Biodiversity Risk in the Corporate Bond Market

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Abstract

We investigate how risks associated with biodiversity loss influence borrowing costs in the US corporate bond market. Using a market-based measure of biodiversity risk for firms, we find that higher biodiversity risk exposure is associated with higher yield spreads among long-term bonds, indicating biodiversity as a long-run risk. This effect is stronger among riskier firms and firms that mention biodiversity, particularly biodiversity regulation, in their financial statements. Using the adoption of the Kunming-Montreal Global Biodiversity Framework as an experiment, we find that the impact of biodiversity risk on yield spreads is more pronounced when biodiversity-related awareness and regulatory risks rise.

Keywords: Biodiversity Risk; Climate Change; Corporate Bonds; Cost of Capital; Yield Spread.

JEL Codes: G12; G18; G32; Q54.

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1. Introduction

Biodiversity—the variety of living species in the ecosystem—is crucial for sustaining the natural environment that humans depend on. Its economic value is estimated to be in the trillions of dollars.[1] This biodiversity, essential to the economy in many ways, is in decline: A quarter of the world's plant and animal species face extinction, driven by factors such as land use, pollution, and overexploitation (OECD (2021)).

Firms that rely on natural inputs could be negatively affected by a decline in biodiversity and the uncertainties created by it (e.g., Costanza et al. (1997), Karolyi and Tobin de la Puente (2023), Giglio et al. (2023)). Policies aimed at preventing biodiversity loss, including legally binding targets and disclosure requirements regarding firms' environmental footprints, may expose firms to additional regulatory risks. Furthermore, these exposed firms may be at a disadvantage compared to firms that benefit from incentive programs and changes in consumer preferences, similar to how brown companies lagged behind green companies as climate concerns mounted (e.g., Pastor, Stambaugh, and Taylor (2022)).

In the spirit of Pastor, Stambaugh, and Taylor's (2021) equilibrium model, if assets with lower biodiversity risk exposure provide a hedge against biodiversity risk, lower (higher) biodiversity risk would be associated with lower (higher) expected returns. On the other hand, unexpected escalations in biodiversity concerns may increase investors' preference for assets with lower biodiversity risk, leading to higher prices and higher realized returns for assets with lower—rather than higher—biodiversity risk, seemingly contradicting the risk return tradeoff. Coqueret, Giroux, and Zerbib (2024) indeed find this to be the case for US stocks.

[1] For the estimated economic value of diversity, refer to the reports by the Organisation for Economic Co-operation and Development (OECD) (2004), the United Nations Environment Programme (2022), or the World Economic Forum (2020). As an example, pollinators alone provide $200 billion worth of ecological services annually (https://usafacts.org/articles/what-is-the-loss-of-bees-costing-the-us/).

The bond market, however, offers a clean setting to understand the influence of biodiversity risk on firms' cost of borrowing. Bond yields should increase with issuers' biodiversity risk exposure to the extent that it negatively impacts issuers' creditworthiness and creditors' preferences. If biodiversity concerns escalate, bond yields should further increase for issuers with higher biodiversity risk exposure. The variation in bond maturities also allows for studying the term-structure effects of biodiversity risk. Our paper is the first to study this hypothesis and to document that higher biodiversity risk exposure is linked to higher cost of long-term borrowing in the US, with short-term borrowing costs also increasing following the United Nations Biodiversity Conference (COP15) that elevated biodiversity-related awareness and regulatory risks.

The ideal measure of a firm's economic exposure to biodiversity risk should capture both physical and transition (i.e., regulatory) risks associated with biodiversity loss. It should also vary over time as a firm's exposure to these risks changes, for instance, due to shifts in actual biodiversity loss, preferences of creditors, biodiversity regulations, and the firm's endogenous responses to such developments. Additionally, it should weigh these risks to the degree of their economic importance for firms. We construct a market-based measure of biodiversity risk exposure for firms that potentially satisfies these criteria.

The intuition is that firms whose stocks react more negatively to the innovations in adverse biodiversity news are expected to have greater financial exposure to biodiversity risk. We use the macro-level biodiversity news index of Giglio et al. (2023) to identify these news, and estimate a firm's biodiversity sensitivity on a rolling window basis by regressing its stock returns on innovations in the news index. We reverse the sign of the biodiversity coefficient so that higher values correspond to greater economic exposure to biodiversity risk.[2] When estimating

[2] We estimate biodiversity sensitivity for a firm using its stock returns instead of its bond returns because stock prices are more informative than bond prices (e.g., Kwan (1996), Downing, Underwood, and Xing (2009), Norden and Weber

biodiversity sensitivity, we also control for innovations in the climate news index of Giglio et al. (2023) to distinguish between biodiversity and climate risks.[3]

Our sample includes 1,360 firms that contribute over one million monthly secondary market yield spreads—the difference between the yields of corporate bonds and maturity-matched Treasury bonds—between 2002 and 2022. To begin with, we examine the drivers of our biodiversity sensitivity estimates and find that they positively correlate with firms' biodiversity footprints. For instance, firms with physical assets located in areas with rich biodiversity, whose operations depend on nature-related inputs, and those that generate more of their revenues from business activities contributing to deforestation have higher biodiversity sensitivities. Additionally, biodiversity sensitivities increase after the COP15 conference, suggesting that they respond to significant biodiversity events.

We then examine the influence of biodiversity sensitivity on yield spreads. Controlling for bond-, issuer-, and macro-level determinants of yield spreads, including firm fixed effects that account for time-invariant unobservable issuer characteristics, we find that biodiversity sensitivity is positively and significantly related to yield spreads among long-term bonds: A one-standard-deviation increase in biodiversity sensitivity is associated with a 3% increase in the yield spreads of bonds maturing in over 20 years. The economic magnitude of this effect is comparable to that of climate risk on long-term bond yields (Painter (2020)). Consistent with biodiversity risk being long term in nature, this relation is statistically insignificant among short-term bonds.

(2009)). Additionally, since biodiversity risk is a firm-level concept, this approach addresses the concern that a firm with multiple bonds outstanding may have conflicting biodiversity sensitivities when estimated at the bond-level. We elaborate on our empirical choices later in the paper.

[3] Biodiversity and climate news indexes are positively correlated, with a correlation coefficient of 0.22.

Next, we examine the mechanism driving the positive relation between biodiversity sensitivity and yield spreads. If this relation is associated with firms' biodiversity risk exposure, we expect it to be more pronounced among firms that mention biodiversity in their annual financial statements (10Ks). This is because investors would pay more attention to these firms' biodiversity characteristics. In line with this prediction, the biodiversity effect is twice as large as our baseline estimate among firms that mention biodiversity in their 10Ks. This estimate is even larger when their 10Ks also mention biodiversity regulation, suggesting that investors pay particular attention to biodiversity regulation (i.e., the transition risk).

These firms, which care enough about biodiversity to mention it in their 10Ks, are mostly from the utilities and energy sectors that are also exposed to high climate risks. This observation is consistent with biodiversity loss and climate change being interconnected environmental risks. In addition, the biodiversity effect is more pronounced during periods of more negative news about climate change, providing further evidence of the interaction between these environmental risks.

We also examine how our baseline estimate varies with the credit quality of bonds. Since prices of riskier bonds tend to be more sensitive to the changes in their issuers' credit quality (e.g., Merton (1974)), we expect the positive relation between biodiversity sensitivity and yield spreads to be more pronounced among riskier bonds. Indeed, we find that to be the case.

If our results are driven by biodiversity-related risks, we expect to find stronger results after events that increase such risks. A significant biodiversity event during our analysis period is the COP15, which formulated global policies to address global biodiversity loss and raised awareness of this problem. The first part of this conference took place in October 2021 with the participation of 188 countries, and the second part took place in December 2022, resulting in the adoption of the Kunming-Montreal Global Biodiversity Framework. This framework sets various biodiversity targets, such as those related to the monitoring and disclosure of firms' biodiversity impact, to be achieved as early as 2030.

We find that the yield spreads of bonds issued by firms with higher biodiversity sensitivities increase after the COP15: A one-standard-deviation increase in biodiversity sensitivity is associated with an approximately 4% higher yield spreads following the COP15. Since the COP15 does not increase the physical risk of biodiversity loss, an increase in transition risk or investor attention to biodiversity could be driving this result.

The COP15 effect observed after October 2021 persists until the end of our analysis period in December 2022, which coincides with the second part of the COP15. Furthermore, we find that this result is significant only among short-term bonds. Among long-term bonds, biodiversity sensitivity is already priced before the COP15. It appears that investors updated their prior beliefs in that, following the COP15, they expect biodiversity-related risks to materialize within 20 years.

Do firms' biodiversity initiatives mitigate these biodiversity-related risks? We find that firms that implement biodiversity initiatives have high biodiversity sensitivity to begin with. However, these initiatives do not appear to mitigate firms' biodiversity risk exposure as reflected in their yield spreads and biodiversity sensitivities. Given the endogenous nature of biodiversity actions, more research is necessary to understand the causal relation between biodiversity-friendly corporate practices and cost of borrowing.

The literature on biodiversity finance has largely focused on problems with funding of biodiversity projects and recommended policy implementations (e.g., Arlaud et al. (2018), Chenet et al. (2022), Flammer et al. (2023), Parker et al. (2010), Rubino (2000)). An emerging literature investigates the implications of biodiversity risk on stock returns. Giglio et al. (2023), Coqueret, Giroux, and Zerbib (2024), and Naffa and Czupy (2024) document that biodiversity risk is priced in the US stock market, but Xiong (2023) and Garel et al. (2024) do not find evidence of it in international stock markets.

On the debt markets side, Cherief et al. (2022) study the Australian and Brazilian corporate bond markets and find that bond spreads of exposed issuers increase after acute biodiversity events. Mulder and Koellner (2011) provide survey evidence that bankers consider biodiversity risk when making lending decisions, and Calice et al. (2023) examine banks' balance sheet exposure to biodiversity risk. Hoepner at al. (2023) document a lower spread on longer-term credit default swaps of firms with more effectively environmental risk management practices. Chen et al. (2024) find that biodiversity regulation increases the cost of public capital in China.

Our paper is the first to examine biodiversity risk in the US corporate bond market and shows that firms with higher biodiversity risk exposure face higher borrowing costs. Given that biodiversity is largely a public good, it necessitates intervention to address the tragedy of the commons problem. Nevertheless, biodiversity policies may be ineffective due to challenges in quantifying a firm's net contribution to a reduction in ecosystem services (Garel et al. (2024)). Our findings suggest that financial markets can help achieve sustainability goals by incentivizing firms to effectively address biodiversity-related issues, as the corporate bond market penalizes (rewards) firms that have high (low) biodiversity risk exposure.

2. Data, Sample Selection, and Variables

Both physical and transition risks associated with biodiversity loss can influence a firm's credit riskiness. The physical risk arises from the firm's dependence on biodiversity-related inputs for operations. The transition risk, on the other hand, is related to the costs of changing regulatory policies and customer preferences that come with transitioning to a biodiversity-conscious economy. Consequently, the ideal biodiversity risk measure should capture both physical and transition risks, and vary through time as these risks evolve.

Since a biodiversity risk measure with such properties is not readily available to us, we construct our own. We define this measure as the sensitivity of a firm's stock returns to innovations in negative biodiversity news. The intuition is that stocks that react more negatively to these adverse biodiversity news are more likely to experience negative shocks when biodiversity-related physical or transition risks materialize in the future.

We use the biodiversity news index of Giglio et al. (2023) to measure the arrival of adverse biodiversity-related news. To construct this news index, the authors first build a biodiversity dictionary that contains biodiversity-related terms, such as ecology, species, and wildlife. They then identify the *New York Times* articles that contain at least two biodiversity sentences. Next, they categorize biodiversity sentences as positive or negative following the Bidirectional Encoder Representations from Transformers Model (Devlin et al. (2018)) and classify a news article as having positive (negative) sentiment if all biodiversity sentences in the article are positive (negative).

The daily biodiversity news index reports the difference between the numbers of negative and positive biodiversity articles every day between 2000 and 2022. Hence, higher index values correspond to more negative biodiversity sentiment. We download this data set from Giglio et al.'s (2023) affiliated website (www.biodiversity.org). Following the authors' approach, we construct the monthly biodiversity news index as monthly averages of the daily series and create the innovations in this index as residuals from an AR(1) model. Figure 1 plots the innovation series and provides anecdotal evidence that the index values respond to major biodiversity-related events, such as the revisions made to the Endangered Species Act by the Trump administration in August 2019, which weakened protections for threatened species.

To estimate biodiversity news sensitivities (henceforth, biodiversity sensitivities) of firms, we obtain their stock returns from the Center for Research in Security Prices (CRSP) database and run the following regression in each month t for each stock of firm i using the previous 5 years of monthly returns on a rolling-window basis:

$$
\begin{aligned}
R_{i,t} = \alpha + \beta_1 &\textit{Biodiversity News Innovation}_t \\
&+ \beta_2 \textit{Climate News Innovation}_t + \beta_3 \textit{Other Controls} + \varepsilon_{i,t} ,
\end{aligned}
\tag{1}
$$

where $R_{i,t}$ is the stock return of firm i in month t minus the return on a 1-month Treasury bill obtained from Kenneth French's website[4], and $\textit{Biodiversity News Innovation}_t$ is the innovations in the monthly biodiversity news index.[5]

The coefficient estimate on $\textit{Biodiversity News Innovation}_t$ (β_1) is the biodiversity sensitivity that we use as a proxy for a firm's biodiversity risk exposure in a month. As we illustrate later, this measure has favorable qualities, as it varies both within (over time) and across (cross-sectionally) firms. We require at least 24 observations to estimate the coefficients. Nevertheless, we show in Section 4 that our baseline finding is robust to enforcing nonmissing observations (60 monthly returns) in this estimation step. We invert the sign of biodiversity sensitivity so that higher biodiversity sensitivity indicates higher exposure to biodiversity risk, reflecting a more negative stock market reaction to negative biodiversity news.

A firm's exposure to biodiversity and climate risks may be jointly determined, since changes in climate influence biodiversity on Earth (e.g., MacDougall (1998), Giglio et al. (2021)).

[4] mba.tuck.dartmouth.edu/pages/faculty/ken.french

[5] We use monthly returns and a 5-year estimation window because this is the standard approach to studying stock return sensitivities (e.g., Fama and French (1992)).

To distinguish between biodiversity and climate risks, the regression model in Equation (1) controls for *Climate News Innovation*$_t$ computed using Giglio et al.'s (2023) monthly climate news index. We invert the sign of this climate news sensitivity (β_2) as well so that its higher values are associated with higher climate risk exposure.

Other Controls in this regression include the Fama–French (1993) factors: excess market return (MKT_t), size (SMB_t), and value (HML_t) factors downloaded from Wharton Research Data Services (WRDS). This way, biodiversity sensitivity (β_1) estimates the sensitivity of stock returns to innovations in biodiversity news independent of the stock's sensitivity to innovations in climate news and other determinants of stock returns. We show in Section 4 that implementing an asset pricing model that also includes the momentum factor (i.e., the four-factor model) does not materially influence our baseline estimates.

We purposely estimate a firm's biodiversity sensitivity using its stock returns rather than its bond returns, because biodiversity risk is a firm-level concept. Another reason for this is that bond-level estimates would be influenced by bond characteristics, creating noise in firm-level estimates of biodiversity risk exposure. To test this argument, we estimate *Biodiversity Sensitivity* for each bond annually in June using its excess bond returns. In these regressions, we control for bond factors (excess bond market returns, term spread, and credit spread) instead of the stock factors (*MKT*, *SMB*, and *HML*). We then examine the within-firm variation in bond-level biodiversity sensitivity.

We run a regression of bond-level biodiversity sensitivity estimates controlling for firm-year fixed effects. One minus R-squared value from this regression indicates the degree to which bond-level biodiversity sensitivity is explained by bond specific characteristics (e.g., seniority, security, liquidity, embedded options).[6] We find in untabulated tests that, among firms with multiple bond-level estimates in a year, firm-year fixed effects explain about 30% of the variation in biodiversity sensitivity. This suggests that the remaining 70% of the variation is driven by bond-specific factors, making bond-level biodiversity sensitivity a poor candidate for measuring a firm's biodiversity risk exposure.

We estimate stock-based biodiversity sensitivities starting in June 2002. This is because the transaction-level bond prices from the TRACE Enhanced database are available since July 2002. As we discuss in Section 3, our baseline regression model estimates the relation between monthly yield spreads on a firm's bonds and its 1-month lagged biodiversity sensitivity.

During our analysis period between July 2002 and December 2022, the TRACE Enhanced database comprises approximately 327 million observations. We use the WRDS codes that follow the methodology of Dick-Nielsen (2009, 2014) to eliminate canceled, corrected, reversed, and doublecounted trades.[7] Additionally, we exclude trades executed on weekends and holidays, identified using the New York Stock Exchange's calendar. After these steps, we are left with approximately 190 million transactions. This roughly 40% reduction in sample size due to erroneous entries is consistent with statistics reported in the literature (Bessembinder et al. (2022), Dick-Nielsen et al. (2012), Edwards et al. (2007)).

We calculate daily prices as the trade-size-weighted average of transaction prices each day. Then, we keep the last day of each calendar month with available prices to construct a data set of monthly bond prices. To remove potential outliers and severely distressed bonds, we drop

[6] We would need to control for firm-month fixed effects for this interpretation, but the large number of firm-month combinations makes it infeasible to fit this regression.

[7] These codes were written and tested by Qingyi (Freda) Song Drechsler in October 2017.

weighted average prices greater than $200 or less than $10. At this stage, our sample includes approximately 3 million monthly bond prices.

Using the WRDS linking file, we merge these monthly bond prices with their issuer identifiers. We obtain the financial characteristics of these issuers from their latest annual reports preceding each trade date using the COMPUSTAT database. We drop financial firms (Standard Industrial Classification (SIC) codes in 6000s) and firms with missing financial information (missing total assets). Then, we obtain bond characteristics from the Fixed Income Securities Database (FISD) and keep the corporate bonds that are US dollar denominated, publicly placed (e.g., non-144A, non-REGS), and nonconvertible. We drop zero coupon bonds and bonds with variable coupon rates.[8] We further restrict our sample to bonds maturing in at least 1 year and exclude perpetual bonds and those maturing in more than 100 years. We run additional sanity checks to ensure data accuracy. For instance, we drop any bond from the sample if it is traded after its maturity date.

Our final sample includes 1,048,168 bond-month observations contributed by 22,359 bonds issued by 1,360 firms. Using coupon and maturity information, we calculate yield to maturities of these bonds in each month using their weighted average prices observed on the last trading day of the month. This last trading day may not coincide with the end of the calendar month if the last trade occurred earlier than that. In Section 4, we show that our findings are robust to using prices during the last 10 calendar days of the month.

To compute yield spreads—the primary dependent variable in this study—we access the historical term structure of interest rates from the Treasury's website.[9] We define yield spread on

[8] We drop zero-coupon corporate bonds, as we notice that they are likely to be equity-linked notes.

[9] https://home.treasury.gov/policy-issues/financing-the-government/interest-rate-statistics

a bond as the difference between the bond's yield on a trade date and the maturity-matched Treasury bond's yield on the same date. When an exact maturity match is unavailable, we use the linearly interpolated Treasury yields to compute yield spreads.

Table 1 reports summary statistics for the dependent (*Yield Spread*) and independent variables used in our baseline regressions, and Appendix A provides their detailed definitions. The average *Yield Spread* is 2.36% with a standard deviation of 4.50%. This indicates that the borrowing costs for firms in our sample are 2.36 percentage points larger than those of maturity-matched Treasury bonds, consistent with corporate bonds being riskier than Treasury bonds.

The average *Biodiversity Sensitivity* (× 100) is 0.36 with a standard deviation of 7.73. Examining the panel properties of the standard deviation, we find that between-firm and within-firm standard deviations are 11.92% and 6.15%, respectively. These statistics indicate that the variation in biodiversity sensitivity is greater across firms than within firms. Consistent with this observation, we find that firm-year fixed effects explain the majority of the variation (87%) in biodiversity sensitivity, while the remaining 13% is attributed to variation within a firm-year.

We control for *Climate Sensitivity*, *Market Beta*, *Size Beta*, and *Value Beta* factors in our regressions. *Climate Sensitivity* has an average value of −0.80. As expected, average *Market Beta* in our large sample of public firms is close to one (1.03), and *Size* (0.04) and *Value* (0.30) *Betas* are within the range reported in the literature (Detzel et al. (2023), Fama and French (2010, 2012)).

The average bond in our sample has a time to maturity of 10.40 years and is traded 79.23 times in a month. Senior bonds (89.99%) and callable bonds (76.86%) make up the majority of the observations in our sample. Secured bonds, puttable bonds, and bonds with sinking fund provisions comprise 8.03%, 1.20%, and 0.29% of our sample, respectively.

The firms in our sample have an average total asset value of $117 billion, consistent with bond issuers being large and established firms. These firms, on average, have a cash-to-assets ratio of 0.08, leverage ratio of 0.40, net income-to-assets ratio of 0.04, and earnings before interest, taxes, depreciation, and amortization (EBITDA) that is 10.00 times their interest expenses. These ratios suggest that our sample firms are on average financially healthy. The average monthly stock return is 0.91% with a standard deviation of 8.72%. This positive monthly return also indicates that the average firm in our sample is far from financial distress.

In addition to firm- and bond-level variables, our regressions control for macro-level variables. As of each trade date, we obtain the term spread (*10yr-2yr Term Spread*) on the Treasury yield curve, the spread between London Inter-Bank Offered Rate (LIBOR) and Overnight Index Swap (OIS) rates (*LIBOR-OIS Spread*), and the credit spread between the yields of BBB- and AAA-rated bonds (*BBB-AAA Spread*) from Bloomberg. Average *10yr-2yr Term Spread* is 1.22%, indicating that the Treasury yield curve is on average upward sloping during our analysis period. *LIBOR-OIS Spread*, which proxies for distress in the banking sector, is on average 0.24%. This is consistent with OIS contracts, in which the principal is not exchanged, facing lower credit risk than LIBOR. Finally, *BBB-AAA Spread* is on average 1.04%, suggesting that yields on BBB-rated corporate bonds are on average 1.04% higher than those on AAA-rated corporate bonds.

3. Empirical Design and Analyses

In this section, we present our empirical design, study the determinants of our biodiversity sensitivity estimates, and report the results from our baseline regressions of yield spreads. We then investigate the mechanisms driving our findings and provide additional evidence from an event study that strengthens our identification strategy.

3.1. Empirical Design

Estimating the influence of a firm's biodiversity risk exposure on its borrowing costs is a challenging task, as this exposure may be linked to industry characteristics (e.g., expected recovery in default) that also influence borrowing costs. Nevertheless, our measure of biodiversity risk exposure varies within a firm over time, allowing us to control for firm fixed effects in our regressions of yield spreads. This way, our regressions account for time-invariant firm characteristics correlated with both biodiversity risk and yield spreads.

Our regression equation is as follows:

$$\textit{Yield Spread (\%)}_{i,j,t} = \alpha_j + \alpha_{\textit{Trade Year}} + \beta \textit{Biodiversity Sensitivity}_{j,t\text{-}1} + X'_{i,j,t}\gamma + \varepsilon_{i,j,t}, \tag{2}$$

where *Yield Spread (%)*$_{i,j,t}$ is the yield spread measured in month t for bond i issued by firm j; α_j and $\alpha_{\textit{Trade Year}}$, respectively, indicate firm and year fixed effects; *Biodiversity Sensitivity*$_{j,t-1}$ is the biodiversity news sensitivity of firm j estimated using the past 5 years of monthly stock returns as of month $t-1$; and $X_{j,j,t}$ is a vector of bond-level, firm-level, macro-level, and beta controls.

Bond-level controls are log(*Time to Maturity in Years*), log(*Number of Trades in a Month*), *Senior Dummy*, *Secured Dummy*, *Sinking Fund Dummy*, *Callable Dummy*, and *Puttable Dummy*. Firm-level controls are log(*Assets in Millions*), *Cash/Assets*, *Debt/Assets*, *Net Income/Assets*, *EBITDA/Interest Expense*, *Ave. of Monthly Stock Returns (%)*, and *St. Dev. of Monthly Stock Returns (%)*. Macro-level controls are *10yr-2yr Term Spread (%)*, *LIBOR-OIS Spread (%)*, and *Baa-Aaa Spread (%)*. Beta controls are *Climate Sensitivity*, *Market Beta*, *Size Beta*, and *Value Beta*.[10] Appendix A provides detailed definitions of these variables.

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[10] We intentionally exclude credit ratings from the list of controls. If we control for credit ratings in our regressions, the coefficient on *Biodiversity Sensitivity* would estimate the biodiversity effect that credit rating agencies do not incorporate in their ratings. We elaborate on this in Section 3.7.

3.2. Determinants of Biodiversity Sensitivity

Before examining the influence of *Biodiversity Sensitivity* on *Yield Spread*, we take a look at the correlation coefficients between *Biodiversity Sensitivity* and the other controls in our sample to identify potential multicollinearity issues. As *Biodiversity Sensitivity* is a firm-level variable, in Table 2, we report its correlation coefficients across other firm-level variables. We find that *Biodiversity Sensitivity* is not strongly correlated with any of these variables, alleviating the concern that *Biodiversity Sensitivity* may spuriously capture the influence of a firm's characteristics on its borrowing costs.

In Appendix B, we further study the cross-sectional determinants of *Biodiversity Sensitivity* to examine whether this variable is positively associated with the credit riskiness of firms. If that were the case, it could create a bias for finding a positive relation between *Biodiversity Sensitivity* and *Yield Spread*. Contrary to this concern, we find that safer firms are more likely to have higher biodiversity sensitivities, as firm size and standard deviation of stock returns are negative and significant determinants of *Biodiversity Sensitivity*. Appendix B also documents significant cross-sectional variation in biodiversity sensitivities by industries, with the utilities, manufacturing, and consumer durables industries exhibiting significantly higher biodiversity sensitivities.

The higher *Biodiversity Sensitivity* in industries such as utilities and manufacturing is consistent with its role as a proxy of biodiversity risk exposure (Giglio et al. (2023)). For more direct evidence on this, we examine the variation in *Biodiversity Sensitivity* based on firms' biodiversity footprints obtained from Bloomberg. These variables, along with their sample averages presented in parentheses, are: *Has Assets in Areas of High Ecosystem Intactness* (37%), *Percentage Revenue from Business Activities with Material Nature Related Dependencies* (51%), *Percentage Revenue from Business Activity in Agricultural Commodities with Risk of*

Deforestation (2%), and *Percentage Revenue from Business Activities in Paper and Forest Products* (1%).

Bloomberg constructs these biodiversity variables largely following the definitions developed by the Taskforce on Nature-related Financial Disclosures (TNFD) and the geographical information from the United Kingdom (UK) Natural History Museum's (NHM) Biodiversity Intactness Index (BII) geospatial data layer. All of these variables are fixed at the firm-level (i.e., has no time-series variation within a firm). We provide their detailed definitions in Appendix C. In brief, higher values of these variables predict higher biodiversity risk exposure.

Table 3 reports that the coefficient estimates on the biodiversity characteristics are all positive and significant. We multiply *Biodiversity Sensitivity* by 100 in these regressions to scale up the coefficient estimates for an easier interpretation. Column (1) shows that firms with assets in areas of high ecosystem intactness have a *Biodiversity Sensitivity* that is 0.81 higher. Moreover, based on the estimates in Columns (2)—(4) of Table 3, firms that are fully dependent on various biodiversity-exposed business activities have *Biodiversity Sensitivity* levels that are 1.12 to 1.99 units higher.

We also examine how *Biodiversity Sensitivity* reacts to events that increase biodiversity-related awareness and regulatory risks. As we discuss in detail later in Section 3.5, one such event is the COP15, which took place in October 11−15, 2021. We examine the changes in *Biodiversity Sensitivity* from the month before COP15 (September, 2021) to the month after COP15 (November, 2021). Column 5 of Table 3 shows that *Biodiversity Sensitivity* increases significantly during the post-COP15 month, providing suggestive evidence that *Biodiversity Sensitivity* responds to major biodiversity events.

Overall, the findings in this section show that *Biodiversity Sensitivity* is positively associated with firms' biodiversity footprints and macro-level biodiversity events, supporting the validity of our biodiversity risk exposure measure. We next investigate the relation between *Sensitivity* and the cost of borrowing in the corporate bond market.

3.3. Baseline Results

We run our baseline regression of yield spreads (Equation (2)) and report the results in Table 4. Column (1) reports that the coefficient estimate on *Biodiversity Sensitivity* is positive, but it is statistically insignificant. This finding suggests that, on average, biodiversity risk is not a significant factor in determining firms' borrowing costs in the corporate bond market. Appendix D reports the coefficient estimates on the other control variables along with their expected signs. The signs and significances of most coefficient estimates are consistent with their economic interpretations. For instance, supporting the findings of Huynh and Xia (2021), the coefficient estimate on *Climate Sensitivity* is positive and significant, suggesting that higher climate risk exposure is associated with higher yield spreads.

Next, we run this regression separately among short-term bonds (maturing within 20 years) and long-term bonds (maturing in 20 years or more). These subsample tests are motivated by the literature documenting that environmental risks are long term in nature (e.g., Bolton and Kacperczyk (2023), Giglio et al. (2021), Painter (2020)). In Table 4, Column (2) reports that the coefficient estimate on *Biodiversity Sensitivity* is insignificant among short-term bonds. Untabulated regression results show that this estimate also remains insignificant without controlling for firm fixed effects.

However, Column (3) of Table 4 reports that the coefficient estimate on *Biodiversity Sensitivity* is 1.18 and significant at the 5% level among long-term bonds. A one-standard-deviation increase in within-firm variation in *Biodiversity Sensitivity* is associated with a 7 bps increase in yield spreads (7.26 = 1.18 × 6.15), which is approximately 3% of the average yield spread in our sample. The economic magnitude of this estimate is comparable to the climate effect reported in the literature, and it is equivalent to that of a 6-year increase in average bond maturity on yield spreads.[11]

Consistent with the long-term nature of biodiversity risk, our findings in this section show that long-term bonds issued by firms with higher biodiversity sensitivities have higher borrowing costs. It appears that investors consider biodiversity risk to be a significant factor in pricing long-term corporate bonds.

3.4. Mechanisms Driving the Relation Between Biodiversity Sensitivity and Yield Spread

In this section, we study the variation in the biodiversity effect by issuer characteristics for evidence on the mechanisms driving the results.

3.4.1. Variation by the Use of Biodiversity-Related Words in 10Ks

First, we run our baseline regression of yield spreads (Column (3), Table 4) among firms that mention "biodiversity" in at least two sentences in their latest 10K statements. We obtain this data set from Giglio et al. (2023). Investors are more likely to pay attention to biodiversity risk when firms mention biodiversity in their 10Ks. Accordingly, if our findings are related to firms' biodiversity risk exposure, we expect to find a stronger positive relation between *Biodiversity Sensitivity* and *Yield Spread* among firms that mention biodiversity in their 10Ks.

[11] Appendix D reports that the coefficient estimate on log(*Time to Maturity in Years*) is 0.16, which suggests that an 6-year increase in the average maturity of bonds in our sample (10.40) is associated with a 9 bps increase in their yield spreads (0.07 = 0.16 × (log(10.40 + 6.00) – log(10.40))).

Regarding the climate effect, Painter's (2020) estimates (Column (1), Panel B of Table 4 in that study) suggest that a one-standard-deviation (0.35) increase in climate risk is associated with a 6 bps (0.06 = 0.35 × 0.161) increase in the yields of long-term bonds.

Columns (1) and (2) of Table 5 report the results of our baseline regression (Column (3), Table 4) for firms that mention and firms that do not mention biodiversity in their latest 10K statements as of the trade date, respectively. The coefficient estimate on *Biodiversity Sensitivity* is 2.48 and significant at the 5% level when 10Ks mention biodiversity, and 0.97 and significant at the 10% level when 10Ks do not mention biodiversity. These findings suggest that, consistent with a biodiversity-related mechanism driving our findings, our estimates of the biodiversity effect are stronger among firms that mention biodiversity in their 10Ks.

Biodiversity risk can arise from both physical and regulatory exposure to biodiversity-related factors. To further understand these channels, we explore the relation between *Biodiversity Sensitivity* and *Yield Spread* among firms that not only mention biodiversity in their 10Ks but also refer to biodiversity regulation. As before, we identify these 10Ks using the data set constructed by Giglio et al. (2023). Columns (3) and (4) of Table 5 show that the coefficient estimate on *Biodiversity Sensitivity* is 4.07 and significant at the 1% level among firms that mention biodiversity regulation in their 10Ks, and it is 1.03 and significant at the 10% level among the remaining firms.

To put these coefficient estimates into perspective, the coefficient estimate on *Biodiversity Sensitivity* is 1.18 in our baseline regression. This estimate more than doubles to 2.48 among firms that mention biodiversity in their 10Ks, and further increases to 4.07 if they also mention biodiversity regulation. These findings provide suggestive evidence that our baseline finding is associated with the biodiversity risk exposure of firms and, in particular, that investors consider biodiversity regulation (i.e., transition risk) to be influencing bond prices.

As a footnote, we notice that mostly energy and utility firms mention biodiversity in their 10Ks. Firms in these industries contribute 64.81% (23.59%) of the observations to the subsample that mentions (does not mention) biodiversity in 10Ks. These are arguably the firms with high climate risk exposure as well. To see how biodiversity risk interacts with climate risk, we run our baseline regression of yield spreads controlling for the interaction of *Biodiversity Sensitivity* and *Climate Sensitivity* variables. We find, in untabulated regression results, that the coefficient estimate on this interaction term is statistically insignificant. This could be because biodiversity risk is distinct from climate risk, or by construction, biodiversity and climate news indexes capture different aspects of environmental risk.[12]

Nevertheless, we find in additional untabulated subsample tests that the biodiversity-effect is more pronounced during periods of above median negative climate news. Investors seem to pay greater attention to biodiversity characteristics of firms when climate risk concerns rise. This finding highlights a potential connection between biodiversity and climate risks for researchers to explore in the future.

3.4.2. Variation by the Credit Quality of Bonds

We explore the variation in our baseline estimates by the credit quality of bonds. As prices of bonds close to default are more sensitive to the credit quality of their issuers (e.g., Merton (1974)), we expect the influence of biodiversity risk on yield spreads to be more pronounced among riskier bonds. To test this prediction, we obtain bond ratings from the FISD and estimate the biodiversity effect among bonds with varying credit qualities.

We split our sample of long-term bonds into three subsamples based on the rounded average of their bond ratings from Standard and Poor's (S&P), Fitch, and Moody's: AAA through A−, BBB+ through BB−, and below BB−. In Columns (1), (2), and (3) of Table 6, we report the results of our baseline regression (Column (3), Table 4) for these subsamples, respectively. We

[12] Giglio et. al (2023) report that the correlation coefficient between biodiversity and climate news indexes is only 0.22.

find that the coefficient estimate on *Biodiversity Sensitivity* is positive and increases monotonically as credit quality declines.

When studying bonds rated AAA through AA− in Column (1), the coefficient estimate on *Biodiversity Sensitivity* is 0.15, but it is statistically insignificant. This insignificant finding could be because bonds with low default risk behave similarly to Treasury bonds, with their prices largely determined by macro-level factors (e.g., Elton et al. (2001)). In contrast, the coefficient estimates are statistically significant with values of 1.15 and 6.50 in Columns (2) and (3), which study bonds rated BBB+ through BB− and those rated below BB−, respectively. This finding aligns with the prediction that biodiversity risk influences the prices of riskier bonds.

To put these estimates into perspective, a coefficient estimate of 6.50 suggests that a one-unit increase in biodiversity sensitivity is associated with a 6.50 bps increase in yield spreads of risky bonds. Based on the estimates in Table 3, this one-unit increase in biodiversity sensitivity could be driven by a firm's dependency on nature-related materials or a 50-percentage-point increase in its revenues from paper and forest products.

3.5. Event Study Around the COP15

The COP15 aimed to address global biodiversity loss by bringing together representatives from governments around the world. The first part of the COP15 was held in a hybrid format, taking place in Kunming, China and online during October 11−15, 2021, with the participation of 188 countries that are members of the Convention on Biological Diversity. Following the policy discussions in October 2021, the participating governments adopted the Kunming-Montreal Global Biodiversity Framework in December 2022 during the second part of this conference held in Montreal, Canada.

The Kunming-Montreal Global Biodiversity Framework consists of biodiversity-related targets to be achieved as early as 2030. These targets include items such as addressing the financial gap in biodiversity projects and requiring firms to monitor and disclose their biodiversity risks and impacts.[13] We use the COP15 as an event that increases investor attention to biodiversity-related risks and examine whether it influences the pricing of biodiversity risk in the corporate bond market.

We investigate changes in yield spreads from the pre-COP15 month (September 2021) to the post-COP15 month (November 2021). Studying this 2-month period around the conference reduces the influence of confounding factors on our estimates. We run our baseline regression of yield spreads by including two additional variables: a dummy variable indicating the post-COP15 month and its interaction with *Biodiversity Sensitivity*. This regression excludes firm fixed effects, as there is little within-firm variation in biodiversity sensitivity during this short event window. To account for industry characteristics of firms, we control for industry dummies based on the Fama–French 12 industry classifications.

Before fitting this regression, we visually investigate the trends in yield spreads during the month before and after the COP15. For a stylized interpretation, we categorize firms with above- (below-) median biodiversity sensitivities as having high (low) biodiversity sensitivity. We plot the average yield spreads for these subsamples in Figure 2. Yield spreads of high- and low-biodiversity-sensitivity subsamples appear to follow similar trends before the COP15 but diverge afterward, in a way that is consistent with an increase in yield spreads with higher biodiversity sensitivities after the COP15.

[13] The full list of targets can be found at: https://www.cbd.int/article/cop15-final-text-kunming-montreal-gbf-221222.

We next study this relation in a structured way using our regression approach described earlier. Column (1) of Table 7 reports the regression results and shows that the coefficient estimate on the interaction term between *Biodiversity Sensitivity* and *Post-COP15* is 1.18, which is statistically significant at the 5% level. This shows that yield spreads of bonds issued by firms with higher biodiversity sensitivities increase after the COP15: A one-standard-deviation increase in *Biodiversity Sensitivity* is associated with a 9 bps higher yield spread ($9.12 = 1.18 \times 7.73$) following the COP15.

In this regression, the coefficient estimate on *Post-COP15* is insignificant, suggesting that yield spreads, on average, do not change significantly around the COP15. This insignificant estimate alleviates the concern that confounding events are driving the interaction results. The coefficient estimates on *Biodiversity Sensitivity* are also insignificant, consistent with the result documented earlier that, on average, *Biodiversity Sensitivity* is not a significant determinant of yield spreads before the COP15.

To test the persistence of this increase in yield spreads after the COP15, we run our regression of yield spreads separately by defining the post-COP15 period cumulatively during the subsequent months. We show the coefficient estimates on the interaction terms (*Post-COP15* × *Biodiversity Sensitivity*) as well as their 5% and 95% confidence intervals in Figure 3. For instance, on the horizontal axis, 11/21 indicates that the post-COP15 month in the sample is November 2021, 12/21 indicates that December 2021 is added to the post-COP15 period, and so on. Our findings indicate that the interaction term remains positive and significant during the rest of our sample period. It seems that the COP15 effect is nontransitory.

As in Table 4, we then run our regressions separately among short- and long-term bonds to understand the term structure effects of the COP15, and report the results in Columns (2) and

(3) of Table 7, respectively. Among short-term bonds, the coefficient estimate on the *Post-COP15* × *Biodiversity Sensitivity* interaction is 1.39 and significant at the 5% level, whereas that on *Biodiversity Sensitivity* is insignificant. These findings suggest that yield spreads are not significantly associated with biodiversity sensitivities among short-term bonds during the pre-COP15 month, but short-term bonds with higher biodiversity sensitivities experience an increase in their yield spreads during the post-COP15 month. It seems that following the COP15, investors pay greater attention to biodiversity characteristic of short-term bonds.

We conduct a placebo test to examine whether this finding arises spuriously, perhaps because of trending variables during our analysis period. To do so, we estimate our 2-month period regression around the COP15 in each month during our analysis period. We find that the probability of obtaining a coefficient estimate on the interaction term that is stronger than that around the COP15 is 1.65%. The results of this placebo test suggest that the COP15 result is unlikely to be spurious.

Among long-term bonds, however, the coefficient estimate on the *Post-COP15* × *Biodiversity Sensitivity* interaction is insignificant. The fact that the interaction term is significant among short-term bonds but insignificant among long-term bonds suggests that after the COP15, investors update their beliefs that biodiversity-related regulatory risks may be materialized within 20 years. The coefficient estimate on *Biodiversity Sensitivity* is positive and significant among long-term bonds, indicating that biodiversity risk is already priced in yield spreads of long-term bonds before the COP15.

Overall, the findings in this section provide additional evidence from an event study that higher biodiversity sensitivity is associated with higher yield spreads.

3.6. Do Biodiversity Initiatives Lower the Biodiversity-related Increase in Cost of Borrowing?

Having found that higher biodiversity sensitivity is associated with higher yield spreads, we now examine whether firms' initiatives to protect biodiversity influence this relation. We obtain data on firms' biodiversity initiatives from Bloomberg. This variable, *Implemented Initiatives to Protect Biodiversity*, indicates whether a firm implemented any initiatives to ensure the protection of biodiversity (Appendix C provides a detailed definition of this variable). Bloomberg reports historical values of this variable in annual frequency starting in 2005.

Implemented Initiatives to Protect Biodiversity is available for 814 firms and 84,114 unique firm-month observations in our sample. Out of these 814 firms, 398 implemented a biodiversity protection initiative at some point during our sample period. We create a new variable—*Ever Implemented Initiatives to Protect Biodiversity*—to identify these firms. The sample averages of *Ever Implemented Initiatives to Protect Biodiversity* and *Implemented Initiatives to Protect Biodiversity* are 0.61 and 0.30, respectively. These statistics show that 61% of the observations are contributed by firms that ever implemented biodiversity initiatives and 30% of the observations are contributed in the years such initiatives were implemented.

Since firms with high biodiversity risk exposure may endogenously undertake biodiversity initiatives, we first examine the cross-sectional relation between *Biodiversity Sensitivity* and *Ever Implemented Initiatives to Protect Biodiversity* using the Fama-MacBeth approach presented in Table 3. Column (1) of Table 8 reports the results from this regression of *Biodiversity Sensitivity* using a sample of 83,396 unique firm-month observations with nonmissing information. The coefficient estimate on *Ever Implemented Initiatives to Protect Biodiversity* is 1.10 and statistically significant. This is consistent with firms taking initiatives to protect biodiversity having higher biodiversity risk exposure.

We next run the same regression while including *Implemented Initiatives to Protect Biodiversity* as an additional control. In this regression, *Ever Implemented Initiatives to Protect Biodiversity* accounts for the fixed characteristics of firms that implement biodiversity initiatives. Controlling for that, the coefficient on *Implemented Initiatives to Protect Biodiversity* estimates the influence of firms' biodiversity initiatives on their biodiversity sensitivities.

Column (2) of Table 8 shows that the coefficient estimate on *Implemented Initiatives to Protect Biodiversity* is statistically insignificant. It appears that, controlling for firm characteristics, implementing biodiversity protection initiatives does not significantly lower firms' biodiversity risk exposure. This result is consistent with the endogenous nature of firms' decision to undertake biodiversity initiatives.

Next, we study if the influence of *Biodiversity Sensitivity* on *Yield Spread* is mitigated by firms' biodiversity initiatives. To do so, we include the interaction of *Implemented Initiatives to Protect Biodiversity* with *Biodiversity Sensitivity* in our baseline regression of yield spreads (Column (3), Table 4). A negative and significant coefficient estimate on the interaction term would be consistent with firms' biodiversity initiatives helping with lowering the biodiversity-related increase in their cost of borrowing.

Column (3) of Table 8 reports that the coefficient estimate on the *Implemented Initiatives to Protect Biodiversity* and *Biodiversity Sensitivity* interaction is negative, but it is statistically insignificant. As mentioned earlier, this non-result could be because firms with higher biodiversity risk exposure endogenously take actions on protecting biodiversity, thereby confounding the potential reduction in their cost of borrowing. Alternatively, investors might perceive these efforts as insufficient or superficial, similar to the case of greenwashing. Further research is necessary to understand the causal relation between firms' biodiversity protection efforts and cost of borrowing.

3.7. Do Rating Agencies Take Into Account Biodiversity Risk?

Our regressions exclude credit rating controls to alleviate the concern that credit ratings may already reflect firms' biodiversity risk exposure. Here, we test whether bond ratings account for biodiversity-related risks. To do so, we run our regressions of yield spreads controlling for dummy variables that indicate the rounded average bond ratings from S&P, Fitch, and Moody's. We construct rating dummies for the following rating ranges: AAA, AA, A, BBB, BB, B, CCC, CC, and below CC. An insignificant coefficient estimate on *Biodiversity Sensitivity* controlling for credit rating dummies would be consistent with biodiversity-related risks being reflected in ratings.

Columns (1) through (6) of Table 9 replicate our main results reported in Column (3) of Table 4, Columns (1) and (3) of Table 5, Columns (2) and (3) of Table 6, and Column (1) of Table 7, respectively, while controlling for credit rating fixed effects. We find that all of these results remain statistically significant when controlling for credit ratings. This suggests that credit rating agencies do not fully account for biodiversity risk in their rating models.

As a caveat, Column (1) of Table 9 shows that controlling for credit ratings reduces the economic and statistical significance of our finding that long-term bonds with higher biodiversity sensitivities have higher yield spreads. This raises the concern that *Biodiversity Sensitivity* could be positively correlated with an omitted variable related to credit risk that bond ratings capture. As Appendix B shows, however, *Biodiversity Sensitivity* is not positively correlated with credit-risk-related firm characteristics. The fact that our other five results are not influenced by controlling for credit ratings also alleviates this concern. The COP15 study, in particular, helps us further dissect the omitted variable bias explanation.

The credit riskiness of firms with higher biodiversity sensitivities is unlikely to increase after the COP15. If credit ratings account for a credit-risk-related variable omitted from our model, credit rating controls should also account for the increase in yield spreads of higher biodiversity firms following the COP15. However, in Column (6) of Table 9, the coefficient estimate on the *Biodiversity Sensitivity* × *Post-COP15* interaction remains positive and significant when controlling for rating fixed effects. This finding further addresses the concern that our estimates may suffer from an omitted variable bias.

4. Robustness Tests

In this section, we test the robustness of our baseline finding that higher biodiversity sensitivity is associated with higher yield spreads among long-term bonds (Column (3), Table 4). We report the coefficient estimates on *Biodiversity Sensitivity* from alternative regressions in Table 10. Consistent with our baseline result, the coefficient estimates on *Biodiversity Sensitivity* are positive and significant across all of the following regression specifications.

We first include year-quarter fixed effects and year-month fixed effects to assess whether macro-level factors, not accounted for by year fixed effects in our baseline specification, influence our estimates. In the next regression, we exclude observations that occurred during the financial crisis periods of 2007 and 2008. The coefficient estimates on *Biodiversity Sensitivity* are all positive and significant in these alternative specifications, suggesting that our baseline model effectively accounts for the macro-trends during our analysis period.

Next, we winsorize all of the continuous variables at the 5% and 95% levels to examine the robustness of our findings to outlier observations. We also exclude puttable and sinkable bonds to see whether these bond features that are rarely observed in our data influence our findings. Our baseline estimate remains robust to these alternative specifications.

In our baseline empirical approach, we compute yields using bond prices observed on the last trading day in a month. Alternatively, we keep bonds whose yields are calculated during the last 10 days of the month. In the next test, we require nonmissing (60) observations when estimating the betas during the 5-year estimation window, instead of requiring 24 monthly observations as in our baseline specification. We also test whether our findings are sensitive to estimating biodiversity risk in a two-step process, where we first fit Equation (1) without controlling for *Biodiversity News Innovation* and obtain the errors from this regression. We then run a second regression of these error terms on *Biodiversity News Innovation* to estimate biodiversity sensitivity. The coefficient estimates on *Biodiversity Sensitivity* from these alternative specifications are comparable to our baseline estimate.

Additionally, we test whether controlling for the innovations in both the climate news and biodiversity news indexes when estimating biodiversity sensitivities in our baseline approach biases our findings. To do so, we reestimate biodiversity sensitivities by excluding *Climate News Innovation* from Equation (1). Moreover, we implement a four-factor model that includes Carhart's (1997) momentum factor in addition to the three factors in our baseline approach to estimate betas. The purpose of this test is to alleviate the concern that *Biodiversity Sensitivity* may capture a fundamental risk factor rather than the sensitivity of stock returns to innovations in biodiversity news. Next, we estimate the betas using stock returns and stock market returns rather than excess stock returns and excess stock market returns. We also estimate the betas in annual frequency by running 5-year rolling window regressions of monthly stock returns in December of each year. The results of these regressions are identical to those from our baseline regression.

Finally, we study the influence of *Biodiversity Sensitivity* on excess bond returns, instead of yield spreads. We compute monthly returns for bond i in month t as follows:

$$Bond\ Ret_{i,t} = \frac{Price_{i,t} + AI_{i,t} + Coupon_{i,t}}{Price_{i,t-1} + AI_{i,t-1}} - 1 \qquad (3)$$

where $Price_{i,t}$ is the weighted average bond price observed on the last trading day of the month, $AI_{i,t}$ is the accrued interest, and $Coupon_{i,t}$ is the coupon payment, if any. When the latest trading days in two consecutive months span less than a month, we standardize the return to span a one-month period. We subtract the maturity-matched risk-free rate from these bond returns, and use this excess bond return as our dependent variable in our regression. We find that the coefficient estimate on *Biodiversity Sensitivity* is 0.90 and statistically significant, consistent with our results from studying yield spreads.[14]

Overall, the findings in this section show that our baseline estimate of the influence biodiversity sensitivity has on long-term borrowing costs is robust to a variety of alternative specifications.

5. Conclusion

The literature identifies biodiversity loss—the decline in the variety of all living forms on Earth—as an emerging risk for the economy (e.g., Karolyi and Tobin de la Puente (2023)). Biodiversity loss may negatively affect firms that rely on natural inputs for production. Changes in consumer preferences and biodiversity regulations pose additional risks for firms that contribute to biodiversity loss. Regulations, however, may be ineffective in addressing this issue, as a firm's contribution to biodiversity loss is not easily measurable. This puts financial markets in a crucial disciplining role.

[14] We find in untabulated tests that the average difference in returns of high and low biodiversity sensitivity portfolios are statistically insignificant. This could be because the sample period is relatively short to attain significance in univariate tests of time-series differences between returns of two portfolios, or because biodiversity sensitivity is a diversifiable risk and hence not a factor in the traditional asset pricing framework.

In this paper, we investigate the pricing of biodiversity risk in the corporate bond market to understand whether creditors recognize this as an important risk and penalize firms that have greater exposure to it. In the spirit of Giglio et al. (2023), we measure a firm's biodiversity risk exposure as the sensitivity of its stock returns to innovations in negative biodiversity-related news. The intuition for this market-based measure is that stocks that react more negatively to negative biodiversity news are also affected more negatively once those risks materialize. We reverse the sign of this sensitivity measure so that higher values correspond to higher biodiversity risk exposure. This biodiversity sensitivity varies predictably with firms' observable biodiversity footprints and major biodiversity events, consistent with its role as a measure of biodiversity risk exposure.

We find that a one-standard-deviation increase in a firm's biodiversity sensitivity is associated with a 3% increase in the yield spreads of its long-term bonds. This relation is insignificant among short-term bonds, consistent with biodiversity risk being long run in nature. We find a stronger biodiversity effect on yield spreads among riskier bonds and those issued by firms that mention biodiversity, particularly biodiversity regulation, in their annual reports. To better understand whether these findings are associated with biodiversity risk, we study the changes in yield spreads around the COP15.

Approximately 190 countries participated in the COP15, whose first and second parts took place in October 2021 and December 2022. Following these meetings, the participating governments agreed on achieving biodiversity targets, such as establishing disclosure requirements for firms' biodiversity footprints, as early as 2030. This conference also raised public awareness about biodiversity loss. If our findings are associated with firms' biodiversity risk exposure, we expect to find the positive influence of biodiversity sensitivity on yield spreads to be more pronounced following the COP15. We indeed find this to be the case.

Our findings show that corporate bond investors consider biodiversity risk as a significant factor affecting firms' borrowing costs. It appears that credit markets contribute to closing the biodiversity financing gap, which is the additional capital needed to mobilize investments to preserve biodiversity. They do so by rewarding (penalizing) firms with lower (higher) biodiversity risk exposure. Although not causal, these associations suggest that firms can lower their borrowing costs by mitigating their biodiversity risk exposure.

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Appendix A. Variable Definitions

This appendix provides the definitions of the variables used in our baseline regressions.

Variables	Definitions
Dependent Variable	
Yield Spread (%)	Difference between yield to maturities of a bond and its maturity-matched benchmark Treasury bond measured as of the last trade date in a month. Source: Bond prices are from the MSRB database, bond characteristics are from the FISD, and Treasury yields are from the Treasury's website.
Beta Controls	
Biodiversity Sensitivity, Climate Sensitivity, Market Beta, Size Beta, and Value Beta	Coefficient estimates on the control variables from monthly regressions of excess stock returns. The control variables are innovations in biodiversity (*Biodiversity News Innovation*) and climate news (*Climate News Innovation*) indexes, excess market returns (*MKT*), size factor (*SMB*), and value factor (*HML*). These regressions are run on a rolling-window basis for each firm-month (*t*), using the previous 5 years of monthly returns data as of month *t-1*. Accordingly, the beta estimates are lagged by a month (*t-1*) relative to the month in which the yield spread is measured (*t*). Source: Stock returns are from the CRSP database, biodiversity and climate news indexes are from www.biodiversity.org, and the remaining variables are from Kenneth French's website at Dartmouth.
Bond-level Controls	
Log(Time to Maturity in Years)	Natural logarithm of bond maturity in years, measured as of the trade date. Source: Bond maturity date is from the FISD, and bond transactions are from the MSRB database.
Log(Number of Trades in a Month)	Natural logarithm of the number of trades in a month. Source: MSRB
Senior, Secured, Callable, Puttable, and Sinking Fund Dummies	Dummy variables indicating whether a bond is senior, secured, callable, puttable, or has a sinking fund provision. Source: FISD
Firm-level Controls	
Log(Assets in Millions)	Natural logarithm of total assets from the annual report prior to the trade date. Source: COMPUSTAT
Cash/Assets	Cash and equivalents divided by total assets from the annual report prior to the trade date. Source: COMPUSTAT
Debt/Assets	Sum of short- and long-term debt divided by total assets from the annual report prior to the trade date. Source: COMPUSTAT
Net Income/Assets	Net income divided by total assets from the annual report prior to the trade date. Source: COMPUSTAT
EBITDA/Interest Expense	EBITDA divided by interest expense from the annual report prior to the trade date. Source: COMPUSTAT
Ave. of Monthly Stock Returns (%)	Average of monthly stock returns during the 5-year beta estimation period. Source: CRSP
St. Dev. of Monthly Stock Returns (%)	Standard deviation of monthly stock returns during the 5-year beta estimation period. Source: CRSP
Macro-level Controls	
10yr-2yr Term Spread (%)	Difference between yield to maturities of 10-year and 2-year Treasury bonds as of the trade date. Source: Bloomberg
LIBOR-OIS Spread (%)	Difference between LIBOR and OIS rates as of the trade date. Source: Bloomberg
Baa-Aaa Spread (%)	Difference between yield to maturities of Baa and Aaa rated corporate bonds as of the trade date. Source: Bloomberg

Appendix B. Firm Characteristics and Biodiversity Sensitivity

This table reports the results of Fama-MacBeth (1973) regressions where the dependent variable is *Biodiversity Sensitivity*, and the independent variables are firm-level controls in Column (1), and additional industry dummies based on Fama-French 12-industry classifications in Column (2). *Biodiversity Sensitivity* is multiplied by 100 in these regressions to scale the coefficient estimates for ease of interpretation. The sample includes 139,173 unique firm-month observations contributed during 246 months. The coefficient estimates reported in the table are the average coefficient estimates from 246 monthly cross-sectional regressions, and the numbers reported in parenthesis are the t-values computed using Newey-West adjusted standard errors using 12-month lags.

Variables	**(1)**	**(2)**
Log(Assets in Millions)	0.22***	0.24***
	(3.12)	(4.01)
Cash/Assets	1.97	3.19**
	(1.37)	(2.56)
Debt/Assets	0.94	1.27
	(0.75)	(1.23)
Net Income/Assets	1.54	0.92
	(0.65)	(0.40)
EBITDA/Interest Expense	0.00	0.01
	(1.19)	(1.56)
Ave. of Monthly Stock Returns (%)	0.32	0.16
	(1.50)	(0.80)
St. Dev. of Monthly Stock Returns (%)	-0.20***	-0.19***
	(-2.98)	(-3.06)
Consumer Nondurables	.	-0.78*
	.	(-1.78)
Consumer Durables	.	1.80***
	.	(4.13)
Manufacturing	.	1.09**
	.	(2.15)
Energy	.	0.23
	.	(0.16)
Chemicals	.	0.40
	.	(1.12)
Business Equipment	.	-0.34
	.	(-0.77)
Telecommunications	.	0.38
	.	(0.47)
Utilities	.	0.99***
	.	(2.74)
Shops	.	-0.20
	.	(-0.36)
Healthcare	.	1.03
	.	(1.28)
Intercept	Yes	Yes
Number of Observations	139,173	139,173
Average R-squared (%)	10.31	16.36

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Appendix C. Definitions of Biodiversity Variables

This appendix provides the definitions of the biodiversity variables used in Tables 3 and 8. These definitions are quoted verbatim from Bloomberg.

Variables	Definitions
Has Assets in Areas of High Ecosystem Intactness	Indicates whether the company has physical assets located in or near areas of high or very high ecosystem intactness. Field is calculated by identifying if any of the company's physical assets are located in areas of high or very high ecosystem intactness according to the United Kingdom (UK) Natural History Museum's (NHM) Biodiversity Intactness Index (BII) geospatial data layer. BII estimates how much of an ecosystem's natural biodiversity can still be found there despite human impacts. A value of 100% means that all the naturally-present species are still as abundant as they were, whereas 0% would mean that none of the original species still persist. High is considered to be 70% or above. Note: Bloomberg reports historical values of this variable during our analysis period, but it is fixed within a firm.
Percentage Revenue from Business Activities with Material Nature Related Dependencies	Provides the percentage of total revenue generated by the company that is derived from business activities with material nature related dependencies and impacts as defined by the Taskforce on Nature-related Financial Disclosures (TNFD). The percentage is calculated by the sum of each security's total revenue percentage within a relevant BICS (Bloomberg Industry Classification Standard) code. Note: Bloomberg reports historical values of this variable starting in 2019. To increase the sample size, we use the firm-level averages of this variable in regressions.
Percentage Revenue from Business Activity in Agricultural Commodities with Risk of Deforestation	Percentage of total revenue generated by the company that is derived from business activity in agricultural commodities that carry risk of deforestation. The percentage is calculated by the sum of each security's total revenue percentage within a relevant BICS (Bloomberg Industry Classification Standard) code. Commodities included are the following: palm oil, soy, rubber, cocoa, beef, leather, dairy, coffee, timber, pulp, paper. Note: Bloomberg reports historical values of this variable starting in 2019. To increase the sample size, we use the firm-level averages of this variable in regressions.
Percentage Revenue from Business Activities in Paper and Forest Products	Provides the percentage of total revenue generated by the company that is derived from business activities with material nature related dependencies and impacts in the paper and forest products sector as defined by the Taskforce on Nature-related Financial Disclosures (TNFD). The percentage is calculated by the sum of each security's total revenue percentage within a relevant BICS (Bloomberg Industry Classification Standard) code. Note: Bloomberg reports historical values of this variable starting in 2019. To increase the sample size, we use the firm-level averages of this variable in regressions.
Implemented Initiatives to Protect Biodiversity	Indicates whether the company has implemented any initiatives to ensure the protection of biodiversity. This might include trees and vegetation as well as wildlife and endangered species. Field is part of the Environmental, Social and Governance (ESG) group of fields. Note: Bloomberg reports historical values of this variable starting in 2005.

Appendix D. Coefficient Estimates on the Control Variables and Their Expected Signs

This appendix presents the coefficient estimates on the control variables from the regression of yield spreads in Column (1) of Table 4, along with their expected signs.

Variables	Expected Signs	Coefficient Estimates on Controls Column (1), Table 4
Log(Time to Maturity in Years)	+	0.16***
		(4.44)
Log(Number of Trades in a Month)	−	-0.11***
		(-3.25)
Senior Dummy	−	-1.36***
		(-6.25)
Secured Dummy	−	-2.09***
		(-7.37)
Sinking Fund Dummy	+	0.67
		(1.17)
Callable Dummy	+	0.04
		(0.34)
Puttable Dummy	−	0.12
		(1.32)
Log(Assets in Millions)	−	-0.29***
		(-2.61)
Cash/Assets	−	0.98
		(0.87)
Debt/Assets	+	2.82***
		(4.70)
Net Income/Assets	−	-3.90***
		(-4.15)
EBITDA/Interest Expense	−	-0.00
		(-0.19)
Ave. of Monthly Stock Returns (%)	−	-0.98***
		(-8.40)
St. Dev. of Monthly Stock Returns (%)	+	0.23***
		(4.33)
10yr-2yr Term Spread (%)	+	0.20**
		(2.03)
LIBOR-OIS Spread (%)	+	1.13***
		(3.62)
Baa-Aaa Spread (%)	+	1.67***
		(3.64)
Climate Sensitivity	+	1.72**
		(2.38)
Market Beta	+	0.37*
		(1.94)
Size Beta	+	-0.34
		(-1.20)
Value Beta	+	-0.08
		(-0.47)

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 1. Descriptive Statistics

This table presents the summary statistics for the variables used in our baseline regressions of yield spreads. See Appendix A for the definitions of these variables and Table 4 for the regression specification.

Variables	N	Mean	Median	St. Dev.
Dependent Variable				
Yield Spread (%)	1,048,168	2.36	1.47	4.50
Beta Controls				
Biodiversity Sensitivity × 100	1,048,168	0.36	0.35	7.73
Climate Sensitivity × 100	1,048,168	-0.80	-0.67	13.58
Market Beta	1,048,168	1.03	0.99	0.58
Size Beta	1,048,168	0.04	-0.07	0.65
Value Beta	1,048,168	0.30	0.21	0.72
Bond-level Controls				
Log(Time to Maturity in Years)	1,048,168	1.96	1.93	0.89
Log(Number of Trades in a Month)	1,048,168	3.29	3.30	1.52
Senior Dummy × 100	1,048,168	89.99	100.00	30.02
Secured Dummy × 100	1,048,168	8.03	0.00	27.17
Sinking Fund Dummy × 100	1,048,168	0.29	0.00	5.33
Callable Dummy × 100	1,048,168	76.86	100.00	42.17
Puttable Dummy × 100	1,048,168	1.20	0.00	10.91
Firm-level Controls				
Log(Assets in Millions)	1,048,168	10.54	10.53	1.62
Cash/Assets	1,048,144	0.08	0.05	0.09
Debt/Assets	1,048,168	0.40	0.38	0.17
Net Income/Assets	1,048,168	0.04	0.03	0.08
EBITDA/Interest Expense	1,043,416	10.00	5.66	129.57
Ave. of Monthly Stock Returns (%)	1,048,168	0.91	0.91	1.09
St. Dev. of Monthly Stock Returns (%)	1,048,168	8.72	7.61	4.65
Macro-level Controls				
10yr-2yr Term Spread (%)	1,048,168	1.22	1.25	0.89
LIBOR-OIS Spread (%)	1,048,168	0.24	0.15	0.28
Baa-Aaa Spread (%)	1,048,168	1.04	0.95	0.41

Table 2. Correlation Coefficients among Firm-level Controls

This table provides the correlation coefficients among the firm-level variables in our baseline regressions of yield spreads. See Appendix A for the definitions of these variables, Table 1 for their summary statistics, and Table 4 for the regression specification. The sample includes 139,173 unique firm-month level observations.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
(1) Biodiversity Sensitivity	1											
(2) Log(Assets)	0.09	1										
(3) Cash/Assets	0.01	0.00	1									
(4) Debt/Assets	-0.05	-0.21	-0.15	1								
(5) Net Income/Assets	0.10	0.19	0.06	-0.28	1							
(6) EBITDA/Interest Expense	0.02	0.00	0.05	-0.04	0.05	1						
(7) Ave. Stock Returns	0.05	-0.07	0.08	-0.06	0.25	0.03	1					
(8) St. Dev. Stock Returns	-0.14	-0.42	0.07	0.31	-0.36	-0.01	0.11	1				
(9) Climate Sensitivity	-0.18	0.02	0.02	-0.04	0.01	0.02	-0.06	-0.11	1			
(10) Market Beta	-0.09	-0.12	0.09	0.15	-0.21	-0.01	0.05	0.62	-0.16	1		
(11) Size Beta	-0.10	-0.38	0.03	0.14	-0.19	-0.02	0.10	0.50	-0.11	0.20	1	
(12) Value Beta	-0.11	-0.22	-0.12	0.14	-0.22	-0.01	-0.04	0.37	0.00	0.23	0.29	1

Table 3. Biodiversity Characteristics, Biodiversity Events, and Biodiversity Sensitivities

Columns (1) through (4) of this table report the results from Fama-MacBeth (1973) regressions of *Biodiversity Sensitivity* that examine its cross-sectional variation by firms' biodiversity characteristics. The control variables include firm characteristics and industry fixed effects based on Fama-French 12-industry classifications as in Column (2) of Appendix B. In addition, each column includes an alternative biodiversity variables. Appendix C provides detailed definitions of these biodiversity characteristics. *Biodiversity Sensitivity* is multiplied by 100 in these regressions to scale the coefficient estimates for ease of interpretation. Column (5) reports the results from ordinary least squares (OLS) regression of *Biodiversity Sensitivity* to test the influence of the COP15 on *Biodiversity Sensitivity*. The sample includes the month before (September, 2021) and after (November, 2021) the first session of the COP15 held in October 11—15, 2021. *Post-COP15* variable equals 1 during the month after the COP15, and 0 otherwise. The full sample includes 139,173 unique firm-month observations contributed during 246 months. The coefficient estimates reported in Columns (1)—(4) are the average coefficient estimates from 246 monthly cross-sectional regressions, and the numbers reported in parenthesis are the t-values computed using Newey-West adjusted standard errors using 12-month lags. In Column (5), the t-values are computed using standard errors clustered at the firm-level.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Has Assets in Areas of High Ecosystem Intactness	0.81***	.	.	.	.
	(4.33)	.	.	.	.
Percentage Revenue from Business Activities with	.	1.12***	.	.	.
Material Nature Related Dependencies	.	(2.91)	.	.	.
Percentage Revenue from Business Activity in	.	.	1.48**	.	.
Agricultural Commodities with Risk of Deforestation	.	.	(2.07)	.	.
Percentage Revenue from Business Activities in	.	.	.	1.99**	.
Paper and Forest Products	.	.	.	(2.33)	.
Post-COP15	.	.	.	.	0.20***
	.	.	.	.	(3.48)
Intercept	Yes	Yes	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	92,441	107,551	107,551	107,551	846
(Average) R-squared (%)	16.85	18.38	17.96	17.85	13.08

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 4. The Relation Between Biodiversity Sensitivity and Yield Spreads

This table reports the results of the following regression:

$$\textit{Yield Spread (\%)}_{i,j,t}=\alpha_j+\alpha_{Trade\ Year}+\beta \textit{Biodiversity Sensitivity}_{j,t-1}+X'_{i,j,t}\gamma+\varepsilon_{i,j,t},$$

where *Yield Spread (%)*$_{i,j,t}$ is the yield spread (in percentages) measured at the end of month t for bond i issued by firm j, α_j indicates firm fixed effects, $\alpha_{Trade\ Year}$ indicates year fixed effects, *Biodiversity Sensitivity*$_{j,t-1}$ is the biodiversity news sensitivity of firm j estimated using past 5 years of monthly stock returns as of month $t-1$, and $X_{j,j,t}$ is a vector of bond-level, firm-level, macro-level, and beta controls. Bond-level controls are log*(Time to Maturity in Years)*, log*(Number of Trades in a Month)*, *Senior Dummy*, *Secured Dummy*, *Sinking Fund Dummy*, *Callable Dummy*, and *Puttable Dummy*, firm-level controls are log*(Assets in Millions)*, *Cash/Assets*, *Debt/Assets*, *Net Income/Assets*, *EBITDA/Interest Expense*, *Ave. of Monthly Stock Returns (%)*, and *St. Dev. of Monthly Stock Returns (%)*, macro-level controls are *10yr-2yr Term Spread (%)*, *LIBOR-OIS Spread (%)*, and *Baa-Aaa Spread (%)*, and beta controls are *Climate Sensitivity*, *Market Beta*, *Size Beta*, and *Value Beta*. See Appendix A for detailed definitions of these variables, Table 1 for their summary statistics, and Appendix D on the coefficient estimates on these control variables from Column (2) along with their expected signs. The samples in Columns (1), (2), and (3) include all bonds, bonds with maturities less than 20 years, and bonds with maturities greater than or equal to 20 years, respectively. The numbers reported in parenthesis are the t-values computed using standard errors clustered at the firm-level.

Sample:	**All**	**Short-term**	**Long-term**
Variables	**(1)**	**(2)**	**(3)**
Biodiversity Sensitivity	1.52	1.34	1.18**
	(1.24)	(1.04)	(2.19)
Intercept	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Bond-level Controls	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes
Macro-level Controls	Yes	Yes	Yes
Beta Controls	Yes	Yes	Yes
Number of Observations	1,043,392	857,357	186,035
Adj. R-squared (%)	18.18	18.89	27.48

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 5. The Variation in the Biodiversity Effect by the Coverage of Biodiversity in Financial Reports

This table reports the results of yield spread regressions for long-term bonds (Column (3), Table 4) among subsamples constructed based on whether firms mention biodiversity in their annual reports. The samples in Columns (1) and (2) include firms that mention biodiversity in at least two sentences in their latest 10K statements as of a trade month, and those firms that do not, respectively. The sample in Column (3) includes a subset of firms studied in Column (1) that also mention biodiversity regulation in their 10K statements, and the sample in Column (4) includes the remaining firms. The list of firms that mention biodiversity in their 10Ks are from Giglio et al. (2023). The numbers reported in parenthesis are the t-values computed using standard errors clustered at the firm-level.

Sample:	**10K Mentions Biodiversity**	**10K Does Not Mention Biodiversity**	**10K Mentions Biodiversity Regulation**	**10K Does Not Mention Biodiversity Regulation**
Variables	**(1)**	**(2)**	**(3)**	**(4)**
Biodiversity Sensitivity	2.48**	0.97*	4.07***	1.03*
	(2.36)	(1.66)	(4.14)	(1.77)
Intercept	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Bond-level Controls	Yes	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes	Yes
Macro-level Controls	Yes	Yes	Yes	Yes
Beta Controls	Yes	Yes	Yes	Yes
Number of Observations	8,824	146,198	6,188	148,834
Adj. R-squared (%)	47.22	28.52	50.91	28.81

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6. The Variation in the Biodiversity Effect by Credit Riskiness of Bonds

This table reports the results of yield spread regressions for long-term bonds (Column (3), Table 4) among subsamples of bonds that have low, medium, and high credit riskiness. The samples in Columns (1), (2), and (3) include bonds that have a median credit rating from Moody's, S&P, and Fitch that is within AAA to A−, BBB+ to BB−, and below BB− credit rating range, respectively. Accordingly, the samples in Columns (1), (2), and (3) include bonds with low, medium, and high credit riskiness, respectively. The numbers reported in parenthesis are the t-values computed using standard errors clustered at the firm-level.

Sample:	**AAA through A−**	**BBB+ through BB−**	**Below BB−**
Variables	**(1)**	**(2)**	**(3)**
Biodiversity Sensitivity	0.15	1.15***	6.59**
	(0.61)	(2.83)	(2.18)
Intercept	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Bond-level Controls	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes
Macro-level Controls	Yes	Yes	Yes
Beta Controls	Yes	Yes	Yes
Number of Observations	102,133	80,109	3,544
Adj. R-squared (%)	42.53	44.06	59.10

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 7. An Event Study Around the COP15

This table investigates the influence of the COP15 on the relation between *Biodiversity Sensitivity* and *Yield Spread*. The sample includes the trades executed in the month before (September, 2021) and after (November, 2021) the first session of the COP15 held in October 11—15, 2021. *Post-COP15* variable equals 1 during the month after the COP15, and 0 otherwise. The regression equation is similar to that in Table 4, except that it includes *Post-COP15* and its interaction with *Biodiversity Sensitivity* as additional controls. This regression excludes firm fixed effects as the event window is short, and instead includes industry fixed effects to account for the systematic differences across industries. Year fixed effects become redundant, as the sample only includes observations contributed in a single year. The sample in Columns (1) includes all observations during the two-month period, while the samples in Columns (2) and (3) include subsets of this two-month sample: bonds maturing in less than 20 years and bonds maturing in at least 20 years, respectively. The numbers reported in parenthesis are the t-values computed using standard errors clustered at the firm-level.

Sample:	**All**	**Short-term**	**Long-term**
Variables	**(1)**	**(2)**	**(3)**
Post-COP15 × Biodiversity Sensitivity	1.18**	1.39**	-0.25
	(2.40)	(2.46)	(-0.78)
Post-COP15	0.12	0.13	-0.03
	(1.23)	(1.16)	(-0.17)
Biodiversity Sensitivity	3.03	3.16	2.39**
	(1.32)	(1.21)	(1.98)
Intercept	Yes	Yes	Yes
Firm Fixed Effects	No	No	No
Year Fixed Effects	No	No	No
Bond-level Controls	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes
Macro-level Controls	Yes	Yes	Yes
Beta Controls	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Number of Observations	9,766	7,314	2,452
Adj. R-squared (%)	47.56	48.38	55.21

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 8. Biodiversity Protection Initiatives and Yield Spreads

This table investigates the influence of a firm's biodiversity protection initiatives on its *Biodiversity Sensitivity*, and examines whether they mitigate the effect of *Biodiversity Sensitivity* on *Yield Spread*. As in Table 3, Columns (1) and (2) report the results from a Fama-MacBeth (1973) regression of *Biodiversity Sensitivity* that examine its cross-sectional variation by the (*Ever*) *Implemented Initiatives to Protect Biodiversity* variable (see Appendix C for a detailed definition of this variable). The full sample includes 139,173 unique firm-month observations contributed during 246 months. The coefficient estimates and R-squared values reported in Columns (1) and (2) are their averages from 246 monthly cross-sectional regressions, and the numbers reported in parenthesis are the t-values computed using Newey-West adjusted standard errors using 12-month lags. Column (3) reports the result from our baseline regression of *Yield Spread* (Column (3), Table 4), controlling for the interaction of *Implemented Initiatives to Protect Biodiversity* with *Biodiversity Sensitivity* as an additional variable. In Column (3), the numbers reported in parenthesis are the t-values computed using standard errors clustered at the firm-level.

Dependent Variable:	**Biodiversity Sensitivity**		**Yield Spread**
Regression Model:	**Fama-MacBeth**		**Fixed Effects**
Variables	**(1)**	**(2)**	**(3)**
Ever Implemented Initiatives to Protect Biodiversity	1.10***	0.97***	.
	(4.31)	(3.88)	.
Implemented Initiatives to Protect Biodiversity	.	0.19	0.00
	.	(0.73)	(0.02)
Implemented Initiatives to Protect Biodiversity × Biodiversity Sensitivity	.	.	-0.10
	.	.	(-0.13)
Biodiversity Sensitivity	.	.	1.21***
	.	.	(2.63)
Intercept	Yes	Yes	Yes
Firm Fixed Effects	No	No	Yes
Industry Fixed Effects	Yes	Yes	No
Year Fixed Effects	No	No	Yes
Bond-level Controls	No	No	Yes
Firm-level Controls	Yes	Yes	Yes
Macro-level Controls	No	No	Yes
Beta Controls	No	No	Yes
Number of Observations	83,396	83,396	151,212
(Average) R-squared (%)	23.31	23.54	28.88

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 9. Regression Results Controlling for Credit Ratings

This table reports our main findings controlling for credit rating fixed effects. Rating fixed effects are based on the median of bond ratings from S&P, Fitch, and Moody's, indicating whether the rating falls in the AAA, AA, A, BBB, BB, B, CCC, CC, and below CC range. Columns (1), (2), (3), (4), (5), and (6) below replicate the results reported in Column (3) of Table 4, Columns (1) and (3) of Table 5, Columns (2) and (3) of Table 6, and Column (1) of Table 7, respectively, while controlling for credit rating fixed effects. The numbers reported in parenthesis are the t-values computed using standard errors clustered at the firm-level.

Study:	**Long-term**	**10K Mentions Biodiversity**	**10K Mentions Biodiversity Regulation**	**BBB+ through BB−**	**Below BB−**	**COP15**
Corresponding Table:	**Table 4**	**Table 5**	**Table 5**	**Table 6**	**Table 6**	**Table 7**
Corresponding Column:	**Column (3)**	**Column (1)**	**Column (3)**	**Column (2)**	**Column (3)**	**Column (1)**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Biodiversity Sensitivity	0.66*	2.46**	4.08***	1.10***	6.77**	0.92
	(1.68)	(2.60)	(4.22)	(2.72)	(2.31)	(1.17)
Post-COP15 × Biodiversity	.	.	.	.	.	1.17**
Sensitivity	.	.	.	.	.	(2.54)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Credit Rating Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
Bond-level Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes	Yes	Yes	Yes
Macro-level Controls	Yes	Yes	Yes	Yes	Yes	Yes
Beta Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	No	No	No	No	Yes
Number of Observations	186,035	8,824	6,188	80,109	3,544	9,766
Adj. R-squared (%)	37.23	51.71	54.22	46.44	61.42	80.99

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 10. Robustness Tests for the Positive Relation between Biodiversity Sensitivity and Yield Spreads of Long-term Bonds

This table examines the robustness of the result reported in Column (4) of Table 4 that higher *Biodiversity Sensitivity* is associated with higher *Yield Spread* among long-term bonds. The robustness tests (1) through (13) below report the coefficient estimates on *Biodiversity Sensitivity* using the following alternative specifications: (1) control for year-quarter fixed effects, (2) control for year-month fixed effects, (3) exclude the observations contributed during the financial crisis periods of 2007 and 2008, (4) winsorize the continues bond- and firm-level variables at the 1% and 99% levels, (5) exclude puttable and sinkable bonds, (6) keep trades during the last 10 days of the month, (7) keep firms with nonmissing stock returns during the estimation of betas, (8) use betas estimated in two steps where first a three-factor model is run on stock returns, and then *Biodiversity* and *Climate Sensitivities* are estimated using the residuals from the three-factor model, (9) estimate *Biodiversity Sensitivity* without controlling for innovations in climate news index, (10) implement a four-factor model that includes momentum as an addition factor when estimating *Biodiversity Sensitivity*, (11) estimate betas using stock returns instead of excess stock returns (in this model, also market returns replace excess market returns), (12) estimate betas annually—instead of monthly—in December of each year, and (13) use excess bond returns as the dependent variable.

Robustness Tests	Coefficient Estimate	t-value	No. Obs.	Adj. R-squared (%)
(1) Include Year-Quarter Fixed Effects	1.16**	2.15	186,035	28.68
(2) Include Year-Month Fixed Effects	1.17**	2.16	186,035	29.03
(3) Exclude the Financial Crisis Period	1.06**	2.07	173,952	24.36
(4) Winsorize at 1% and 99%	0.96**	2.24	186,035	38.38
(5) Drop Puttable and Sinkable Bonds	1.13**	2.10	181,209	28.20
(6) Keep Trades During the Last 10 Days of the Month	1.27**	2.27	165,078	27.49
(7) Keep Firms with Nonmissing Stock Returns During the Estimation Period	1.01**	2.08	163,238	29.86
(8) Use Betas Estimated in Two Steps	1.23**	2.11	186,035	27.46
(9) Estimate Biodiversity Sensitivity without Controlling for Climate News	1.24**	2.07	186,035	27.47
(10) Estimate Biodiversity Sensitivity from a Four-Factor Model	1.20**	2.32	186,035	27.51
(11) Estimate Biodiversity Sensitivity using Returns instead of Excess Returns	1.19**	2.20	186,035	27.48
(12) Estimate Biodiversity Sensitivity in Annual Frequency	1.43**	2.40	180,878	28.98
(13) Using Monthly Excess Bond Returns as the Dependent Variable	0.90*	1.80	173,472	6.85

*, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

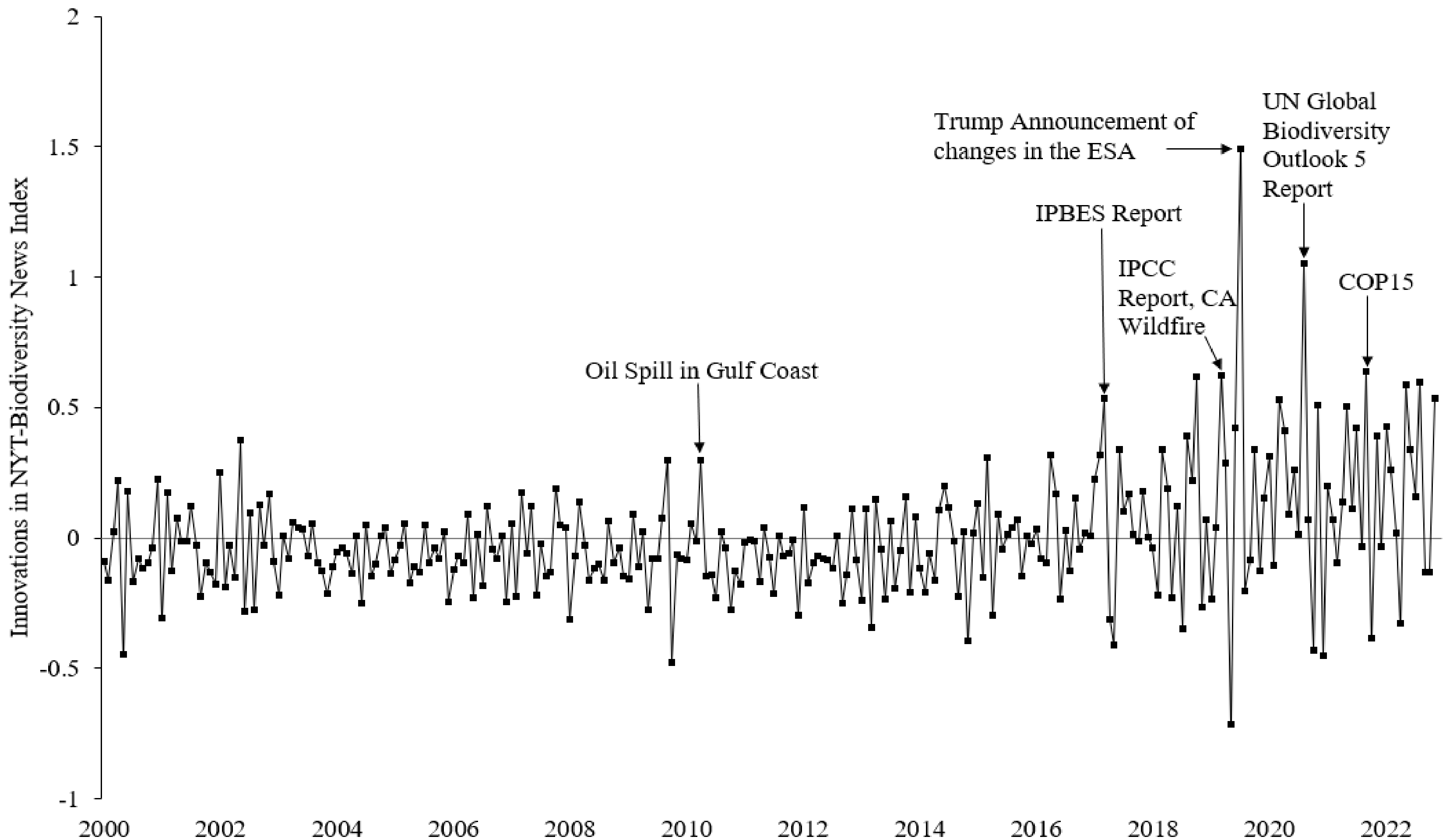

Figure 1. Innovations in Biodiversity News Index

This figure plots the monthly innovations in Biodiversity News Index. A higher value indicates more negative sentiment about biodiversity. The events mentioned in the figure are from Giglio et al. (2023).

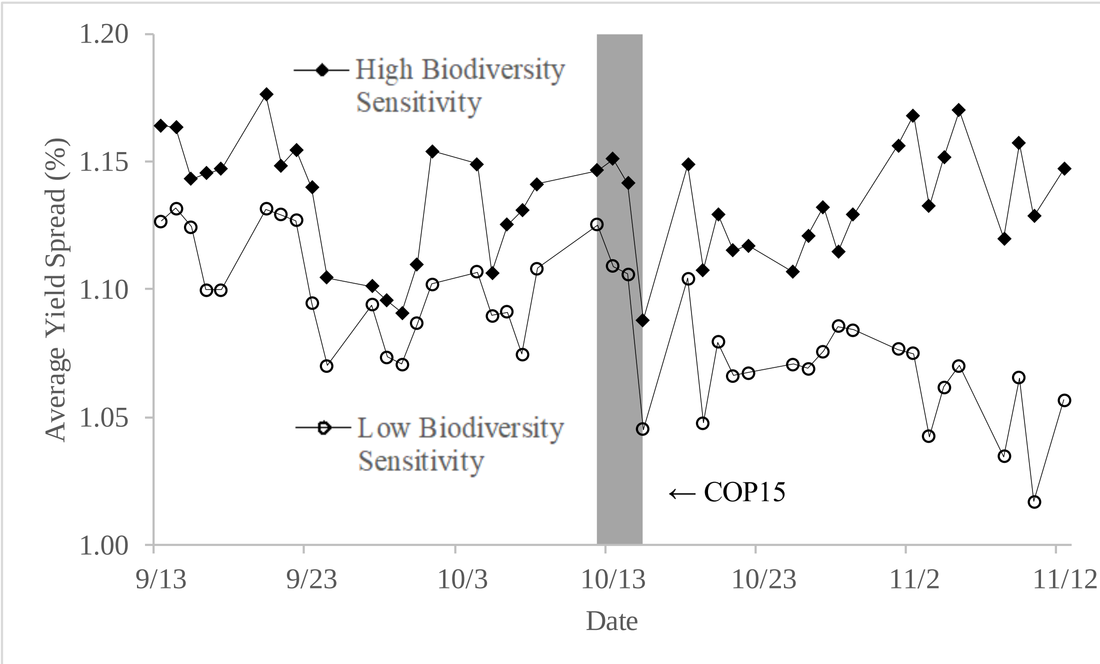

Figure 2. Average Daily Yield Spreads around the COP15

This figure reports the average of daily yield spreads (in percentages) on bonds of firms with above median (high biodiversity sensitivity sample) and below median (low biodiversity sensitivity sample) biodiversity sensitivities during the 30-day period before and after the COP15. To mitigate the influence of outlier observations to the visual interpretation of the graph, we require at least 100 observations per day when plotting average yield spreads. The shaded area indicates the COP15 period between October 11 and 15 of 2021.

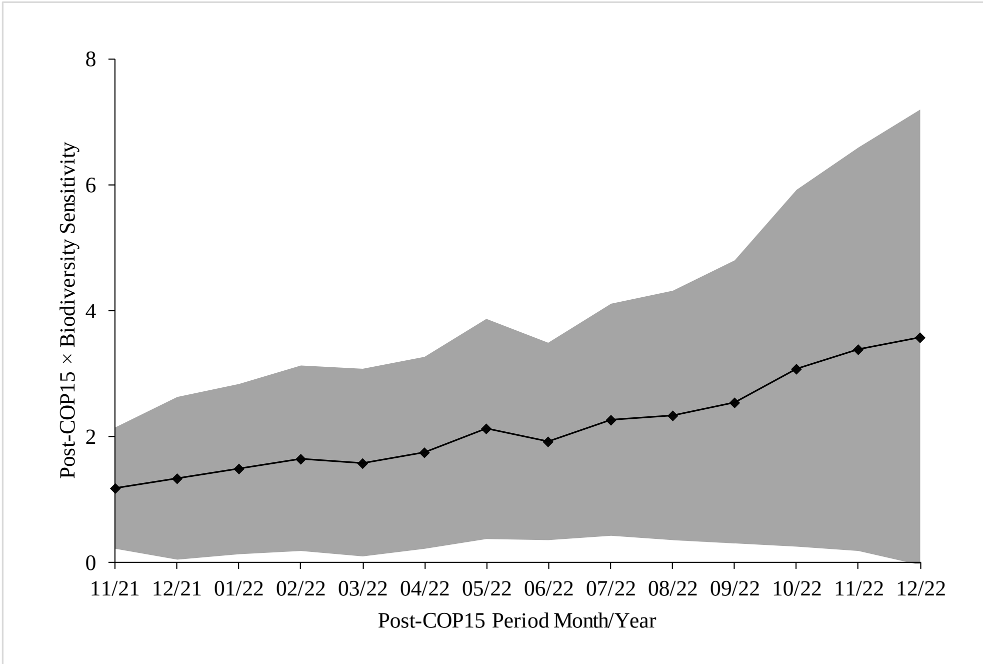

Figure 3. Persistence of the COP15 Effect

This figure reports the coefficient estimates on the *Post-COP15* × *Biodiversity Sensitivity* interaction from regressions of yield spreads (Column (1), Table 7) using sequentially longer post-COP15 periods, and their confidence intervals at the 5% and 95% levels. The vertical axis reports the coefficient estimates on the interaction variable using the corresponding cumulative post-COP15 periods on the horizontal axis. For instance, a post-COP15 of 11/21 indicates that the sample includes yield spreads contributed during the pre-COP15 month (September, 2021) and the post-COP15 month of November, 2021. A post-COP15 of 12/21 indicates that the post-COP15 period includes November and December of 2021. Hence, an additional month is added to the post-COP15 period sequentially until the end of our analysis period (December, 2022).