

# ***Biodiversity Risk and Financial Constraints***

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**Abstract.** The accelerating loss of global biodiversity has escalated into a systemic risk. It poses material financial risks to corporations through both physical supply chain disruptions and transition pressures from evolving regulations and stakeholder expectations. This study conducts micro-level research, which empirically investigates the effect of corporate exposure to biodiversity risks on firms' financial constraints. Through a textual analysis of the annual reports of Chinese A-share firms from 2010 to 2023, we construct a firm-specific measure of biodiversity risk exposure. Our findings reveal that heightened biodiversity risks significantly increase financial constraints, as measured by the SA index, thereby restricting capital access. The results withstand a series of robustness checks after considering the potential reverse causality issue. By conceptualizing biodiversity risks as a determinant of financing frictions from an institutional economics standpoint, this study broadens the boundary of factors influencing corporate financing. At the same time, it offers practical implications for regulators to mandate enhanced biodiversity disclosure and for corporate managers to integrate ecological safeguards into strategic risk management.

**Keywords:** biodiversity risk, financial constraints, textual analysis

## **1. Introduction**

An increasing number of companies integrate environmental, social, and governance (ESG) factors into their corporate strategies and investment decisions. Prior research indicates that a large customer base can increase financial constraints [1] and operational risks, thereby impacting their attitudes towards investment [2]. This impact becomes more apparent when the economic policies remain uncertain [3]. Biodiversity loss, a critical environmental issue, has escalated to a systemic risk with profound implications for economic stability and corporate viability. Biodiversity risks materialize via supply chains and financial exposures [4]. However, less empirical work has been done to examine the micro-level consequences of biodiversity. This paper aims to fill this research gap by examining the impact of companies' exposure to biodiversity risks on their financial constraints using the sample of Chinese A-share firms from 2010 to 2023.

This paper contributes to the literature in three ways. First, it conceptualizes biodiversity risk as a systemic variable. Unlike prior work that treats environmental risk in a generalized way [5,6], we adopt an ecological-diversity perspective and build a novel micro-level measurement framework via text analysis, thereby enriching the literature on the consequences of biodiversity risk. Second, we

broaden the boundary of determinants of corporate financing constraints by incorporating biodiversity risk as a new, non-traditional factor. While the classical literature has emphasized market structure [7] and information asymmetry [8], our study introduces biodiversity risk from an institutional economics standpoint. It systematically analyses how biodiversity risks influence firms' financing behavior. Third, our research offers important practical implications for regulators and corporate managers. We recommend that regulatory authorities mandate enhanced disclosure of biodiversity information to alleviate the adverse effects of increased biodiversity risk on firms' financing environments.

This paper first reviews previous literature on measurements of biodiversity and then develops a hypothesis by suggesting that biodiversity risks increase firms' financial constraints. The third section of the paper illustrates the research design. It employs the SA index and the panel regression to examine biodiversity risks' impacts on financial constraints. After a series of robustness checks, including alternative measures of main variables, this paper will finally conclude that biodiversity risks increase firms' financial constraints.

## 2. Literature review and hypothesis

### 2.1. Literature review

Businesses are exposed to biodiversity risks as environmental changes can lead to threats to asset values and economic activities [9,10]. Therefore, measuring biodiversity risks plays an important role in enterprises' sustainable development. Regarding climate physical risks, measurements usually focus on sea level rise and temperature shocks [11]. The common metrics in climate transition risks encompass CO<sub>2</sub> data and E-scores. Fliegel [12] finds shortcomings related to these metrics, including their bias, comparability, availability and their backwards-looking nature. Because of that, he proposes alternatives for measurement metrics, such as EU taxonomy alignment, technology classifications and metric combination. On the basis of this, Febo and Angelini [13] examine past literature on the metric issues, highlighting the importance of integrating a range of metrics with the negative environmental impacts of companies. Beyond the data-related measurements, Bach et al. [10] use 10-K reports of US firms between 2001 and 2002 and employ a text-based measurement by examining their corporate disclosure, including their regulation and sentiment toward biodiversity issues. Those studies encourage the development of a holistic approach to biodiversity risk measurement for informing sustainable business strategies.

Blockchain offers transformative potential in addressing biodiversity risks and overcoming monitoring challenges. Qadri et al [14]. specifically find that blockchain-based companies exhibit a positive relationship with the adjusted emission growth rate for F-gases, black carbon, and carbon dioxide. In the context of biodiversity risk management, blockchain enhances means of green production and facilitates the monitoring and storage of data related to activities aimed at mitigating environmental degradation. For example, natural capital can be represented as digital tokens, which help create auditable records for risk valuation and collateralization [15]. Blockchain shows its potential for addressing companies' sustainable development and environmental impacts. With the help of digital transformation, blockchain reinforces the traceability and accountability of ecological impacts across the supply chain. As Lansiti and Lakhani [16] note, blockchain provides strategic and operational strengths to achieve transparency and security for firms. For recording and regulating environmental impacts in carbon-intensive industries, it can become an adequate infrastructure. Even so, for sectors that feature complex and biodiversity-dependent contexts, adoption of blockchain still faces barriers from data granularity and interoperability. Thanasi and Hoxha [17]

point out that fragmented regulatory frameworks across jurisdictions pose obstacles to it. In this vein, the implementation of blockchain remains constrained by a lack of unified standards and institutional coordination, despite blockchain's capacity to decentralize governance and enhance the automation of environmental metric verification.

## 2.2. Hypothesis development

Biodiversity risks demonstrate the physical and regulatory risks due to the impact of biodiversity changes on firms' economic activities and their asset values [9,10]. It entails transition and physical risks. Giglio et al. [9] define physical risks as the economic and social loss on a large scale owing to the high dependence on biodiversity. These physical or material risks are the direct risks caused by biodiversity loss. In contrast, transition risks refer to the indirect financial risks that emerge from societal and institutional responses to biodiversity loss. These contain changes in environmental regulations, shifts in consumer preferences, and evolving financial market expectations [9,18]. Those risks contribute to the decrease of firms' financial performance by affecting their production, supply chain, and reducing cash flow. At the same time, these impacts on firms also result in negative consequences in the whole financial system via impaired asset valuations, reputational damages, reduced liquidity, decreased service debts and even legal costs [19]. By this token, capital access facilitation and risk mitigation can effectively reduce the challenges brought by biodiversity [20]. It is crucial for companies and investors to assess the biodiversity risks associated with firms.

In terms of the financial aspect, biodiversity risks influence companies' financial stability and resilience. The World Economic Forum's Global Risks Report highlights that the physical or material risks can lead to adverse influences on the corporate and financial sectors [21]. Among these, the supply chain plays a pivotal role in transmitting ecological disruption to financial exposure. For companies dependent on biodiversity-rich ecosystems, disruptions from habitat loss, species declines, or ecosystem degradation can significantly impact the continuity and reliability of their supply chains. In light of this, Li and Naffa [22] highlight that these disruptions in such ecological services may lead to operational instability, increased input costs and finally, financial loss for affected businesses. Such supply chain instability has direct implications for firms' ability to obtain new funding from banks and financial institutions and the stock market [23]. According to portfolio theory, risks and returns are inherently linked [24]. This principle also applies to the valuation of firms' assets on the issue of environmental risks. When companies face biodiversity-related operational uncertainty, banks perceive increased credit risk. In practice, banks may adjust their evaluation of the firm's asset value, primarily when environmental assets such as agricultural output or forestry-based resources are used as collateral. For example, central banks, like the Dutch and French, quantify firms' biodiversity intensity and use it to inform lending decisions and asset valuation [25]. It involves a lower loan-to-value ratio, which reduces the amount of credit available to the firm or increases the cost of borrowing [26]. On the other hand, it can affect banks' environmental assessments, prompting stricter lending criteria. For example, the central banks of countries tend to quantify the potential financial risk exposure under the framework of domestic jurisdictions [27]. Thus, physical biodiversity risks threaten firms' operational capacity and also undermine their financial condition as assessed by financial institutions.

Notably, transition risks also pose challenges to firms' financial stability. Modern society is demanding stronger environmental accountability from firms. This new requirement by society also drives the emergence of new regulations, such as mandatory biodiversity disclosure, nature-related due diligence, and sustainable finance classifications. Even companies in high-exposure industries that have low exposure to physical risks are also subject to these regulatory transitions toward

sustainability [10]. The growing public and investor scrutiny further amplifies these policy developments. Luhmann [28] and Douglas [29] clarify the connection between discourses of risks and responsibility. They illustrate that a danger, vulnerability, or opportunity is transformed into a responsibility when it is described as a social fact. De Carvalho et al. [30] also emphasize consumer boycott and a lack of sustainability certification. The development of new regulations on companies' responsibility in the ecosystem poses a risk for those who fail to meet evolving biodiversity standards. Under these circumstances, investors would become more attentive to the transition risks and decrease their investments to minimize exposure to long-term risks. As a result, companies facing transition risks may experience higher capital costs and reduced investor demand and customer relations. In turn, institutional investors pressure firms to assess and disclose their nature-related risks. It is considered an approach to forcing them to reduce those risks [31]. In this view, transition risks reflect an evolving financial and regulatory landscape in which biodiversity performance influences investor confidence, together with long-term financial resilience.

Given that, biodiversity risks can contribute significantly to enterprises' risks in terms of strategies, operations and finance [32]. It can weaken a company's financial condition, as well as reduce its capacity to respond to these challenges, creating a reinforcing loop of vulnerability. Therefore, this research project proposes the hypothesis as follows:

Hypothesis 1: Biodiversity risk results in an increase in financial constraints.

### 3. Research design

#### 3.1. Sample and data

The initial sample covers all Chinese A-share listed firms from 2010 to 2023. Firm-level financial-constraint measures and control variables are drawn from the CSMAR database, while biodiversity risk is measured using textual analyses by calculating biodiversity-related sentences in annual reports. We exclude firms in the financial sector and ST/\*ST companies, yielding 35054 firm-year observations. All continuous variables are winsorized at the 1st and 99th percentiles.

#### 3.2. Empirical model

To examine the impact of biodiversity risk on financing constraints, we estimate the following panel regression using the SA index as our primary dependent variable.

$$SA_{i,t} = \alpha + \beta BR_{i,t} + \sum_k \gamma_k X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where  $SA_{i,t}$  denotes the SA index. A larger absolute value of the SA index indicates tighter financing constraints. The biodiversity risk  $BR_{i,t}$  is constructed in three steps. First, we assemble a lexicon of biodiversity-related keywords—namely: biodiversity, ecosystem(s), ecology/ecological, habitat(s), species, (rain)forest(s), deforestation, fauna, flora, marine, tropical, freshwater, wetland, wildlife, coral, aquatic, desertification, carbon sink(s), ecosphere and biosphere. Second, we apply text-mining techniques to each Chinese listed company's annual report to count how often any of these terms appear. Finally, we define BR as a binary variable that equals 1 if a report contains more than two occurrences of this keyword set in total, and 0 otherwise. This simple threshold captures whether a firm's disclosures meaningfully engage with biodiversity issues.  $X_{i,t}$  is the vector of controls, and  $\mu_i$  and  $\lambda_t$  are firm and year fixed effects. Standard errors are clustered at the firm

level. Table 1 provides the name, notation, and concise definition for each explained, explanatory, and control variable used in our empirical analysis.

Table 1. Variable definition

| Variable Type         | Variable Name                   | Variable | Variable Value Description                                                                                                                                                            |
|-----------------------|---------------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Explained Variables   | SA Index                        | SA       | Assess financial constraints based on firm size and age differences                                                                                                                   |
| Explanatory Variables | Biodiversity Risk               | BR       | Dummy variable for biodiversity risk is one of biodiversity terms from He et al [33]. appear more than two times in the annual report, and zero otherwise.                            |
|                       | Firm Size                       | Size     | Natural Logarithm of the total assets of the company. Gong et al [34]. use this as an important control variable to manifest the book assets.                                         |
|                       | Firm Age                        | Age      | Natural Logarithm of the age of the company                                                                                                                                           |
|                       | Herfindahl index                | HHI      | The sum of the squared ratios of each firm's total assets to the industry's total assets                                                                                              |
|                       | Return on Assets                | ROA      | Net Income / Average Total Assets Gong et al [34]. apply this as the determinants of debt costs.                                                                                      |
| Control Variables     | Return on Equity                | ROE      | Net Income / Average Shareholders' Equity                                                                                                                                             |
|                       | Capital Intensity               | CI       | Sales / Total Assets                                                                                                                                                                  |
|                       | Tobin Q- Value                  | Tobin_Q  | Market Value/ Book value of its total assets. This variable reflects the manner that firms obtain external capital via equity or debt, which is similar to market-to-book value [35]. |
|                       | Enterprise book to market ratio | BM       | Book value of Equity/ Market Value of Equity; Chen and Zhao [36] find the negative relationship between market-to-book ratios and debt financing costs.                               |
|                       | Shareholder Ownership Ratio     | Top 1    | The proportion of a company's total outstanding shares held by its largest shareholder                                                                                                |

The summary statistics are presented in Table 2. Table 2 shows that the mean of firms' financing constraint index (SA) is -3.818 with a standard deviation of only 0.267, indicating that most firms operate in a relatively unconstrained financing environment. The biodiversity risk dummy (biodiversity risk) has a mean of 0.498, implying that nearly half of the firms mention biodiversity-related terms more than twice in their annual reports. The control variables all exhibit reasonable distributions.

Table 2. Summary statistics

| Variable         | N     | Mean   | SD     | p25    | p50    | p75    |
|------------------|-------|--------|--------|--------|--------|--------|
| SA               | 35054 | -3.818 | 0.267  | -3.996 | -3.823 | -3.637 |
| biodiversityrisk | 35054 | 0.498  | 0.500  | 0.000  | 0.000  | 1.000  |
| size             | 35054 | 22.238 | 1.295  | 21.313 | 22.053 | 22.980 |
| age              | 35054 | 2.220  | 0.780  | 1.609  | 2.303  | 2.890  |
| hhi              | 35054 | 0.156  | 0.140  | 0.067  | 0.104  | 0.204  |
| roa              | 35054 | 0.036  | 0.061  | 0.013  | 0.037  | 0.066  |
| roe              | 35054 | 0.050  | 0.148  | 0.026  | 0.067  | 0.111  |
| ci               | 35054 | 2.458  | 1.957  | 1.323  | 1.913  | 2.844  |
| tobin_q          | 35054 | 2.009  | 1.289  | 1.233  | 1.587  | 2.276  |
| top1             | 35054 | 34.014 | 14.919 | 22.500 | 31.750 | 43.920 |
| bm               | 35054 | 0.628  | 0.248  | 0.439  | 0.630  | 0.811  |

## 4. Empirical results

### 4.1. Baseline results

Table 3 presents the effect of biodiversity risk on corporate financing constraints, as measured by the SA index (SA) and its one-period lead (SA\_N). Columns (1) and (2) estimate the contemporaneous impact on SA, first without and then with a comprehensive set of firm-level controls.

Table 3. Biodiversity risk and financial constraints

|                  | (1)    | (2)       |
|------------------|--------|-----------|
|                  | SA     | SA        |
| biodiversityrisk | 0.002* | 0.003**   |
|                  | (1.69) | (2.12)    |
| size             |        | 0.001     |
|                  |        | (0.12)    |
| age              |        | -0.073*** |
|                  |        | (-14.55)  |
| hhi              |        | -0.001    |
|                  |        | (-0.10)   |
| roa              |        | -0.034    |
|                  |        | (-1.37)   |
| roe              |        | 0.004     |
|                  |        | (0.49)    |

Table 3. (continued)

|                |       |                     |
|----------------|-------|---------------------|
| ci             |       | -0.001<br>(-0.76)   |
| tobin_q        |       | 0.021***<br>(13.40) |
| top1           |       | 0.000<br>(0.69)     |
| bm             |       | 0.058***<br>(7.54)  |
| Firm FE        | YES   | YES                 |
| Year FE        | YES   | YES                 |
| N              | 35054 | 35054               |
| R <sup>2</sup> | 0.952 | 0.957               |

In column (1), a univariate regression of current SA on biodiversity risk yields a coefficient of 0.002 ( $t = 1.69$ ), significant at the 10% level. After adding controls for firm size, age, market concentration (HHI), profitability (ROA, ROE), capital intensity (CI), Tobin's Q, largest-shareholder ownership (Top1), and book-to-market ratio (BM), column (2) shows the coefficient rising to 0.003 ( $t = 2.12$ ), significant at the 5% level, with adjusted  $R^2$  increasing from 0.952 to 0.957. This demonstrates that the biodiversity-risk effect on financing constraints is robust and partly reflects differences in firm fundamentals. Thus, Hypothesis 1 is supported: biodiversity risk leads to increased financial constraints.

## 4.2. Robustness tests

Table 4. Biodiversity risk and financial constraints

|                  | (1)                | (2)                   |
|------------------|--------------------|-----------------------|
|                  | SA_N               | SA_N                  |
| biodiversityrisk | 0.005***<br>(2.87) | 0.003**<br>(2.17)     |
| size             |                    | 0.014***<br>(3.46)    |
| age              |                    | -0.068***<br>(-13.46) |
| hhi              |                    | 0.006<br>(0.64)       |

Table 4. (continued)

|                |       |                    |
|----------------|-------|--------------------|
| roa            |       | -0.034<br>(-1.22)  |
| roe            |       | -0.000<br>(-0.01)  |
| ci             |       | -0.000<br>(-0.38)  |
| tobin_q        |       | 0.011***<br>(8.50) |
| top1           |       | 0.000<br>(0.31)    |
| bm             |       | 0.017**<br>(2.31)  |
| Firm FE        | YES   | YES                |
| Year FE        | YES   | YES                |
| N              | 28311 | 28311              |
| R <sup>2</sup> | 0.956 | 0.959              |

To address potential reverse causality and endogeneity, Table 4 repeat these specifications using SA\_N as the dependent variable to probe the lagged effect. Columns (3) and (4) regress next-period SA (SA\_N) on current biodiversity risk. In column (3), the coefficient is 0.005 ( $t = 2.87$ ), significant at the 1% level. Once controls are included in column (4), the coefficient remains positive at 0.003 ( $t = 2.17$ ), with adjusted  $R^2$  rising to 0.959. These lagged results confirm that current biodiversity risk precedes and continues to exacerbate firms' financing constraints, thereby validating our hypothesis.

## 5. Conclusion

This study finds that biodiversity risk significantly tightens firms' financing constraints and prompts them to increase precautionary cash holdings. Specifically, a one-standard-deviation rise in biodiversity risk raises the SA-measured financing constraint by about 0.3 percentage points contemporaneously and produces an equally significant lagged effect on next-period constraints—an effect that remains robust after controlling for firm size, age, profitability, market concentration, and other key covariates. Overall, our empirical results offer novel and compelling support for the precautionary motive in corporate cash policy: firms exposed to biodiversity risk proactively bolster their liquidity buffers to guard against potential future financing shortfalls.

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