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Research on biodiversity risk and corporate short-term debt for long-term use under disclosure regulation

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ABSTRACT

This paper uses A-share enterprises from 2000 to 2023 as the sample to explore how biodiversity risk affects corporate short-term debt for long-term use. Results show that biodiversity risk exacerbates corporate short-term debt for long-term use. Mechanism analysis reveals that biodiversity risk does so by weakening corporate risk-taking capacity and asset turnover. Heterogeneity tests find that the impact of biodiversity risk is more significant for enterprises that have heavier tax burdens, face more intense industry competitions, and receive less attentionfrom institutional investors. Economic consequence tests indicate that corporate short-term debt for long-term use may affect corporate tax avoidance, high-quality development, and default risk. This paper offers empirical insights for coordinating enterprise biodiversity and investment and financing strategies.

1. Introduction

The pressure exerted by biodiversity risks on the environment has been recognized as a great challenge to human survival and development (Ahmad and Karpuz, 2024). Due to the significant externalities of biodiversity issues, it is difficult to achieve effective conservation and restoration by relying only on spontaneous market regulation mechanisms. Nevertheless, at the macro level, the frequent introduction of governmental biodiversity regulations can lead to false expectations of behavior. This is because market players will not be able to know if, when, and how the government will change the current production methods. At the micro level, it is crucial to further standardize and strengthen corporate biodiversity risk disclosure regulations, not only to provide investors with the necessary risk prevention information, but also to promote the transition to sustainable development. However, there is a "silence without disclosure obligation is not misrepresentation" principle in the securities law (Griffin and Jaffe, 2022). In the absence of clear legal requirements, enterprises may be reluctant to invest the necessary resources to improve the quality of disclosure, resulting in biodiversity information disclosure relying mostly on voluntary behavior of enterprises (Flammer et al., 2021). It is particularly important to develop and implement effective guidelines and standards for biodiversity risk disclosure (Bassen et al., 2024). The Shanghai, Shenzhen and Beijing Stock Exchanges issued "A Practical Guide to Sustainability Reporting of Listed Companies" in 2024. This regulation puts forward specific requirements for corporate biodiversity disclosure and standardizes corporate disclosure behaviors.

Along with the rapid rise of biodiversity risks, the enterprise's debt maturity mismatch problem has become more and more serious.

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Although short-term debt for long-term use meets the long-term development needs of enterprises, once the capital chain breaks, it may trigger the risk of default spreading to the whole financial system and become a potential trigger of systemic financial risk (Bali et al., 2021). Some studies have shown that risks in the external environment lead creditor institutions such as banks to demand higher risk premiums (Bretscher et al., 2023; Jeon et al., 2024). Indeed, the impact of biodiversity risk on corporate operations cannot be ignored as well. Due to biodiversity risks, corporate decision makers must also adapt their business strategies in a timely manner to cope with compliance costs, disruptions in the supply of raw materials, delays in the delivery of intermediate commodities, and the transformation of resources (Wang et al., 2023). Based on an event study approach, Garel et al. (2024) found that the stock prices of firms with higher biodiversity footprints declined significantly after the release of the Kunming Declaration. Liang et al. (2024) argue that biodiversity risk increases the risk of a firm's stock crash. Li et al. (2025) find that biodiversity risk raises firms' operating costs and reduces firms' efficiency. Biodiversity loss leads to shorter-term project decisions by companies and higher borrowing thresholds by banks. Thus, biodiversity risk may motivate firms to adopt short-term debt for long-term use. This paper aims to answer the following questions: (1) does biodiversity risk affect corporate short-term debt for long-term use? (2) What mechanisms are involved? (3) Is there heterogeneity in the impact? (4) What are the economic consequences?

2. Research design

2.1. Samples and data sources

This paper selects Chinese A-share listed companies from 2000 to 2023 as the sample. The data on biodiversity risk is obtained from the research of He et al. (2024). The corporate financial data are from CSMAR database. This paper processes the sample as follows: (1) exclude ST, *ST and PT firms. (2) Exclude the samples with serious missing data. (3) Remove outliers.

2.2. Variable selection

2.2.1. Dependent variable

Referring to Liu and Liu (2019), this paper uses the difference between (short-term debt/total liabilities) and (short-term assets/total assets) to measure the level of short-term debt for long-term use (*SDLA*), with larger values of this indicator representing a higher degree of firms' investment and financing maturity mismatch.

2.2.2. Independent variable

He et al. (2024) selected terms related to biodiversity such as "biodiversity, ecosystem(s), ecology/ecological, habitat(s), species" in the annual report, and calculated the proportion of the word frequency of these terms total word frequency. This paper uses the data provided by He et al. (2024) and employs the word frequency proportion to assess corporate biodiversity risk.

2.2.3. Control variable

Drawing on related literature (Liang et al., 2022; Ren et al., 2022), the control variables include: firm size (*Size*), firm value (*TobinQ*), operating income growth rate (*Growth*), non-debt tax shields (*Ntds*), cash flow ratio (*Cflow*), independent director size (*Board*), dual position (*Dual*), and firm age (*Age*). The definitions of variabes are presented in Table 1.

2.3. Modeling

This paper constructs the following model to analyze the impact of biodiversity risk on the short-term debt for long-term use.

$$SDLA_{it} = \beta_0 + \alpha_1 BiodiversityRisk_{it} + \alpha_2 Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

The subscript i denotes the firm and t denotes the year. $SDLA_{it}$ denotes the level of short-term debt for long-term use of firm i in year

Table 1
Variable definition.

Type	Symbol	Variable	Definition
Dependent variable	*SDLA*	Short-term debt for long-term use	(Short-term debt / total liabilities) - (short-term assets / total assets)
Independent variable	*BiodiversityRisk*	Biodiversity risk	The proportion of the word frequency of terms related to biodiversity in the annual report's total word frequency
Control variable	*Size*	Firm size	Natural logarithm of the annual total assets
	TobinQ	Firm value	Enterprise value / total assets
	Growth	Operating income growth rate	(Current year's operating income - previous year's operating income) / previous year's operating income
	Ntds	Non-debt tax shields	Depreciation and amortization / Total assets
	Cflow	Cash flow ratio	Net cash flow from operating activities / Total assets
	Board	Independent director size	Natural logarithm of the number of board members
	Dual	Dual position	If the chairman and general manager are the same person, take 1, otherwise 0
	Age	Firm age	The natural logarithm of the corporate age

t. $BiodiversityRisk_{it}$ denotes the level of biodiversity risk faced by firm *i* in year *t*. $Control_{it}$ is the control variable. μ_i is the firm fixed effect. δ_t is the time fixed effect. ε_{it} is the error term.

3. Results

3.1. Benchmark regression

Table 2 reports the impact of biodiversity risk on short-term debt for long-term use. The coefficient of biodiversity risk is significantly positive, indicating that biodiversity risk exacerbates firms' short-term debt for long-term use. Firstly, rational corporate management will be conservative, which will reduce the motivation of enterprises to fulfill the responsibility of biological conservation, and reduce the demand for bank loan financing in the long run. Secondly, banks will shift the risk premium of long-term loans under biodiversity risk to above interest rates, so companies will also tend to make their own scale investments through multiple short-term debts (Adamolekun, 2024).

3.2. Endogeneity test

3.2.1. Instrumental variable test

BiodiversityRisk and *SDLA* may have a reverse causality problem. Drawing on Goldsmith et al. (2020) in designing Bartik instrumental variable, this paper uses the annual average of biodiversity risk of other firms in the same industry as the impact share, global mean surface temperature (*GMSF*) as the exogenous shock, and the product of the two (*GMSF_Risk*) as the instrumental variable. The results of the first stage regression in column (1) of Table 3 show that the instrumental variable (*GMSF_Risk*) is positively associated with firms' biodiversity risk (*BiodiversityRisk*). The second stage regression results in column (2) of Table 3 indicate that biodiversity risk remains significantly positively correlated with short-term debt for long-term use (*SDLA*). This test indicates that the baseline regression results are robust.

3.2.2. Heckman two-step method

This paper adopts the Heckman two-step method to mitigate the sample selection bias problem. A dummy variable (*Biodiversity_dummy*) of whether firms disclose biodiversity risks is used as a dependent variable. The paper continues with *GMSF_Risk* as the instrumental variable and calculates the Inverse Mills Ratio (*IMR*). The results in columns (3)-(4) of Table 3 show that the impact of biodiversity risk on short-term debt for long-term use is still significant.

3.2.3. Omitted variable test

This paper tests the omitted variable problem by including financial leverage ratio (*FL*) and operating leverage rato (*OL*) as additional control variables. Column (5) of Table 3 reports that there is still a significant positive relationship between *BiodiversityRisk* and *SDLA*.

3.2.4. Joint fixed effects

This paper introduces joint firm-city fixed effects. Column (6) of Table 3 reports the estimation results: the benchmark results are still robust after controlling for trend errors.

3.3. Robustness test

3.3.1. Propensity score matching test

This paper sets a dummy variable. If the biodiversity risk is in the top 50 %, then the dummy variable is assigned a value of 1, otherwise it is 0. The control variables are used as covariates. The samples are grouped by randomness using the nearest neighbor matching method. Figs. 1 and 2 show that the propensity score matching is of high quality. Column (1) of Table 4 reports the results after matching indicates that the baseline regression results are robust.

Table 2
Benchmark regression.

Variable	(1) *SDLA*	(2) *SDLA*	(3) *SDLA*	(4) *SDLA*
BiodiversityRisk	7.8917***	10.7852***	6.1689***	7.7864***
	(5.7424)	(4.2949)	(4.4868)	(3.2202)
Controls	YES	YES	YES	YES
Constant	YES	YES	YES	YES
R-squared	0.140	0.551	0.155	0.559
Firm	NO	YES	NO	YES
Year	NO	NO	YES	YES

Note: ***, ** and * are significant at 1 %, 5 % and 10 %, respectively, and *t*-test statistics are within ().

Table 3
Endogeneity test.

Variable	Instrumental variable test		Heckman two-step test		Omitted variable	Joint Fixed Effects
	(1) *SDLA*	(2) *SDLA*	(3) *Biodiversity_dummy*	(4) *SDLA*	(5) *SDLA*	(6) *SDLA*
BiodiversityRisk		214.4446***		6.3075**	7.2681***	7.9852***
		(3.8600)		(2.5111)	(2.9971)	(3.2633)
GMSF_Risk	0.0151***		25.2891***			
	(4.8300)		(4.8154)			
IMR				0.0939***		
				(5.3542)		
FL					0.000013**	
					(2.0031)	
OL					0.000005	
					(0.7036)	
Cragg-Donald Wald F-value	189.366 (16.38)					
Underidentification test P-value	0.0000					
Controls	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES
Firm	YES	YES	NO	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Industry	NO	NO	YES	NO	NO	YES
City	NO	NO	NO	NO	NO	YES
Firm-City	NO	NO	NO	NO	NO	YES

3.3.2. *Entropy balancing method*

This paper uses the entropy balance matching method for the test, and the results of the matched regression are shown in column (2) of Table 4, where the regression coefficient of biodiversity risk is significantly positive.

3.3.3. *Replace the independent variable*

Using data from the research of He et al. (2024), this paper selects the following proxy variables to measure biodiversity risk: (1) if the frequency of biodiversity-related words is more than two times, it is assigned a value of 1, otherwise 0. (2) The proportion of the number of characters related to biodiversity to the total number of characters in the annual report. (3) The proportion of the number of Chinese characters related to biodiversity to the total number of Chinese characters. Columns (3)-(5) of Table 4 show that the regression coefficients of independent variables are still significantly positive.

3.3.4. *Two-way clustered standard errors*

This paper adds firm and year two-way clustered standard errors to the model (1). Column (6) of Table 4 shows that the coefficient of biodiversity risk remains significantly positive.

3.3.5. *Exclude the special-year sample*

Considering the shock of the financial crisis in 2008, this paper regresses again after removing the samples in 2008. The results in column (7) of Table 4 show that the coefficient of biodiversity risk is still significantly positive after removing the data in 2008.

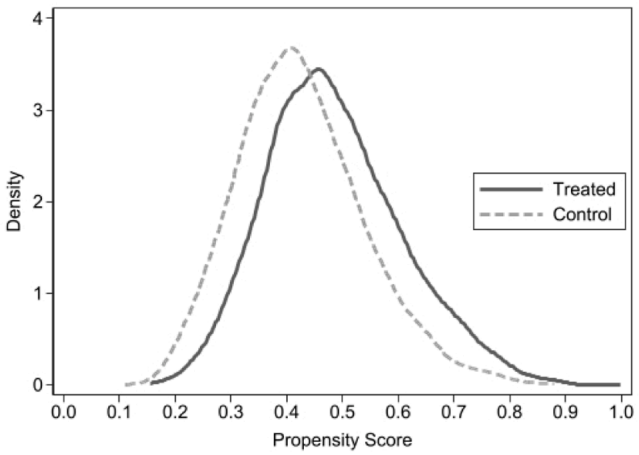

Fig. 1. Kernel density before matching.

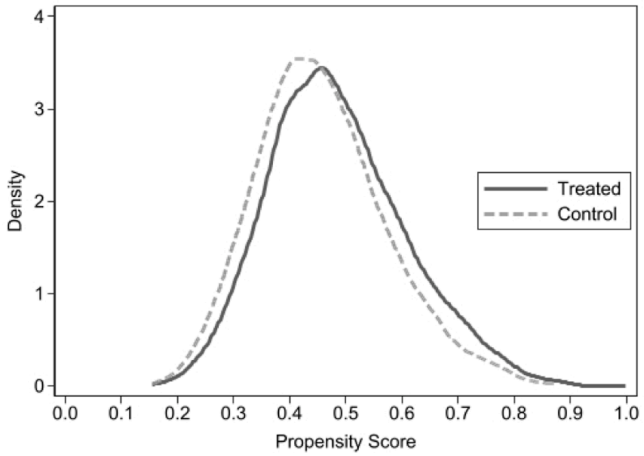

Fig. 2. Kernel density after matching.

Table 4
Robustness test.

Variable	PSM test	Entropy balancing match	Replace the independent variable			Two - Way Clustered Standard Errors	Exclude samples
	(1) SDLA	(2) SDLA	(3) SDLA	(4) SDLA	(5) SDLA	(6) SDLA	(7) SDLA
BiodiversityRisk	8.6912***	8.0266***	0.0096***	23.9165***	11.2719***	7.7864**	7.3585***
	(2.6633)	(3.4037)	(3.6358)	(3.7016)	(3.2244)	(2.2864)	(3.0392)
Controls	YES	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES	YES
R-squared	0.658	0.629	0.559	0.559	0.559	0.559	0.559
Firm	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES

3.4. Mechanism analysis

This paper argues that the impact mechanism of biodiversity risk on corporate short-term debt for long-term use can be analyzed from two paths: corporate risk-taking capacity and asset turnover. The model is as follows:

$$Mechanism_{it} = \beta_0 + \alpha_1 BiodiversityRisk_{it} + \alpha_2 Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

$Mechanism_{it}$ is the mechanism variable including the risk-taking ability (*Risk*) and the asset turnover (*ATO*).

3.4.1. Risk-taking ability

Biodiversity risks may change the profit patterns and cost structures of enterprises, and increase pressure on their cash flows, which in turn affects their risk-taking capacity. Enterprises with insufficient risk-taking capacity often find it difficult to obtain long-term financing because of their poor credit profile and financial performance, and therefore rely more on short-term debt. As shown in model (3), this paper refers to the method of Luo et al. (2024), and uses the logarithm of the standard deviation of annualized weekly returns to measure the level of corporate risk-taking (*Risk*).

Table 5
Mechanism analysis.

Variable	(1) *SDLA*	(2) *Risk*	(3) *ATO*
BiodiversityRisk	7.7864**	-7.3939**	-6.5324**
	(2.1526)	(-2.5176)	(-2.2096)
Controls	YES	YES	YES
Constant	YES	YES	YES
R-squared	0.559	0.528	0.737
Firm	YES	YES	YES
Year	YES	YES	YES

$$Risk_{ijt} = Ln\left[\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(r_{ijt} - \frac{1}{T}\sum_{t=1}^{T} r_{ijt}\right)^2}\right] \tag{3}$$

Where, r denotes the corporate rate of return. Columns (1)-(2) of Table 5 report the results of the corporate risk-taking mechanism: biodiversity risk reduces the level of corporate risk-taking and further exacerbates short-term debt for long-term use.

3.4.2. Asset turnover

Low asset turnover (*ATO*) leads to a slower return of funds to the enterprise. Columns (1) and (3) of Table 5 shows that enterprise asset turnover decreases as a result of increased biodiversity risk, which exacerbates the extent of short-term debt for long-term use as enterprises are unable to generate sufficient cash inflows in a timely manner to cover short-term debt financing gaps.

3.5. Heterogeneity test

There may be heterogeneity in the impact of biodiversity risk on firms' short-term debt for long-term use: (1) when firms face a heavier tax burden, they have less money at their disposal, which exacerbates short-term debt for long-term use. (2) Intense industry competition may require firms to respond to market changes with faster debt financing. (3) Increased attention to a firm by institutional investors leads other investors to follow suit. If institutional investors reduce their attention to a firm, the market may also see this as a negative signal, making it difficult for firms to raise external financing.

This paper uses the annual median of corporate comprehensive tax rate (*Tax*), industry Herfindahl index (*HHI*) and institutional investor shareholding ratio (*Inst*) as the basis for group regression respectively. The results are shown in Table 6: the effect of biodiversity risk on corporate short-term debt for long-term use is more significant when enterprises have heavier tax burdens, face more intense industry competitions, and receive less attention from institutional investors.

3.6. Economic consequences test

It has been shown that biodiversity risk can exacerbate short-term debt for long-term use. However, the economic consequences of short-term debt for long-term use have not been explored. Specifically, this paper argues that the economic consequences can be as follows. Firstly, taxes constitute an important part of a firm's financial burden, so short-term debt for long-term use may prompt firms to possibly alleviate their cash flow constraints through tax avoidance behavior. Secondly, the nature of short-term debt for long-term use is a maturity mismatch between firms' investment and financing, which may affect firms' high-quality development. Finally, the long use of short-term debt increases the cash flow pressure of enterprises, which in turn aggravates the risk of corporate default. This paper establishes the following model to examine the economic consequences:

$$Tax\_diff_{it} = \beta_0 + \beta_1 SDLA_{it} + \beta_2 Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{4}$$

$$TFP_{it} = \beta_0 + \beta_1 SDLA_{it} + \beta_2 Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{5}$$

$$DD_{it} = \beta_0 + \beta_1 SDLA_{it} + \beta_2 Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{6}$$

Models (4)-(6) test the impact of short-term debt for long-term use strategy on tax avoidance behavior (*Tax_diff*), quality development (*TFP*) and firm debt default risk (*DD*), respectively. This paper draws on Desai and Dharmapala's (2006, 2009) approach to portray the degree of tax avoidance (*Tax_diff*) using accounting and tax differences net of the effect of accrued profits. This paper draws on Cheng and Meng's (2023) approach to use firms' total factor productivity measured by the LP method to represent *TFP*. Following the basic principles of Merton (1974) in designing the model, this paper calculates the firm's debt default distance (*DD*) by subtracting the face value of the debt from the firm's market value and dividing it by the estimated volatility of the firm's value. A larger default distance (*DD*) indicates that the risk of debt default is also lower. The results in Table 7 suggest that the short-term debt for long-term use strategy of firms induced by biodiversity risk may affect tax avoidance, high-quality development, and default risk to some extent.

4. Research conclusion and implication

How biodiversity risk affects firms is the focus of research in the field of biodiversity disclosure regulation. Conclusions are as follows: (1) biodiversity risk exacerbates corporate short-term debt for long-term use. (2) Biodiversity risk exacerbates the extent of short-term debt for long-term use by reducing corporate risk-taking capacity and asset turnover. (3) The effect of biodiversity risk on corporate short-term debt for long-term use is more significant when enterprises have heavier tax burdens, face more intense industry competitions, and receive less attention from institutional investors. (4) This paper also explores the economic consequences of biodiversity risk. Short-term debt for long-term use may affect corporate tax avoidance, high - quality development and debt default to some extent.

The implications are as follows: (1) the government should promote the establishment of broader biodiversity disclosure regulations, and consider strengthening existing corporate disclosure regulations. (2) The government should avoid high-frequency changes in biodiversity regulation, provide a predictable policy environment for enterprises, and reduce the adjustment of financial strategies

Table 6
Heterogeneity test.

Variable	(1) Low_Tax	(2) High_Tax	(3) Low_HHI	(4) High_HHI	(5) Low_Inst	(6) High_Inst
BiodiversityRisk	6.0117	7.3700**	8.4093	6.7048**	8.2540***	7.9202*
	(1.3918)	(2.4651)	(1.3289)	(2.3024)	(2.6668)	(1.8844)
Controls	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES
R-squared	0.603	0.592	0.640	0.520	0.635	0.588
Firm	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES

Table 7
Economic consequences test.

Variable	(1) *Tax_diff*	(2) *TFP*	(3) *DD*
SDLA	0.0027***	-0.1033***	-0.2614**
	(3.5925)	(-6.1817)	(-2.2280)
Controls	YES	YES	YES
Constant	YES	YES	YES
R-squared	0.460	0.898	0.546
Firm	YES	YES	YES
Year	YES	YES	YES

of enterprises due to biodiversity risks. (3) The government should reduce their financing pressure through financial subsidies and tax breaks, help them overcome short-term financial difficulties and promote long-term sustainable development. (4) Enterprises should construct more comprehensive risk management systems. This initiative aims to enhance enterprises' adaptability to biodiversity risks. (5) Enterprises should make differentiated strategic decisions according to the heterogeneous environment.

5. Limitation and direction

The limitations are as follows: (1) the experience and characteristics of different corporate decision makers also affect the choice of corporate debt maturity. Limited to data availability, this paper does not consider corporate decision making differences. (2) This paper does not explore the financial compensation mechanism to mitigate short-term debt for long-term use. Accordingly, this paper proposes future research directions: (1) text mining based on corporate financial report data to explore the impact of biodiversity risk under the influence of corporate decision-making differences. (2) From the perspective of financial derivatives design, explore the possibility of mitigating short-term debt for long-term use of enterprises.

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CRediT authorship contribution statement

Guang Yang: Writing – original draft, Methodology, Investigation, Formal analysis. **Yu Li:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization.

Data availability

Data will be made available on request.

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