 31(7), 3371-3387. <https://doi.org/10.1002/bse.3089>

Annex

Table 1A: Regression model results exploring relationship between biodiversity attentions and firm performance including year effects

	(1) ROA _{diff}	(2) ROA _{diff}	(3) ROA	(4) ROA
L.BiC	-0.616 (0.366)		-0.053 (0.654)	
L.BiC x Post2020		1.923** (0.726)		2.390 (1.380)
L.BM	-0.633* (0.298)	-0.677* (0.298)	-7.119*** (0.601)	-7.174*** (0.599)
L.REV _g	-0.832 (0.484)	-0.841 (0.484)	3.972*** (0.566)	3.960*** (0.566)
L.Tang	-0.094 (1.034)	-0.095 (1.032)	-1.241 (1.326)	-1.243 (1.324)
L.Lev	5.084*** (0.915)	5.075*** (0.915)	-4.813** (1.628)	-4.824** (1.628)
L.Size	-1.337*** (0.200)	-1.316*** (0.199)	0.001 (0.414)	0.027 (0.412)
2003	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)
2004	2.604*** (0.574)	2.602*** (0.576)	-1.856 (1.430)	-1.859 (1.430)
2005	1.213*** (0.309)	1.218*** (0.311)	0.422 (0.478)	0.428 (0.474)
2006	0.416 (0.289)	0.421 (0.291)	0.499 (0.468)	0.506 (0.464)
2007	0.074 (0.271)	0.077 (0.273)	0.256 (0.477)	0.260 (0.473)
2008	-0.370 (0.292)	-0.369 (0.294)	-0.374 (0.508)	-0.373 (0.505)
2009	-0.658* (0.331)	-0.648 (0.333)	0.568 (0.477)	0.581 (0.473)
2010	2.644*** (0.317)	2.642*** (0.319)	2.071*** (0.475)	2.069*** (0.471)
2011	1.436*** (0.268)	1.435*** (0.270)	1.188* (0.478)	1.187* (0.474)
2012	0.625* (0.257)	0.624* (0.259)	1.503** (0.463)	1.502** (0.459)
2013	0.657* (0.260)	0.656* (0.262)	1.494** (0.500)	1.494** (0.496)
2014	0.977*** (0.287)	0.970*** (0.289)	0.633 (0.525)	0.623 (0.521)
2015	0.598* (0.275)	0.587* (0.277)	0.403 (0.516)	0.390 (0.512)
2016	0.266 (0.276)	0.260 (0.278)	0.756 (0.527)	0.748 (0.522)

2017	1.361*** (0.283)	1.354*** (0.284)	0.972 (0.515)	0.964 (0.511)
2018	2.173*** (0.291)	2.165*** (0.293)	1.694** (0.549)	1.684** (0.544)
2019	0.229 (0.288)	0.225 (0.290)	1.807** (0.552)	1.802** (0.548)
2020	-0.625 (0.348)	-1.402** (0.530)	0.393 (0.593)	-1.126 (0.605)
2021	3.560*** (0.347)	2.779*** (0.533)	3.135*** (0.644)	1.612** (0.573)
2022	1.597*** (0.361)	0.809 (0.524)	2.058** (0.662)	0.526 (0.529)
2023	0.787 (0.576)	0.000 (.)	1.531 (0.857)	0.000 (.)
Constant	26.152*** (4.083)	25.741*** (4.058)	11.196 (8.528)	10.685 (8.496)
Observations	9731	9731	9731	9731
R^2	0.085	0.086	0.131	0.132
Adjusted R^2	0.083	0.084	0.128	0.129
F	17.093	16.640	17.146	16.762

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2A: Regression model results exploring the relationship between regulation (transition) risk and firm performance including year effects

	(1) ROA _{diff}	(2) ROA _{diff}	(3) ROA	(4) ROA
L.BiR	-1.306* (0.591)		-0.955 (1.050)	
L.BiR x post2020		2.785** (0.978)		4.102* (1.720)
L.BM	-0.621* (0.298)	-0.688* (0.298)	-7.108*** (0.602)	-7.207*** (0.599)
L.REV _g	-0.828 (0.485)	-0.834 (0.484)	3.974*** (0.566)	3.965*** (0.566)
L.Tang	-0.108 (1.033)	-0.111 (1.031)	-1.250 (1.326)	-1.255 (1.322)
L.Lev	5.062*** (0.915)	5.045*** (0.915)	-4.846** (1.626)	-4.870** (1.625)
L.Size	-1.342*** (0.200)	-1.322*** (0.198)	-0.004 (0.413)	0.026 (0.411)
2004	2.603*** (0.573)	2.599*** (0.575)	-1.858 (1.429)	-1.864 (1.429)
2005	1.203*** (0.309)	1.203*** (0.312)	0.414 (0.478)	0.414 (0.471)
2006	0.410 (0.289)	0.411 (0.293)	0.494 (0.468)	0.496 (0.462)

2007	0.068 (0.270)	0.067 (0.274)	0.254 (0.477)	0.252 (0.471)
2008	-0.369 (0.292)	-0.367 (0.295)	-0.374 (0.508)	-0.371 (0.502)
2009	-0.656* (0.331)	-0.641 (0.335)	0.570 (0.477)	0.592 (0.470)
2010	2.646*** (0.317)	2.647*** (0.320)	2.068*** (0.475)	2.070*** (0.468)
2011	1.444*** (0.267)	1.445*** (0.270)	1.195* (0.476)	1.196* (0.469)
2012	0.625* (0.257)	0.625* (0.260)	1.503** (0.463)	1.502** (0.456)
2013	0.663* (0.260)	0.665* (0.264)	1.503** (0.500)	1.505** (0.493)
2014	0.983*** (0.287)	0.975*** (0.290)	0.638 (0.525)	0.626 (0.518)
2015	0.603* (0.274)	0.594* (0.277)	0.408 (0.516)	0.394 (0.509)
2016	0.270 (0.276)	0.267 (0.278)	0.760 (0.526)	0.754 (0.519)
2017	1.368*** (0.283)	1.364*** (0.285)	0.980 (0.514)	0.974 (0.506)
2018	2.186*** (0.292)	2.184*** (0.294)	1.707** (0.548)	1.703** (0.540)
2019	0.237 (0.288)	0.241 (0.291)	1.816** (0.552)	1.822*** (0.545)
2020	-0.612 (0.348)	-1.422** (0.530)	0.405 (0.592)	-1.173 (0.604)
2021	3.571*** (0.347)	2.761*** (0.533)	3.147*** (0.643)	1.568** (0.573)
2022	1.603*** (0.361)	0.792 (0.524)	2.068** (0.662)	0.489 (0.529)
2023	0.783 (0.577)	0.000 (.)	1.539 (0.857)	0.000 (.)
Constant	26.284*** (4.087)	25.900*** (4.049)	11.340 (8.512)	10.773 (8.471)
Observations	9731	9731	9731	9731
R^2	0.086	0.087	0.131	0.133
Adjusted R^2	0.083	0.084	0.129	0.131
F	17.101	16.571	17.105	16.742

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Regression results examining the relationship between Biodiversity physical risk and firm performance

	(1)	(2)	(3)	(4)
--	-----	-----	-----	-----

	ROAdiff	ROAdiff	ROA	ROA
L.BiN	-0.161 (0.713)		-0.016 (0.914)	
BiN x post2020		3.029** (0.969)		4.335*** (1.080)
L.BM	-0.635* (0.297)	-0.694* (0.298)	-7.119*** (0.600)	-7.204*** (0.596)
L.REV _g	-0.832 (0.485)	-0.823 (0.484)	3.972*** (0.566)	3.984*** (0.566)
L.Tang	-0.094 (1.034)	-0.093 (1.034)	-1.241 (1.327)	-1.240 (1.326)
L.Lev	5.105** (0.916)	5.111** (0.916)	-4.811** (1.630)	-4.803** (1.630)
L.Size	-1.335*** (0.200)	-1.325*** (0.199)	0.002 (0.414)	0.016 (0.413)
2003	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)
2004	2.604*** (0.574)	2.602*** (0.575)	-1.856 (1.430)	-1.860 (1.429)
2005	1.213*** (0.309)	1.210*** (0.312)	0.422 (0.478)	0.418 (0.473)
2006	0.415 (0.289)	0.416 (0.292)	0.499 (0.468)	0.500 (0.463)
2007	0.071 (0.270)	0.071 (0.273)	0.256 (0.477)	0.256 (0.471)
2008	-0.371 (0.292)	-0.371 (0.295)	-0.374 (0.508)	-0.374 (0.503)
2009	-0.659* (0.331)	-0.648 (0.334)	0.568 (0.477)	0.585 (0.471)
2010	2.650*** (0.317)	2.653*** (0.320)	2.072*** (0.475)	2.076*** (0.469)
2011	1.435*** (0.268)	1.434*** (0.271)	1.188* (0.478)	1.186* (0.472)
2012	0.624* (0.256)	0.625* (0.260)	1.503** (0.463)	1.503** (0.457)
2013	0.653* (0.260)	0.660* (0.264)	1.494** (0.500)	1.505** (0.494)
2014	0.976*** (0.287)	0.980*** (0.289)	0.632 (0.525)	0.638 (0.519)
2015	0.597* (0.275)	0.598* (0.278)	0.403 (0.516)	0.404 (0.510)
2016	0.266 (0.276)	0.274 (0.279)	0.756 (0.526)	0.768 (0.521)
2017	1.360*** (0.283)	1.369*** (0.285)	0.972 (0.515)	0.985 (0.509)
2018	2.170*** (0.292)	2.176*** (0.294)	1.694** (0.549)	1.703** (0.543)
2019	0.225 (0.288)	0.241 (0.290)	1.806** (0.552)	1.829*** (0.548)

2020	-0.628 (0.348)	-1.439** (0.530)	0.393 (0.593)	-1.194* (0.603)
2021	3.555*** (0.347)	2.746*** (0.532)	3.135*** (0.645)	1.549** (0.571)
2022	1.589*** (0.360)	0.779 (0.523)	2.057** (0.663)	0.473 (0.527)
2023	0.771 (0.576)	0.000 (.)	1.529 (0.858)	0.000 (.)
Constant	26.084*** (4.081)	25.893*** (4.060)	11.190 (8.534)	10.917 (8.520)
Observations	9731	9731	9731	9731
R^2	0.085	0.087	0.131	0.133
Adjusted R^2	0.083	0.084	0.128	0.130
F	17.025	16.451	17.260	17.100

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$