Corporate Biodiversity Risk Exposure and Debt Financing: Evidence from the UK, China, and India

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Abstract

This study investigates the impact of corporate biodiversity risk exposure on debt financing structures, including informal debt through trade credit and formal debt in the form of short- and long-term borrowings. Using panel data from listed firms in the UK, China, and India from 2012 to 2023, the analysis integrates pecking order theory, risk-adjusted trade-off theory, and institutional theory to conceptualize biodiversity risk as a persistent constraint on external financing. Mixed-effects models are used as the baseline estimator, while propensity score matching, system GMM, and placebo tests address endogeneity and measurement concerns. Results consistently show a negative relationship between biodiversity risk and both forms of debt across institutional settings. However, firms with government procurement ties or geographically diversified operations are more likely to overcome such financing constraints. These findings offer theoretical insights and policy relevance, highlighting the role of public procurement and cross-border value chain strategies in alleviating ecological financing frictions.

Keywords: Biodiversity Risk; Debt Financing; Government-related Relations; Geographical Offshoring Activities
JEL Classification: G32; G38; Q57; L25

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1. Introduction

Biodiversity, defined as the variety of living organisms and ecosystems, is fundamental to ecological stability and human development. It supports vital services such as food supply, clean water, natural medicine, and climate regulation. However, growing human-induced pressures, including habitat destruction, overexploitation of resources, and environmental pollution, have led to a substantial decline in biodiversity. Recent global assessments report severe reductions in wildlife populations and ecosystem health, reflecting an urgent ecological crisis. For instance, the World-Wide Fund for Nature highlights a 73 percent decline in wildlife populations over recent decades. Economic projections by the World Bank (Johnson et al., 2021) suggest that the loss of ecosystem functions, such as pollination and marine resources, could reduce global GDP by approximately $2.7 trillion annually by 2030. Similarly, broader ecosystem degradation is estimated to incur annual losses of up to $20 trillion (Giglio et al., 2023), indicating the magnitude of biodiversity-related economic risks. In response, global governance bodies and policymakers have increasingly prioritized biodiversity conservation. The United Nations Convention on Biological Diversity (CBD), established in 1993, has provided a central framework for international action. More recently, initiatives such as the Taskforce on Nature-related Financial Disclosures (TNFD), the Kunming Declaration, and the Montreal Agreement have been introduced to integrate biodiversity considerations into economic and policy decisions (Hutchinson & Lucey, 2024; Ma et al., 2023). These

developments reflect a growing recognition that biodiversity loss is not only an environmental concern but also a systemic economic and financial risk that requires coordinated institutional responses.

The loss of biodiversity presents growing challenges for firms, particularly in sectors that are directly dependent on natural ecosystems such as agriculture, fisheries, forestry, and pharmaceuticals. As ecosystems decline, companies encounter reduced access to essential raw materials, higher input costs, and potential threats to product quality. Additionally, the degradation of natural systems contributes to broader operational risks, including water scarcity, soil degradation, and increased vulnerability to climate-related disruptions. These risks lead to supply chain instability and increased long-term costs. Despite the material nature of these threats, financial markets have been slow to incorporate biodiversity-related considerations into investment evaluations, as noted by Flammer et al. (2018). It is only in recent years, particularly after the adoption of global frameworks such as the Kunming Declaration, that investors have begun to demand risk premiums that reflect biodiversity exposure (Boiral, 2016). However, evidence remains limited on how firms are developing internal strategies to address these challenges. As Karolyi and Tobin-de la Puente (2023) observe, leading finance journals have yet to systematically explore the financial risks associated with biodiversity loss, highlighting a critical gap in the literature that warrants further academic inquiry.

This study investigates how firms that face biodiversity-related risks make decisions about their debt financing choices. These choices include both formal sources, such as short-term and long-term borrowings, and informal sources, such as trade credit. This line of inquiry is crucial because debt financing is closely linked to a firm's operational planning, earnings consistency, and ability to manage external challenges (Shahzad, Luo, & Liu, 2021; Tian & Tian, 2022; Yang & Li, 2025). Pressures related to biodiversity, including limited access to natural inputs, rising material costs, and production disruptions, often reduce operational efficiency and increase the unpredictability of cash flows. These factors can also exacerbate information asymmetry, raise the risk of financial instability, and negatively influence overall financial outcomes (Hoffmann & Kleimeier, 2021; Yang & Li, 2025).

In addition to these pressures, firms are also operating in environments with increasingly strict regulatory expectations and heightened public scrutiny regarding environmental performance. These overlapping challenges necessitate that firms approach financing decisions with greater caution and a more strategic mindset (Adamolekun, 2024; Bhattacharya & Bhattacharya, 2019; Yue et al., 2023). For instance, trade credit allows companies to defer payments to suppliers, which can help manage cash flows without immediate borrowing. However, during periods of ecological disruption or supply chain strain, suppliers may respond by tightening credit terms or reducing repayment periods (Tian & Tian, 2022). This limits firms' flexibility and adds financial stress. Short-term loans are typically used to cover

urgent liquidity needs and are often more readily available than long-term financing. At the same time, they also bring the risk of frequent refinancing, especially when firms face unstable earnings or delays in customer payments. Under such conditions, companies may encounter stricter lending criteria, higher interest rates, and reduced borrowing capacity (Adamolekun, 2024; Choi, 2024). On the other hand, long-term borrowing provides more stable funding for capital investments but comes with fixed repayment responsibilities over time. When firms experience shocks to cash flows, such obligations can undermine financial resilience and increase the risk of credit downgrades, covenant breaches, or default (Shahzad, Luo, & Liu, 2021; Yang & Li, 2025). Overall, while each type of debt serves a helpful function under normal conditions, the presence of biodiversity risks significantly complicates financing decisions. Firms carefully evaluate the costs and constraints associated with each option, as poor debt choices under high uncertainty threaten both financial flexibility and long-term solvency. This raises a critical and timely research question that examines whether, and through which mechanisms, firms highly exposed to biodiversity risk can access and sustain debt financing amid escalating ecological uncertainty.

To investigate the research question, this study employs firm-level biodiversity risk data developed by He et al. (2024), which identifies firms' exposure based on textual analysis of 10-K disclosures. This dataset is merged with financial and accounting records, resulting in a sample of 4,611 unique firms, including 2,967 from

China, 943 from India, and 701 from the UK, covering 42,943 firm-year observations from 2012 to 2023. The analysis is grounded in a multi-theoretical framework comprising pecking order theory, risk-adjusted trade-off theory, and institutional theory. These theories offer complementary insights that help overcome each other's limitations. Pecking order theory explains how firms prioritize financing sources under uncertainty, but does not consider the structural costs associated with debt, which are central to the risk-adjusted trade-off theory (Frank & Goyal, 2008; Hackbarth et al., 2007). However, both frameworks operate under the implicit assumption of a uniform institutional environment. Institutional theory addresses this gap by emphasizing the influence of country-specific legal systems, regulatory quality, and governance structures on firms' financing capacity (Turk Ariss, 2016; Waisman et al., 2015). Together, these perspectives provide a more comprehensive understanding of how biodiversity-related risks affect corporate debt decisions across diverse institutional contexts.

The selection of the UK, China, and India reflects a deliberate effort to incorporate institutional diversity. The UK represents a mature market with strong legal protections and transparent credit systems (Correia, 2008; Michaelas et al., 1999). China offers a context where state-driven credit allocation and selective enforcement shape financing conditions (Cumming et al., 2016; Shahzad, Liu, & Luo, 2021). India presents a setting marked by bureaucratic inefficiencies and moderate creditor rights (Vig, 2013). Relying on a single-country sample would limit

generalizability and overlook important contextual differences. By integrating these varied settings, the study offers stronger theoretical and empirical insights into the role of biodiversity risk in shaping corporate debt structures.

Our findings show that firms facing biodiversity risks are less likely to depend on external debt financing. This includes formal sources, such as short-term and long-term debt, as well as informal sources, like trade credit. Compared to firms not exposed to such risks, those affected by biodiversity challenges reduce their use of trade credit by 2.8%, short-term debt by 3.1%, and long-term debt by 3.9%. We test this relationship across countries with varying institutional environments and find that the negative association remains statistically significant. These results suggest that biodiversity risk serves as a persistent constraint on debt financing, and differences in institutional quality do not mitigate this constraint. Regardless of the legal or governance context, creditors remain cautious about extending credit to firms exposed to uncertainties that lie beyond managerial control, particularly those arising from ecological degradation. These findings remain consistent across several robustness checks, including dynamic system GMM estimation, propensity score matching, and placebo tests.

This study identifies two key mechanisms that help firms reduce the financial impact of biodiversity risk. The first mechanism relates to government-linked procurement. Firms engaged in public procurement or holding government contracts are better positioned to manage biodiversity risks and sustain their borrowing

capacity. Evidence from previous studies confirms that government affiliations can ease financial constraints, serving as a form of institutional endorsement that enhances creditor confidence (Bessonova, 2023; Dhaliwal et al., 2011; Paglia & Harjoto, 2014). The second mechanism involves geographical diversification through offshoring. By sourcing inputs from multiple countries, firms can enhance their innovation capacity, boost profitability, and increase shareholder value while mitigating exposure to economic policy uncertainty, as supported by prior research. When biodiversity loss restricts local resource availability, such international diversification becomes increasingly important in offsetting ecological disruptions and supporting access to debt financing (Hsu et al., 2015; Massini & Miozzo, 2012; Xiao & Yu, 2024). Together, these mechanisms reinforce the strategic importance of both supply chain diversification and institutional relationships in maintaining financial stability under ecological pressure.

Our theoretical and policy implications are discussed in detail in the discussion section. However, the core theoretical contributions of this study introduce several novel insights. First, the research advances capital structure theory by framing biodiversity risk as an exogenous and persistent ecological constraint that limits firms' access to both formal and informal debt. This extends existing frameworks by incorporating environmental uncertainty as a distinct source of financing friction, beyond traditional concerns such as information asymmetry or bankruptcy costs. Second, the study refines institutional theory by showing that biodiversity risk

functions as a boundary condition. Even in settings with robust legal protections and creditor rights, ecological disruptions persist in constraining debt financing, thereby challenging the assumption that institutional strength alone ensures financial access. Third, the findings contribute to the literature on financial risk mitigation by identifying two strategic mechanisms that enhance firms' resilience. Government-related procurement relationships serve as institutional endorsements that improve perceived creditworthiness, while geographical offshoring diversification reduces exposure to local ecological shocks and supports more stable borrowing capacity. Together, these contributions call for a broader theoretical framework in corporate finance that integrates ecological risks and firm-level adaptation strategies.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature and develops the research hypotheses. Section 3 outlines the data sources and empirical methodology. Section 4 presents the analysis and discussion of the empirical results. Section 5 concludes with key findings and implications.

2. Related Literature and Hypothesis Development

In corporate finance, Modigliani and Miller's (1958) irrelevance theory argues that, under perfect market conditions, a firm's value is independent of its capital structure. However, such ideal conditions are rare, as modern firms operate within environments shaped by uncertainty (Waisman et al., 2015), regulatory pressure (Qian & Strahan, 2007), and environmental obligations (Apergis et al., 2022). These factors

introduce costs and institutional constraints that make financing decisions strategically relevant. Biodiversity risk exposure is one such emerging factor that may influence regulatory compliance and increase financing costs; yet, its impact remains largely neglected, particularly in the corporate finance literature. Alternative theories, such as the pecking order theory (Myers, 1984), risk-adjusted trade-off theory (Hovakimian et al., 2001), and institutional theory (Brick & Ravid, 1985) provide useful perspectives to understand how biodiversity risks shape debt financing behavior. A multi-theoretical approach is therefore necessary, as financial decisions are shaped by both internal firm dynamics and the surrounding institutional context, which no single theory fully captures.

From the perspective of pecking order theory, firms prefer financing methods that reduce resistance and minimize information asymmetry (Myers, 1984). Debt financing is often avoided because it signals internal weakness and financial instability (Fama & French, 2002). This concern becomes stronger when firms operate under high-risk exposure, uncertainties, limited transparency, or external shocks (Choi et al., 2016). In such conditions, the risk of cash flow volatility and bankruptcy increases, making it difficult for creditors to assess the firm's financial health. As a result, firms face higher interest rates and reduced access to credit. Supporting this view, conservative debt ratios are commonly observed in early-stage innovative firms due to high information asymmetry (Choi et al., 2016; My et al., 2019), in start-ups, because of growth uncertainties (Bhattacharyya & Subrahmanya, 2024; Shimizu,

2023), and in firms with significant environmental footprints due to potential legal penalties (Lin et al., 2025; Zhang & Jia, 2025).

In the case of biodiversity risk, firms encounter non-linear and often irreversible changes, including species extinction and supply chain disruptions (Bhattacharya & Bhattacharya, 2019), which do not follow predictable patterns (Yue et al., 2023). These disruptions can occur gradually or abruptly, making it difficult for firms to anticipate cash flow stability and confidently commit to financial obligations (Adamolekun, 2024). This unpredictability heightens information asymmetry, as firms struggle to predict revenue streams in a manner that aligns with investor expectations (Marco-Fondevila & Álvarez-Etxeberría, 2023). As a result, creditors are more likely to perceive such firms as riskier, often responding with higher interest rates or more restrictive lending conditions (Adamolekun, 2024).

In the context of trade credit, prior literature shows that when firms exhibit financial instability, such as erratic cash flows, suppliers anticipate delayed or missed payments, which increases concerns about credit risk (Shahzad, Liu, Mahmood, et al., 2021). This leads to information asymmetry, as suppliers struggle to assess the firm's financial condition. To avoid sending negative signals and to maintain supplier relationships, firms often reduce their reliance on trade credit (Tian & Tian, 2022). Short-term debt also becomes less attractive for firms facing irregular revenues, weak liquidity, or operational disruptions, since lenders respond with tighter terms and higher interest rates (Adamolekun, 2024; Choi, 2024). These challenges are prevalent

among firms operating in environmentally sensitive sectors. Long-term debt is similarly affected, as ongoing environmental risks raise concerns about the stability of future cash flows. In response, lenders impose stricter covenants and demand greater transparency, including detailed environmental disclosures (Yang & Li, 2025). To preserve strategic flexibility and avoid restrictive financial obligations, firms often refrain from long-term borrowing. This behavior aligns with the pecking order theory, supporting the view that firms facing high biodiversity risk exposure consider debt the least preferred financing option.

However, the pecking order theory does not sufficiently account for external factors that help explain the diminishing benefits of debt financing, even when internal resources are constrained (Frank & Goyal, 2008). External conditions such as dynamic business environments, political instability, and macroeconomic volatility can undermine cash flow stability and increase the cost of borrowing (Turk Ariss, 2016; Waisman et al., 2015). To address this limitation, the risk-adjusted trade-off theory proposes that firms facing high external uncertainty are more likely to avoid debt, as the elevated cost of financial distress in volatile contexts often outweighs traditional benefits associated with debt, such as tax shields (Hackbarth et al., 2007).

Building on risk-adjusted trade-off theory, previous studies have shown that environmental risks such as extreme weather events, resource scarcity, and evolving regulations introduce significant uncertainty into business operations and reduce the predictability of future revenues (Ginglinger & Moreau, 2023; Lemma et al., 2021). In

a similar way, political risks, including policy reversals, trade tensions, and regime changes, suddenly alter market access, taxation, and regulatory obligations (Waisman et al., 2015). Together, these external factors contribute to increased volatility in cash flows and earnings, which in turn raises the likelihood of financial distress (Duong et al., 2021; Jens, 2017). As financial distress becomes more likely, the marginal benefit of debt financing, including tax advantages, tends to decline. When viewed through the lens of external uncertainty, biodiversity risk similarly increases the cost of debts, particularly for firms reliant on short-term debt requiring frequent refinancing (Tian & Tian, 2022; Yang & Li, 2025). In addition, lenders may impose stricter covenants in response to ecological disruptions. These conditions collectively reduce the marginal benefit and increase the marginal cost of debt financing. As a result, firms tend to move away from debt and instead prioritize liquidity buffers, consistent with the risk-adjusted trade-off theory.

Finally, corporate finance literature increasingly acknowledges that the broader institutional environment influences financing decisions (Danielson & Scott, 2004; Hernández-Cánovas & Koëter-Kant, 2011). In particular, debt issuance is more feasible when lenders have confidence in legal enforcement and creditor protection mechanisms. These considerations become especially important in cross-country analyses, as legal systems, governance structures, and institutional frameworks vary significantly across economies. In some contexts, strong institutions enhance lender

confidence, while in others, institutional weaknesses may discourage debt financing due to perceived enforcement risks.

Institutional theory emphasizes the impact of creditor protection and legal enforcement on access to external finance, either by fostering lender confidence or creating barriers to borrowing (Hernández-Cánovas & Koëter-Kant, 2011). For instance, the United Kingdom provides strong creditor rights and transparent regulations, which collectively reduce risk perception and support long-term lending (Correia, 2008; Michaelas et al., 1999). By contrast, India's delayed legal procedures and inconsistent enforcement erode creditor trust and constrain long-term financing options (Vig, 2013). China presents a transitional institutional setting where legal reforms coexist with state-led credit allocation, primarily benefiting state-owned enterprises (Bhabra et al., 2008). As a result, private firms in China largely depend on short-term borrowing (Shahzad, Liu, Mahmood, et al., 2021). These insights highlight the relevance of institutional theory in explaining corporate financing decisions, as borrowing is closely influenced by the broader institutional context in which both firms and lenders operate. This external dimension is largely overlooked in both the pecking order theory and the risk-adjusted trade-off theory.

However, when firms encounter heightened operational and financial uncertainty that threatens operational strength, cash flow stability, and long-term solvency, they tend to be more cautious in using debt, even in countries with strong institutional frameworks (Bilicka et al., 2022; Hernández-Cánovas & Koëter-Kant,

2011). In weaker institutional settings, limited legal protections and ineffective enforcement further amplify these risks, discouraging debt financing due to concerns over enforcement gaps and creditor opportunism (Fan et al., 2012). In China, despite progress in legal reforms and improved creditor protection, the dominance of state-owned banks and selective enforcement contribute to institutional opacity (Cen et al., 2017). Private firms, particularly in environmentally sensitive sectors, face difficulties in risk disclosure due to regulatory ambiguity and political sensitivities (Shahzad, Liu, & Luo, 2021). These factors reduce lender confidence and borrower willingness to engage in debt contracts. The United Kingdom, by contrast, offers robust legal protections, transparent institutions, and low levels of corruption. Yet, even in this setting, firms exposed to significant uncertainty often avoid debt to maintain financial flexibility (Atieh & Hussain, 2012; Bilicka et al., 2022). Environmental risks, in particular, have led UK firms to adopt conservative financing strategies, despite predictable enforcement mechanisms. India represents a third institutional context, characterized by moderate creditor protections and bureaucratic complexity. These conditions obstruct clear communication of environmental risks and increase uncertainty surrounding regulatory enforcement and collateral reliability. Consequently, lenders impose stricter terms or risk premiums, discouraging both short-term and long-term borrowing (Bhattacharya & Bhattacharya, 2019; Bose et al., 2021).

Across diverse institutional settings, a consistent pattern can be observed. Firms that face operational and regulatory uncertainties often struggle to commit to fixed financial obligations, which leads to a reduced reliance on debt financing. Institutional theory helps explain this tendency by emphasizing how ecological exposure, combined with regulatory ambiguity, transparency, and creditor confidence, restricts firms' access to external capital. This suggests that corporate debt decisions are shaped not only by the level of institutional development but also by the interaction between environmental risks and the credibility of institutional frameworks. Collectively, drawing on the frameworks of pecking order theory, risk-adjusted trade-off theory, and institutional theory, we argue that firms with high exposure to biodiversity risk are more likely to reduce their reliance on debt financing, including trade credits, short-term debts, and long-term debts.

Hypothesis 1: Corporate biodiversity risk exposure and debt financing is negatively related.

While firms exposed to biodiversity risks often face restricted access to debt financing due to heightened lender concerns, such constraints are not absolute. Various mechanisms may alleviate these barriers by addressing the underlying risk perceptions. The following section outlines these mechanisms and establishes a foundation for exploring their potential moderating effects.

Government-related procurement relationship

Government-related procurement relationship refers to formal supply chain partnership in which firms engage with public sector entities, including local authorities, government agencies, and state-owned enterprises, either as suppliers of goods and services or as recipients of public demand (Bessonova, 2023; Flammer, 2018). In these arrangements, the government assumes a critical role in the firm's supply chain, offering operational stability through predictable revenue streams, reduced market uncertainty, and increased institutional legitimacy.

Prior research suggests that government-related business relationship serves as a visible signal of firm credibility and public sector endorsement, particularly in uncertain and fragile market environments (Bessonova, 2023). When the government is a firm's primary customer or supplier, such contracts provide ex-ante assurances of reliable payments, enforceable obligations, and operational transparency (Cai et al., 2024). Huang et al. (2016) find that government-related procurement tie reduces the perceived risk of credit default and strengthen a firm's ability to meet its debt commitments. As a long-term business partner, the government contributes to lower cash flow volatility and mitigates financial distress. Further evidence indicates that governments rarely replace their supply chain partners, reinforcing stable and enduring business relationships (Fu et al., 2024). This continuity enhances corporate stability, improves financial resilience, and strengthens reputational standing, which collectively contribute to a lower cost of capital (Dhaliwal et al., 2011; Paglia &

Harjoto, 2014). Additionally, the government's presence in supply chain can function as an implicit institutional safeguard, increasing lenders' confidence and willingness to provide credit. In environments where legal enforcement is limited or environmental liabilities remain uncertain, government contracts act as quasi-collateral, signaling the firm's strategic relevance and financial capacity even during environmental disruptions (Liu et al., 2025). The study by Bessonova (2023) provides further evidence that government contracts can serve as a form of financial support, helping firms navigate periods of disruption. As a result, firms with government-related procurement relationship are perceived as lower-risk borrowers, more likely to receive policy support or regulatory leniency during adverse conditions.

These insights suggest that, in the context of biodiversity risk exposure, government-related business relationships can play a crucial role in supporting firms through multiple channels. First, firms engaged in government-related procurement relationships are more likely to adopt sustainability criteria in response to public procurement policies (Cai et al., 2024). This encourages more responsible resource use, improved planning, and reduced environmental impact, thereby mitigating the operational risks associated with biodiversity loss. Second, government-related relationships provide a stable revenue stream, which helps firms manage financial distress during periods of resource scarcity or supply chain disruption (Huang et al., 2016). Finally, association with the government enhances a firm's reputation and increases its appeal to environmentally conscious investors (Pyun, 2025). This

reputational benefit can improve access to a broader range of financial resources and strengthen long-term financial resilience. Therefore, we suggest that government-related procurement relationship moderates the negative impact of biodiversity risk exposure on debt financing by improving transparency, reducing uncertainty, and reinforcing institutional credibility. Therefore, the following hypothesis is framed:

Hypothesis 2: Government-related procurement relationships positively moderate the negative relationship between biodiversity risk exposure and debt financing.

Geographic offshoring diversification

Geographic offshoring diversification refers to the strategic allocation of a firm's offshore activities, including manufacturing, research and development, and service delivery, across multiple foreign countries. It is typically comprised of the number of countries where the firm operates (Chen et al., 2024), the count of foreign subsidiaries (Hsu et al., 2015; Xiao & Yu, 2024), or the proportion of offshore assets and employees across different regions (Massini & Miozzo, 2012).

Previous research identifies offshoring diversification as both a risk-mitigation strategy and a cost-reduction approach (Massini et al., 2010). From a risk-mitigation perspective, substantial evidence indicates that firms engaged in offshoring are more likely to sustain profitability and enhance corporate value during geopolitical crises (Brandon-Jones et al., 2014; Jain & Wu, 2023; Lartey et al., 2021). When confronted with events such as trade sanctions, civil unrest, or abrupt policy shifts, these firms demonstrate greater flexibility by relocating production, sourcing, or service delivery

to unaffected regions. This adaptability ensures business continuity and minimizes revenue losses. As a result, offshoring not only shields operations from localized disruptions but also strengthens investor confidence, contributing to higher shareholder value. Charoenwong et al. (2023) highlight the importance of geographical offshoring diversification to mitigate the adverse effects of economic policy uncertainty. Firms with geographically dispersed operations are better equipped to manage policy-related risks by shifting activities to countries with more stable regulatory environments. This distribution acts as a hedge against sudden policy changes. For instance, if one country imposes tighter regulations or higher tariffs, operations can be redirected to alternative offshore sites.

Geographical offshoring diversification can be an effective strategy for firms exposed to biodiversity risk to lower borrowing costs and improve access to external financing. By spreading operations across multiple countries, firms reduce their reliance on a single ecological or regulatory environment, which helps limit the impact of localized biodiversity disruptions (Lartey et al., 2021). This approach decreases concentration risk and promotes earnings stability, thereby strengthening the firm's credit profile and reducing its perceived default risk. As a result, firms are more likely to secure financing at favorable rates. In addition, operating in diverse jurisdictions introduces firms to a variety of institutional settings, reporting standards, and financial systems (Alghamdi et al., 2024; Wang et al., 2024). These differences enhance operational transparency and increase the availability of information. Finally,

geographical offshore diversification allows firms to engage with a broader pool of lenders, including both domestic and international financial institutions (Shan et al., 2023). Taken together, these factors enhance a firm's financial resilience, reduce environmental exposure concentration, and increase its appeal to creditors, ultimately improving its ability to raise debt. Therefore, the following hypothesis is framed.

Hypothesis 3: Geographical offshoring diversification positively moderates the negative relationship between biodiversity risk exposure and debt financing.

3. Materials and Methods

3.1. Data Source

To obtain the financial and accounting data for UK and Indian firms, this study accessed Thomson Reuters Datastream and Eikon platforms through the Wharton Research Data Services (WRDS) provided by the University of Pennsylvania, which facilitates academic access to LSEG (formerly Refinitiv) databases. Firms were identified using unique identifiers such as International Securities Identification Numbers (ISINs) and Reuters Instrument Codes (RICs). For the United Kingdom, listed firms were selected using the RIC suffix ".L". For Indian firms, the National Stock Exchange was identified using ".NS" and the Bombay Stock Exchange using ".BO". The accounting and financial data on Chinese firms is taken from Chinese Stock Market Accounting Research (CSMAR). The sample period spans from 2012 to 2023, justified by data limitations in earlier years, particularly the unavailability of

reliable records on subsidiary counts and supply chain-level information, which are essential for calculating firm-level government-related procurement relationships. This range ensures both data completeness and compatibility with the study's analytical framework.

Biodiversity risk data were sourced from the Biodiversity Concerns Index developed by He et al. (2024), which evaluates firms' attention to biodiversity through an analysis of their annual reports. The data is freely accessible and can be downloaded using the link provided in the methodology section of their publication. The robustness of their Biodiversity Concerns Index is validated by comparing it with the Chinese Climate Policy Uncertainty Index (Ma et al., 2023). Their findings indicate that corporate actions on biodiversity protection, as reported in their index, are not influenced by shifts in climate policy. This validates the reliability and validity of the index. We select Chinese enterprises as our sample due to their increasing attention to biodiversity since 2007, particularly in the agriculture, forestry, and water sectors (He et al., 2024). In addition, Government initiatives further promote biodiversity awareness among companies in production landscapes, driving Chinese corporation's increased exposure to biodiversity risk management (Liang et al., 2024).

3.2. Sample characteristics

This study draws on a multi-country sample of firms from the United Kingdom, China, and India to capture a comprehensive view of corporate debt financing decisions under varied institutional conditions. The selection of these countries is

both theoretically sound and empirically relevant, as each represents a distinct financial system. The United Kingdom offers a developed market with strong creditor rights, transparent reporting standards, and effective legal enforcement (Correia, 2008), making it an ideal environment for examining debt financing in high-quality institutional settings. India, by contrast, represents a system with procedural delays, weaker legal enforcement, and moderate investor protections, allowing for insights into the effects of institutional frictions on financing behavior (Vig, 2013). China, with its transitional economy and state-led credit allocation, exemplifies how government influence and politically driven lending can influence financing decisions beyond those driven by pure market forces (Bhabra et al., 2008). Together, these three contexts provide a balanced framework to explore how institutional quality, legal efficiency, and state intervention affect corporate debt choices. The initial dataset contained 62,820 firm-year observations. After removing firms with missing data, those younger than five years, and firms with negative shareholder value, the final unbalanced panel comprises 42,923 observations spanning the period from 2012 to 2023. The final sample includes 2,967 Chinese firms, 943 Indian firms, and 701 UK firms across 15 industries. The year 2012 was chosen as the starting point due to the availability of data on biodiversity risk exposure and supply chain disclosures. A detailed classification of industries and firm counts is provided in **Table 1**.

<**Table 1** ABOUT HERE>

3.3. Variable measurement

For the dependent variable, and in line with prior literature, the study defines debt choices as comprising both informal and formal debt components. Informal debt is proxied by trade credits, calculated as the sum of accounts receivable and notes receivable minus accounts payable and notes payable, scaled by total assets. Formal debt is measured using the short-term and long-term debt ratios. Short-term debt comprises loans due within one year, expressed as a percentage of total assets. Long-term debt includes loans with maturities exceeding one year, also scaled by total assets. These measures are widely recognized and frequently employed in corporate finance research.

For the independent variable, and in line with the text-based measurement approach developed by Giglio et al. (2023) for U.S. firms and subsequently applied by He et al. (2024) in the contexts of China, the UK, and India, this study adopts a binary indicator of corporate biodiversity risk exposure. This variable is coded as 1 if the firm's 10-K report contains at least two sentences referencing biodiversity, and 0 otherwise. From a mechanism perspective, the study uses government-related procurement relationships and geographical offshoring diversification. First, geographical offshoring diversification is commonly measured by the number of countries from which firms source inputs (Chen et al., 2024). However, firms in emerging markets, such as India and China, often do not disclose detailed information about their foreign input sourcing. Instead, they regularly report data on their overseas

affiliated entities. Following prior studies that use the number of foreign subsidiaries as a proxy for offshoring breadth (Hsu et al., 2015; Xiao & Yu, 2024; Zhong et al., 2025), this study measures geographical offshoring diversification by the total number of a firm's overseas subsidiaries. Second, Government Contracting Count captures the number of distinct government agencies with which a firm engages in business, either as a supplier or customer (Bessonova, 2023; Flammer, 2018). This information is derived from data on the firm's top five suppliers and customers.

The study includes several control variables that may influence corporate debt financing (Adamolekun, 2024; Shahzad, Luo, & Liu, 2021; Yang & Li, 2025). Sales growth is measured as the change in sales from the previous year to the current year, divided by the previous year's sales. Firms with high sales growth often need external funds to support expansion, which makes them more likely to use debt. Inventory ratio is calculated as closing stock divided by total assets. A higher inventory ratio reflects operational scale, which may help firms access debt more easily. Tangibility is the ratio of fixed assets to total assets. It represents the availability of collateral and is expected to have a positive link with debt. Firm size is measured as the natural logarithm of total assets. Larger firms are usually more stable and creditworthy, making it easier for them to borrow. Earnings per share (EPS) is calculated by dividing net income, after deducting preferred dividends, by the average number of ordinary shares. Higher EPS indicates profitability and strengthens a firm's ability to attract debt. In contrast, return on assets (ROA) is calculated as net profit divided by total

assets. Firms with higher ROA rely more on internal funds and are less dependent on debt. Operating cash flow is measured as cash flow from operating activities divided by total assets. Similar to ROA, strong cash flow reduces the need for external borrowing. Finally, the WW index is a measure of financial constraints, indicating that a higher WW index means tighter financial constraints and lower access to debt. The *WW index* is computed using the following weighted formula: –0.091 × Cash Flow – 0.062 × Dividend dummy + 0.021 × Long-term debt – 0.044 × Firm size + 0.102 × Industry sales growth – 0.035 × Sales growth.

3.4. Model Specification

To examine the impact of biodiversity risk on corporate debt financing choices, this study follows established approaches in the literature (Cho & Im, 2023; Datta et al., 2024; Maes et al., 2019; Shahzad, Luo, & Liu, 2021) and specifies the model as follows.

$$Debt\ Financing_{i,t+1} = \alpha + \beta Biodiversity\ Risk_{i,t} + \zeta X_{i,t} + \lambda_{i,t} + \varepsilon_{i,t} \quad (1)$$

In this model, debt financing includes both informal and formal components. Trade credits measure informal debt, while formal debt is captured through short-term and long-term debt ratios. Biodiversity Risk is a binary variable coded as 1 if firm *i* in year *t* discloses at least two sentences related to biodiversity concerns in its 10-K report, and 0 otherwise. The coefficient β estimates the effect of biodiversity risk on the firm's debt financing decisions. The vector ζ contains the coefficients for the control variables *Xi,t*, which include sales growth, return on assets (ROA), inventory

ratio, tangibility, firm size, cash flow, earnings per share (EPS), and the WW index. Industry-by-year fixed effects ($\lambda j \times t$) are included to account for unobserved industry-level variations over time. The error term $\varepsilon i,t$ is assumed to have a mean of zero. Standard errors are clustered at the firm-year level to correct for potential within-firm correlation.

3.5. Empirical methodology

The study assesses the suitability of its empirical approach using a series of diagnostic tests. A Hausman test was first conducted, and the results supported the fixed-effects model ($p < 0.05$), suggesting that unobserved heterogeneity is correlated with the regressors. However, the panel data structure involves observations nested within firms or industries, indicating a hierarchical pattern. To account for this, the intraclass correlation coefficient (ICC) was estimated using STATA's "estat icc" command. The ICC value of 0.5667 indicates that 56.67% of the variance in the dependent variable is attributable to group-level differences. This justifies the use of a mixed-effects model, which captures both within-group and between-group variation, offering greater flexibility in modeling panel data with nested structures. Model assumptions were examined using a Q-Q plot, which showed that residuals closely followed the 45-degree line, especially in the mid-range, indicating approximate normality. Although slight deviations appeared at the distribution tails, these were acceptable given the large sample size (Bill et al., 2023). Normality was further confirmed by the Jarque-Bera and Shapiro-Wilk tests, with p-

values of 0.098 and 0.064, respectively, showing no significant violation of distributional assumptions. Taken together, these diagnostics validate the mixed-effects model as an appropriate baseline method for estimating the theoretical framework. To strengthen the credibility of the results, the study employs several robustness checks. First, Propensity Score Matching (PSM) is used to address potential endogeneity by balancing observable characteristics between treated and control groups. Second, a two-step System Generalized Method of Moments (GMM) estimator is applied to control for dynamic endogeneity and unobserved heterogeneity, particularly in the presence of lagged dependent variables. Third, a placebo test is conducted by randomly reassigning biodiversity risk exposure across firms to ensure that spurious correlations do not drive the observed effects. These additional methods help validate the robustness of the findings and demonstrate the methodological rigor of the empirical strategy.

4. Empirical Results

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics of the study variables. On average, informal debt, measured by the trade credit ratio, accounts for 30.92% of total liabilities. Within formal debt, short-term debt represents 23.08%, while long-term debt comprises 11.81%. These averages are consistent with prior findings in the contexts of the UK, China, and India. Additionally, 23.65% of the sampled firms report

concerns related to biodiversity risks in their 10-K filings. The control variables also show distributions aligned with earlier studies. Specifically, the mean values of return on assets (ROA), sales growth, inventory ratio, and earnings per share (EPS) are 0.0338, 0.360, 0.137, and 0.048, respectively.

<**Table 2** ABOUT HERE>

Table 3 reports the correlation matrix. Overall, biodiversity risk exposure shows a negative correlation with both formal and informal debt measures. While several control variables exhibit statistically significant correlations, the magnitudes are modest and do not indicate strong associations that would raise concerns about multicollinearity. To further assess this, we calculated the variance inflation factors (VIF), all of which remain below the commonly accepted threshold of 5, confirming that multicollinearity is not a significant issue in our panel data.

<**Table 3** ABOUT HERE>

4.2. Baseline Results

Table 4 presents the baseline regression results from Equation (1), which investigates the relationship between biodiversity risk exposure and firms' debt financing decisions. The analysis distinguishes between informal debt, measured through trade credit, and formal debt, which comprises both short-term and long-term borrowings. Across all model specifications, whether control variables are included or not, the coefficients for biodiversity risk exposure remain negative and statistically

significant at the 1 percent level. From an economic perspective, firms exposed to biodiversity risks show a reduced tendency to rely on debt financing compared to those not exposed. Specifically, biodiversity-exposed firms reduce their use of trade credit by approximately 2.8% (column 2), short-term debt by 3.1% (column 4), and long-term debt by 3.9% (column 6). The intraclass correlation coefficients, reported at the bottom of each column, support the application of a mixed-effects model given the hierarchical structure of the panel data. These findings provide empirical support for the hypothesis that exposure to biodiversity risk negatively influences debt financing. Firms that are highly exposed to biodiversity loss often raise concerns among creditors about their repayment capacity, cash flow stability, and information transparency. Lenders often struggle to assess the underlying risks associated with these firms accurately. As a result, affected firms are more likely to avoid debt financing in order to manage heightened transactional risks, elevated borrowing costs, and the possibility of asset misallocation or forced liquidation.

<**Table 4** ABOUT HERE>

Our sample comprises firms from diverse institutional contexts, including the United Kingdom, India, and China. These countries differ in creditor rights and regulatory environments, which may raise concerns about the consistency of our estimates across countries. UK firms operate under a strong institutional framework with high transparency and well-established creditor protections (Atieh & Hussain,

2012; Bilicka et al., 2022). Indian firms, by contrast, are embedded in a bureaucratically complex environment where creditor protection is moderate (Bhattacharya & Bhattacharya, 2019; Bose et al., 2021). Chinese firms benefit from improved legal credit rights but function within a state-led credit allocation system that often involves selective enforcement (Cen et al., 2017; Shahzad, Luo, & Liu, 2021). To address this potential source of heterogeneity, **Table 5** reports the regression results from Equation (1) separately for each country. Across all specifications, the findings align with our baseline results, indicating that biodiversity risk exposure is associated with reduced debt financing regardless of the national context.

The consistency of our findings across countries aligns with the existing literature, which suggests that although strong institutional frameworks can help mitigate external financing risks, such as weak legal enforcement and information asymmetries, they are insufficient to overcome internal operational challenges (Atieh & Hussain, 2012; Bilicka et al., 2022). Our results identify biodiversity-related disruptions as a critical internal factor that affects firms' financing behavior. Companies dealing with ecological degradation often face volatile cash flows and uncertain earnings. These conditions reduce their ability to service debt, even in environments with well-developed legal protections. As a result, lenders adopt a cautious approach by imposing stricter lending terms or requiring higher risk premiums. In anticipation of such constraints, firms tend to maintain conservative

capital structures to preserve liquidity and avoid financial distress. Therefore, institutional quality cannot fully mitigate the increased risk perceptions associated with environmental uncertainty, especially when such uncertainty is systemic and beyond the control of managers.

<**Table 5** ABOUT HERE>

4.3. Robustness test

This section presents several robustness tests to address potential endogeneity concerns. First, the direction of causality may be questioned. It is unclear whether biodiversity risk exposure influences firms' debt financing decisions or whether the existing debt structure affects how firms experience or report biodiversity risks. Second, omitted variable bias may be present if unobserved factors, such as managerial quality, investor pressure, or technological capabilities, influence both biodiversity risk exposure and debt choices. This could lead to misleading correlations. Third, the validity of our biodiversity risk measure may be challenged. Specifically, one may argue that estimating risk based on sentence counts in corporate reports does not accurately reflect actual exposure and may serve as an imperfect proxy, thereby biasing the results. We address each of these concerns in the following analysis.

4.3.1. Omitted variable concerns

To address concerns related to omitted variable bias, we follow established practices in the literature by transforming the data to eliminate time-invariant, firm-specific effects. The most common method involves taking the first differences of the regression equation. Instead of regressing debt choices directly on biodiversity risk and control variables, we estimate the relationship by regressing changes in debt levels on changes in biodiversity risk and control variables. This differencing technique effectively removes any firm-specific characteristics that remain constant over time, such as inherent managerial quality, geographic location advantages, or stable organizational culture. As a result, it mitigates a key source of omitted variable bias that is typically addressed through firm-level fixed effects. The results of this approach are presented in **Table 6** and remain consistent with our baseline estimates. These findings indicate that the negative relationship between biodiversity risk exposure and debt financing persists even after accounting for unobserved, time-invariant firm heterogeneity. This consistency reinforces the credibility of our main results, suggesting that the observed association is not merely driven by omitted firm-level characteristics.

<**Table 6** ABOUT HERE>

4.3.2. Propensity score matching

One may challenge that a firm's exposure to biodiversity risks is not random but rather influenced by its specific characteristics, which raises concerns about potential selection bias. To strengthen the causal interpretation of our results and address this concern, we adopt a Propensity Score Matching (PSM) approach. In this method, firms identified as exposed to biodiversity risks are treated as the treatment group, while firms without such exposure serve as the control group. As shown in **Table 7**, Column 1, we begin by estimating a logistic regression in which biodiversity risk exposure is the dependent variable. This model produces propensity scores that reflect the likelihood of a firm being exposed to biodiversity risks based on observable characteristics. We then match firms from the treatment and control groups using nearest neighbor matching. This process includes exact matching on industry and year and applies a strict caliper value of 0.001 to ensure close similarity. To evaluate the effectiveness of the matching procedure, we re-estimate the logistic regression on the matched sample, presented in Column 2. In the unmatched sample, several firm characteristics significantly predict biodiversity risk exposure. However, these differences become statistically insignificant after matching, indicating that the two groups are now well balanced in terms of observable features. The key advantage of the PSM approach lies in its ability to construct a sample where treatment and control firms share similar observable traits. This helps to reduce endogeneity concerns stemming from firm-specific factors. We then re-estimate our baseline regressions

using the matched sample. The results, shown in Columns 3 to 5, are consistent with our main findings and confirm that biodiversity risk exposure remains negatively associated with debt financing choices.

<**Table 7** ABOUT HERE>

4.3.3. Dynamic system GMM

One may argue that debt financing decisions are influenced by prior financial behavior or unobserved time-varying factors, thereby raising concerns about endogeneity in baseline models. The dynamic system Generalized Method of Moments (GMM) estimator addresses these issues by combining equations in first differences and levels. In the differenced model, lagged levels (e.g., debt at t–2) serve as instruments for changes between periods. In contrast, in the level equation, lagged differences are used as instruments to enhance efficiency when variables are persistent. This approach allows us to control for unobserved firm-specific effects and correct for endogeneity stemming from simultaneity, reverse causality, and dynamic feedback, including the influence of past debt on current financing decisions and the joint determination of biodiversity risk and debt choices.

The results reported in **Table 8** support the robustness of our findings. The lagged dependent variables are positive and highly significant across all specifications, confirming the presence of strong dynamic persistence in debt structures. The coefficients for biodiversity risk exposure are consistently negative

and statistically significant, indicating that firms exposed to higher biodiversity risks tend to reduce their use of both formal and informal debt. We also assess model validity through standard diagnostic tests. The AR(1) test shows significant first-order autocorrelation in the differenced residuals, as expected in a correctly specified dynamic model. The AR(2) test reveals no evidence of second-order autocorrelation, confirming the absence of residual serial correlation. Finally, the Hansen test of overidentifying restrictions reports p-values above the conventional significance level, indicating that the instruments used are valid and uncorrelated with the error term. Taken together, these results confirm that the dynamic system GMM approach effectively addresses potential biases in our estimation. The persistent negative association between biodiversity risk and debt financing remains robust even after correcting for endogeneity, dynamic feedback effects, and firm-specific unobserved heterogeneity.

<**Table 8** ABOUT HERE>

4.3.4. Placebo test

This section examines the possibility that the measurement of biodiversity risk exposure may be subject to random error. To test this, we generate a placebo variable by randomly assigning values of one or zero to firms using a uniform distribution, treating this as a simulated biodiversity risk indicator. We then re-estimate Equation 1 using this placebo variable and repeat the procedure 1,000 times. **Figure 1** presents the distribution of the estimated coefficients for the placebo variable across three

financing outcomes: Panel A shows trade credits, Panel B shows short-term debt, and Panel C shows long-term debt. In all cases, the placebo estimates cluster around zero and are statistically insignificant. In contrast, the red lines in each panel mark the actual estimates derived from the accurate biodiversity risk data, which lie well outside the simulated distribution. These results provide strong evidence that our main findings are not the result of random variation and confirm the validity of our biodiversity risk measurement.

<**Figure 1** ABOUT HERE>

4.4. Mechanisms

4.4.1. Government-related procurement relations

Table 9 investigates the moderating effect of government-related procurement relations on the link between biodiversity risk exposure and firms' debt financing choices. Our variable of interest, *Govt. Procurement Relations* × *Biodiversity Risk*, is positive and statistically significant across all three models, including trade credits (column 1), short-term debt (column 2), and long-term debt (column 3). These results offer strong support for Hypothesis 2. Consistent with our expectations, when biodiversity-risk-exposed firms engage in procurement relationships with government entities, the negative impact of biodiversity risk on debt financing is significantly reduced, and in some cases, even reversed. This interaction signals to creditors that the firm benefits from a more secure and predictable revenue stream, backed by government contracts. Given that government agencies are less likely to terminate

supplier relationships abruptly and typically ensure timely payments, such partnerships improve lenders' confidence in the firm's cash flow stability and reduce perceived default risk. Furthermore, these relationships reflect a degree of operational transparency and institutional credibility, which lowers information asymmetry between the firm and creditors. Overall, the positive and significant interaction terms across all debt categories indicate that government procurement ties serve as a credible mechanism through which biodiversity-risk-exposed firms can enhance their access to debt financing.

<**Table 9** ABOUT HERE>

4.4.2. Geographical offshoring diversification

Table 10 evaluates the moderating role of geographical offshoring diversification in shaping the relationship between biodiversity risk exposure and firms' debt financing choices. Our variable of interest, *Subsidiary Count × Biodiversity Risk*, is positive and statistically significant. These findings offer strong support for the proposed mechanism that geographical diversification helps mitigate the adverse effects of biodiversity risk on firms' ability to access external finance. Consistent with the prior literature, geographical offshoring is often adopted as a strategic risk management tool to buffer against location-specific threats such as trade sanctions, political instability, and abrupt regulatory changes. In the context of biodiversity risk, firms with more foreign subsidiaries are less dependent on a single ecological or institutional landscape. This diversification not only reduces concentration risk but

also signals to creditors that the firm is actively managing exposure to environmental disruptions through a spatial dispersion strategy. Additionally, a geographically diversified operational structure enables firms to access a broader range of credit markets, including local financial institutions and international lenders. The resulting expansion of financing options enhances a firm's borrowing capacity, especially under conditions of biodiversity loss. Overall, the evidence supports the argument that geographical offshoring diversification functions as an effective mechanism through which firms can neutralize some of the financing disadvantages associated with biodiversity risk exposure.

<**Table 10** ABOUT HERE>

5. Discussion

The financing behavior of firms under environmental uncertainty is an increasingly important subject in corporate finance. Ecological disruptions, particularly biodiversity loss, create systemic and long-term risks that threaten business operations. Although existing research has explored the impact of macroeconomic volatility, policy uncertainty, and geopolitical risks on debt capacity, the specific implications of biodiversity risk remain largely understudied. This study contributes to the literature by providing robust empirical evidence that biodiversity risk exposure is negatively associated with firms' use of debt financing. This negative relationship is evident across both informal debts, such as trade credit, and formal

debt, including short-term and long-term borrowings. Biodiversity risk differs from cyclical risks because it is persistent, difficult to diversify, and often poorly understood by lenders. Firms exposed to such risk commonly experience unstable revenues, disrupted supply chains, and increased operational volatility. These factors raise lenders' concerns about repayment capacity, resulting in higher borrowing costs, tighter loan covenants, or limited access to credit. The consistency of this negative relationship is confirmed across three diverse institutional environments. In the United Kingdom, firms operate under strong creditor rights and transparent legal enforcement. In China, firms are influenced by a state-led credit allocation system. In India, businesses face bureaucratic obstacles and weaker enforcement mechanisms. Despite these institutional differences, the negative link between biodiversity risk and debt financing remains significant. This suggests that ecological risk operates independently of national governance structures. When uncertainty stems from environmental factors that lie beyond managerial or state control, legal protections or institutional strength offer limited assurance to creditors. Under such conditions, lenders remain cautious regardless of the country context. However, our findings also uncover two significant moderating mechanisms that enable firms to partially overcome biodiversity-related financial disadvantages. First, government-related procurement relationships improve debt access for biodiversity-risk-exposed firms. These relationships signal revenue stability, government endorsement, and reduced default risk. Public procurement contracts often act as implicit guarantees that

reassure creditors of the firm's continuity and reliability, even under environmental stress. Second, geographical offshoring diversification enhances resilience by distributing operational risk across multiple ecological and regulatory environments. Firms with wider offshore presence demonstrate lower exposure to localized biodiversity threats, higher adaptability, and greater access to diverse financial institutions. These strategic structures not only mitigate ecological concentration risk but also broaden the firm's credit base.

5.1. Theoretical Implications

The study makes several important theoretical contributions to the corporate finance literature by integrating biodiversity risk into established frameworks of capital structure, institutional quality, and risk mitigation. It introduces biodiversity risk as a systemic and persistent environmental constraint that operates independently of firm-specific characteristics and institutional strength, offering new insights into how firms respond to external uncertainty in their financing decisions.

First, the study extends traditional capital structure theories by conceptualizing biodiversity risk as a distinct exogenous factor that constrains firms' access to debt. While pecking order theory and risk-adjusted trade-off theory have primarily addressed financing frictions through information asymmetry, taxation, or bankruptcy costs, this research introduces ecological degradation as independent sources of financing constraints. The findings demonstrate that firms exposed to biodiversity risk reduce their reliance on both formal and informal debt instruments, even when

institutional and market conditions are otherwise favorable. This extension adds a new dimension to capital structure theory by incorporating ecological uncertainty into the firm's risk-return calculus.

Second, the findings refine institutional theory in corporate finance by identifying biodiversity risk as a boundary condition. Institutional quality, including legal protections and creditor rights, is often associated with lower financing frictions. However, the persistent negative association between biodiversity risk and debt financing across institutional contexts suggests that even strong institutions cannot fully compensate for ecological disruptions. This insight challenges the assumption that institutional development uniformly enhances financial access and suggests the need to integrate environmental vulnerability into institutional analyses of capital structure decisions.

Third, the study contributes to the literature on financial risk mitigation by identifying two strategic mechanisms that enable firms to offset the adverse financing effects of biodiversity risk. Government-related procurement relationships serve as a quasi-certification mechanism, reducing perceived credit risk. This finding supports and extends theories of third-party endorsement by showing that affiliation with public institutions enhances credibility in the eyes of lenders, particularly under environmental uncertainty. Geographical offshoring diversification, on the other hand, functions as a structural risk management strategy. By dispersing operations across jurisdictions, firms reduce exposure to localized ecological shocks, stabilize cash

flows, and signal resilience, thereby improving their debt capacity. These findings introduce spatial diversification and relational public-sector ties as underexplored but important determinants of financial flexibility. Together, these theoretical contributions highlight the need for a broader framework in corporate finance that accounts for non-market and sustainability-related risks. They call for future research to incorporate ecological dimensions into models of capital structure and to investigate how firms strategically respond to environmental constraints through both financial and operational adaptations. By bridging corporate finance with environmental systems thinking, this study offers a new direction for understanding capital structure choices in an era of increasing ecological uncertainty.

5. 2. Policy Implications

The study's findings call for corporate decision-makers to formally recognize biodiversity risk as a material financial factor, not merely an ESG concern. Biodiversity loss impacts firms' cost of borrowing, access to credit, and overall financial flexibility by increasing lender perceptions of default risk. Therefore, firms should integrate biodiversity-related metrics into their enterprise risk management (ERM) systems and capital structure planning. This includes conducting biodiversity exposure assessments across supply chains, quantifying potential disruptions, and disclosing ecological risks in financial reports. Such integration enables firms to proactively communicate risk mitigation measures to creditors and investors, thereby reducing information asymmetry and signaling their strategic preparedness. Furthermore, firms

should consider adopting spatial diversification strategies, such as geographical offshoring of operations, to reduce the concentration of environmental exposure and enhance resilience against location-specific ecological shocks. These efforts not only improve access to capital under conditions of environmental uncertainty but also align internal governance with long-term financial sustainability.

For policymakers, the results highlight the strategic role of public procurement in supporting financially constrained firms operating under high biodiversity risk. Firms with procurement relationships with government agencies were found to have improved credit access, even when facing significant ecological exposure. This suggests that governments can use procurement programs not only as industrial policy tools but also as indirect financial stabilizers. Policymakers should therefore prioritize the inclusion of sustainability-exposed but strategically important firms in public procurement frameworks, particularly in sectors vulnerable to ecological disruption (e.g., agriculture, natural resources, logistics, and manufacturing). Governments may also develop formal certification programs tied to procurement contracts, which signal creditworthiness to private lenders. Additionally, public agencies could consider offering procurement-backed credit guarantees or risk-sharing arrangements to de-risk private lending to environmentally exposed firms. These measures would help stabilize critical sectors without distorting credit markets, while reinforcing government commitment to ecological and economic resilience.

For environmental research and policy communities, the study urges a reframing of biodiversity loss as a systemic financial risk, not just an ecological crisis. Current environmental risk assessments and biodiversity indices are often detached from corporate finance models and fail to capture how ecological degradation translates into firm-level financial constraints. To improve policy relevance and inter-disciplinary alignment, environmental research institutions should develop standardized indicators that link biodiversity risk to corporate performance metrics such as cash flow volatility, credit risk scores, or capital expenditure patterns. Future environmental modeling should account for the financial transmission channels of biodiversity loss. Doing so will foster cross-sector collaboration between environmental science and finance, and equip policymakers with more effective tools to manage the economic consequences of ecological collapse.

5.3. Future Research

Future research can extend this study by investigating the dynamic interplay between biodiversity risk and firm-level financial adaptation strategies over time. A promising avenue would involve longitudinal analyses that track how firms adjust their capital structure, operational scope, or relational strategies, including government procurement and alliance formation, in response to evolving ecological pressures and regulatory landscapes. Such work could incorporate event-based or panel vector autoregression (VAR) methods to examine causal feedback loops between biodiversity events and financial decisions. Additionally, future research could explore

the moderating role of informal institutional factors, including political embeddedness, cultural norms of environmental responsibility, or stakeholder activism, in shaping firms' access to debt under biodiversity stress. By moving beyond formal legal indicators, this line of inquiry would refine institutional theory and reveal how extra-legal mechanisms mediate financial resilience in ecologically fragile settings. These directions would deepen our understanding of how biodiversity-related risks reconfigure corporate financing behavior in complex institutional environments.

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Tables

Table 1. Firms over industry and countries

Industry Type	China	India	UK	Total
Agriculture & Forestry	26	0	15	41
Business Services	14	9	37	60
Education & Research	46	23	34	103
Finance & Insurance	10	50	63	123
Healthcare & Life Sciences	1	11	4	16
IT & Services	360	0	22	382
Manufacturing	2117	690	327	3134
Media & Entertainment	6	9	43	58
Mining & Minerals	42	23	11	76
Real Estate	37	15	44	96
Retail & Consumer Goods	49	24	28	101
Telecommunication	107	46	23	176
Transport & Logistics	84	0	23	107
Utilities & Energy	63	40	23	126
Others	5	3	4	12
Total	2967	943	701	4611

Table 2. Descriptive Statistics

Variables	N	Mean	Std.	P25	P50	P75
Trade Credits	42,923	0.3092	0.1239	0.1197	0.3752	0.5762
Short Term Debts	42,943	0.2306	0.1826	0.0900	0.1142	0.3529
Long Term Debts	42,923	0.1181	0.2019	0.0541	0.2181	0.2514
Biodiversity Risk Exposure	42,923	0.2365	0.2959	0	0	1
Sales Growth	42,923	0.3600	1.1016	-0.0723	0.0500	0.3129
ROA	42,943	0.0338	0.0547	0.0082	0.0291	0.0597
Inventory Ratio	42,923	0.1370	0.1285	0.0517	0.1083	0.1785
Tangibility	42,923	0.2087	0.1629	0.0806	0.1750	0.3000
Firm Size	42,923	22.180	1.4435	21.192	21.917	22.898
Operating Cash Flow	42,943	0.1919	0.1426	0.0920	0.1531	0.2518
Earnings Per Share	42,923	0.0480	0.0732	0.0083	0.0471	0.0893
WW Index	42,923	-0.8865	0.3493	-1.0531	-0.9970	-0.9365

Note: The table shows summary statistics of the variables used in the study. Following Li et al. (2025), *Trade credits* are measured as the sum of accounts receivable and notes receivables minus accounts payable and notes payable, divided by total assets. *Short-term debt* refers to loans due within one year, expressed as a percentage of total assets. *Long-term debt* includes loans with a maturity of more than one year, also measured as a percentage of total assets. *Biodiversity risk* is a binary variable coded as 1 if the firm's 10-K report includes at least two sentences related to biodiversity, and 0 otherwise. *Sales growth* is the change in sales from the previous year to the current year, divided by the previous year's sales. *Return on assets (ROA)* is calculated by dividing net profit by total assets. *Inventory* is the ratio of closing stock to total assets. Tangibility is the ratio of fixed assets to total assets. *Firm size* is measured as the natural logarithm of total assets. Operating cash flow is the ratio of cash from operating activities to total assets. *Earnings per share (EPS)* is calculated by dividing net income, after deducting preferred dividends, by the average number of ordinary shares outstanding. The *WW index* is computed using the following weighted formula: –0.091 × Cash Flow – 0.062 × Dividend dummy + 0.021 × Long-term debt – 0.044 × Firm size + 0.102 × Industry sales growth – 0.035 × Sales growth.

Table 3. Correlation index

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Trade Credits	1											
(2) Short Term Debts	0.540***	1										
(3) Long Term Debts	0.389***	0.770***	1									
(4) Biodiversity Risk	-0.175***	-0.003	0.061***	1								
(5) Sales Growth	-0.026***	-0.053***	-0.077***	-0.090***	1							
(6) ROA	-0.077***	-0.288***	-0.341***	-0.060***	-0.062***	1						
(7) Inventory Ratio	-0.280***	-0.361***	-0.264***	-0.061***	-0.023***	-0.052***	1					
(8) Tangibility	-0.029***	-0.041***	-0.105***	-0.056***	-0.042***	-0.067***	-0.222***	1				
(9) Firm Size	-0.061***	-0.141***	-0.458***	-0.253***	-0.112***	-0.084***	-0.012*	-0.014**	1			
(10) Cash Flow	-0.060***	-0.254***	-0.373***	-0.065***	-0.034***	-0.255***	-0.157***	-0.328***	-0.242***	1		
(11) Earning Per Share	-0.044***	-0.119***	-0.138***	0.006	0.005	0.363***	-0.186***	-0.221***	-0.031***	-0.124**	1	
(12) WW Index	-0.109***	-0.145***	-0.323***	-0.034***	-0.076***	-0.078***	-0.046***	-0.094***	-0.378***	-0.127**	-0.0157*	1

Note: Table 2 provides the definitions of all variables. Asterisks denote significance levels as follows: *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table 4. Baseline results: corporate biodiversity risk exposure and debt financing

Variables	Trade Credits		Short term Debts		Long Term Debts	
	(01)	(02)	(03)	(04)	(05)	(06)
Biodiversity Risk	-0.047***	-0.028***	-0.039***	-0.031**	-0.040***	-0.039**
	(-4.73)	(-2.14)	(-4.57)	(-3.16)	(-6.79)	(-2.37)
Sales Growth		0.002***		0.005***		0.005***
		(5.47)		(10.25)		(9.24)
ROA		-0.117***		-0.494***		-0.536***
		(-13.58)		(-4.08)		(-5.57)
Inventory Ratio		0.223***		0.363***		0.313***
		(4.59)		(9.57)		(4.92)
Tangibility		-0.026***		0.025***		0.071***
		(-5.79)		(4.12)		(11.24)
Firm Size		0.010***		0.024***		0.057***
		(6.39)		(6,72)		(6.75)
Cash Flow		-0.040***		-0.162***		-0.217***
		(-10.38)		(3.81)		(-4.78)
EPS		0.116***		0.119***		0.062***
		(8.77)		(4.78)		(7.40)
WW Index		-0.002***		-0.009***		-0.035***
		(-2.44)		(4.55)		(-7.60)
Time and Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.111***	-0.125***	0.287	-0.197***	0.424***	-0.783***
	(8.52)	(-4.50)	(5.75)	(-4.35)	(7.52)	(-7.046)
N	42,923	42,923	42,923	42,923	42,923	42,923
Number of Groups	4,708	4,708	4,708	4,708	4,708	4,708
Wald chi2	1641.19***	19597.18***	1339.56***	10416.23***	1868.82***	17721.61***
Random intercept variance	0.00475	0.0041	0.0184	0.0125	0.0236	0.0124
Residual variance	0.00571	0.0054	0.0104	0.0088	0.0126	0.0098
Inter-class Correlation (ICC)	0.4874	0.4337	0.639	0.585	0.651	0.559

Note: Table 2 provides the definitions of all variables. Reported values represent z-statistics, with significance levels denoted as *** ($p<0.01$), ** ($p < 0.05$), and * ($p < 0.1$).

Table 5. Baseline results: Corporate biodiversity risk and debt financing over countries

Variables	Trade Credits			Short Term Debts			Long term Debts		
	China	India	UK	China	India	UK	China	India	UK
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Biodiversity Risk	-0.016**	-0.053**	-0.063*	-0.052**	-0.014***	-0.033*	-0.018**	-0.011***	-0.019*
	(-2.46)	(-2.01)	(-1.95)	(-2.37)	(-3.99)	(-1.75)	(2.54)	(3.23)	(-1.96)
Sales Growth	0.002***	0.019	0.059**	0.005***	0.003***	0.004	0.005***	0.004***	0.033
	(4.95)	(1.63)	(2.01)	(9.92)	(3.09)	(1.29)	(8.47)	(3.62)	(0.89)
ROA	-0.112***	-0.115***	-0.189***	-0.455***	-0.579***	-0.633***	-0.506***	-0.610***	-0.623***
	(-8.55)	(-5.47)	(-4.56)	(-7.11)	(-9.02)	(-8.53)	(-8.69)	(-2.91)	(-4.53)
Inventory Ratio	0.219***	0.231***	0.264***	0.364***	0.334***	0.530***	0.321***	0.271***	0.439***
	(4.47)	(9.10)	(7.91)	(4.15)	(9.76)	(4.93)	(6.68)	(6.09)	(9.03)
Tangibility	-0.017***	-0.063***	0.048*	0.044***	-0.043***	0.070**	0.090***	0.009	0.069*
	(3.20)	(-6.15)	(1.92)	(6.43)	(-2.97)	(2.09)	(12.45)	(0.63)	(1.91)
Firm Size	0.011***	0.008***	0.004	0.026***	0.016***	0.001	0.057***	0.060***	0.026***
	(5.32)	(5.52)	(0.85)	(6.27)	(7.66)	(0.22)	(4.85)	(8.51)	(3.98)
Cash Flow	-0.041***	-0.023**	0.023	-0.171***	-0.052***	-0.141***	-0.225***	-0.119***	-0.254
	(-9.74)	(-2.08)	(0.83)	(-9.72)	(-3.44)	(-3.79)	(-9.26)	(-7.85)	(-6.54)
EPS	0.118***	0.103***	0.075**	0.123***	0.071***	0.135***	0.080***	-0.023	0.088*
	(6.70)	(7.24)	(2.12)	(3.80)	(3.61)	(2.87)	(8.43)	(-1.19)	(1.71)
WW Index	-0.066	-0.019***	-0.016*	-0.007***	-0.020***	-0.030***	-0.035***	-0.040***	-0.052***
	(-0.04)	(-4.06)	(-1.85)	(-3.58)	(-3.14)	(-2.58)	(-6.80)	(-6.30)	(4.00)
Control Variables	Included	Included	Included	Included	Included	Included	Included	Included	Included
Time & Ind Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.141***	-0.079	-0.237**	-0.298***	0.106	0.537***	-0.819***	-0.707***	0.104
	(-4.41)	(-1.32)	(-2.29)	(-5.75)	(1.12)	(3.83)	(-15.50)	(-7.71)	(0.79)
N	33,963	7,841	1,119	33,963	7,841	1,119	33,963	7,841	1,119
Groups	4,071	567	70	4,071	567	70	4,071	567	70
Wald chi2	5262.44***	3708.89***	685.06***	9246.10***	1429.61***	436.71***	15366.52***	2348.94***	454.06***
Random variance	0.0039	0.0051	0.0035	0.0122	0.0134	0.0073	0.0124	0.0123	0.0066
Residual variance	0.0051	0.0064	0.0043	0.0079	0.0122	0.0075	0.0091	0.0122	0.0092
ICC	0.433	0.439	0.447	0.605	0.523	0.492	0.576	0.501	0.416

Note: Table 2 provides the definitions of all variables. Reported values represent z-statistics, with significance levels denoted as *** (p<0.01), ** (p < 0.05), and * (p < 0.1).

Table 6. Robustness: Omitted Variable Bias

VARIABLES	Δ Trade Credits	Δ Short Term Debts	Δ Long Term Debts
	(1)	(2)	(3)
Δ Biodiversity Risk	-0.013***	-0.025**	-0.029**
	(-3.78)	(-1.99)	(-2.21)
Δ Sales Growth	0.051**	0.002***	0.002***
	(2.18)	(5.85)	(5.46)
Δ ROA	-0.051***	-0.256***	-0.351***
	(-7.05)	(-9.89)	(-4.41)
Δ Inventory Ratio	0.236***	0.319***	0.266***
	(3.48)	(3.70)	(9.30)
Δ Tangibility	-0.082	0.030***	0.076***
	(-1.37)	(4.27)	(10.90)
Δ Size	0.013***	0.037***	0.077***
	(9.32)	(9.60)	(5.53)
Δ Cash Flow	-0.041***	-0.109***	-0.141***
	(-8.94)	(-10.33)	(-6.58)
Δ EPS	0.116***	0.086***	0.060***
	(23.99)	(14.92)	(10.53)
Δ WW Index	-0.046***	0.001	-0.021***
	(-3.51)	(0.60)	(-13.18)
Time & Ind Effects	Yes	Yes	Yes
Constant	-0.004*	-0.009***	-0.013***
	(-1.91)	(-3.79)	(-5.36)
N	38,110	38,110	38,110
R-squared	0.178	0.091	0.153

Note: The symbol Δ denotes the first difference of the respective variable, capturing the year-over-year change in its value. This transformation eliminates time-invariant firm-specific characteristics, thereby addressing a key source of omitted variable bias typically targeted by the firm fixed effects methodology. Table 2 provides the definitions of all variables. Reported values represent t-statistics, with significance levels denoted as *** ($p<0.01$), ** ($p < 0.05$), and * ($p < 0.1$).

Table 7. Robustness Test: Propensity score matching

Variables	Biodiversity Risk		Trade Credits	Short Term Debts	Long Term Debts
	Pre match	Post Match			
	(1)	(2)	(3)	(4)	(5)
Biodiversity Risk			-0.045***	-0.013***	-0.025***
			(-6.44)	(-5.18)	(-11.38)
Sales Growth	0.129***	-0.006	-0.033***	0.008***	0.007***
	(13.73)	(-0.44)	(-2.99)	(7.46)	(6.86)
ROA	-2.321***	0.063	-0.169***	-0.819***	-0.936***
	(-11.23)	(0.22)	(-8.27)	(-3.36)	(-6.59)
Inventory Ratio	-1.577***	0.068	0.259***	0.568***	0.357***
	(-18.32)	(0.58)	(5.10)	(5.52)	(8.04)
Tangibility	-1.334***	0.023	0.022***	0.094***	0.094***
	(-18.17)	(0.23)	(4.26)	(10.04)	(10.43)
Firm Size	0.395***	0.212**	0.051***	0.004***	0.051***
	(-4.47)	(2.08)	(7.22)	(3.43)	(5.15)
Cash Flow	-0.700***	0.032	0.011**	-0.066***	-0.138***
	(-8.28)	(0.27)	(4.51)	(-5.65)	(-12.54)
EPS	0.821***	-0.096	0.052***	0.066***	-0.084***
	(5.18)	(-0.43)	(2.51)	(2.99)	(-4.17)
WW Index	0.395***	-0.059	-0.026	-0.035***	-0.083***
	(12.63)	(-1.41)	(0.96)	(-10.10)	(-4.95)
Time and Industry Effects	Yes	Yes	Yes	Yes	Yes
Constant	-8.059***	-0.102	-0.070***	0.159***	-0.784***
	(-13.28)	(-0.41)	(-3.04)	(6.46)	(-7.40)
N	42,923	9,218	9,218	9,218	9,218
Pseudo R-Square	0.166	0.097			
Adjusted R-Square			0.124	0.232	0.218

Note: Reported values represent t-statistics, with significance levels denoted as *** ($p<0.01$), ** ($p < 0.05$), and * ($p < 0.1$).

Table 8. Robustness: Dynamic System GMM

VARIABLES	Trade Credits	Short Term Debts	Long Term Debts
	(1)	(2)	(3)
Lag (TC/STD/LTD)	0.539***	0.636***	0.542***
	(31.39)	(36.45)	(67.02)
Biodiversity Risk	-0.044***	-0.033*	-0.029*
	(-2.70)	(-1.71)	(-1.72)
Sales Growth	0.017***	0.036***	0.003***
	(3.69)	(8.44)	(6.80)
ROA	-0.063***	-0.396***	-0.403***
	(-4.69)	(-25.77)	(-23.05)
Inventory Ratio	0.131***	0.198***	0.180***
	(7.35)	(16.30)	(14.06)
Tangibility	-0.005	0.002	0.008
	(-0.50)	(0.22)	(0.65)
Size	0.031	0.014***	0.034***
	(0.62)	(8.10)	(15.30)
Cash Flow	-0.039***	-0.080***	-0.126***
	(-5.64)	(-9.56)	(-14.91)
EPS	0.074***	0.043***	-0.004
	(6.25)	(3.86)	(-0.35)
WW Index	-0.071	0.004***	-0.017***
	(-0.33)	(2.89)	(-9.86)
Time Effects	Yes	Yes	Yes
Observations	33,705	33,705	33,705
Number of Groups	3,950	3,950	3,950
Number of Instruments	14	12	13
AR1 (p-value)	-24.07 (0.000)	-26.03 (0.000)	-21.72 (0.031)
AR2 (p-value)	-1.23 (0.220)	0.15 (0.581)	1.32 (0.178)
Hansen (p-value)	53.07 (0.137)	17.84 (0.218)	40.67 (0.162)

Note: TC = trade credits, STD = Short-term Debts, and LTD = Long-term Debts. Reported values represent t-statistics, with significance levels denoted as *** (p<0.01), ** (p < 0.05), and * (p < 0.1).

Table 9. The role of government-related procurement relations for the role of corporate biodiversity risk exposure on debt financing choices

Variables	Trade Credits	Short Term Debts	Long Term Debts
	(1)	(2)	(3)
Govt. Procurement Relations × Biodiversity Risk	0.066**	0.071***	0.076***
	(5.25)	(10.91)	(5.76)
Govt-related Procurement Relations	0.013***	0.011***	0.079***
	(8.31)	(6.31)	(6.70)
Biodiversity Risk	-0.021***	-0.013***	-0.014***
	(-5.68)	(-5.68)	(6.06)
Sales Growth	0.066***	0.075***	0.045***
	(10.19)	(10.19)	(9.21)
ROA	-0.119***	-0.488***	-0.531***
	(-13.74)	(-4.49)	(-5.07)
Inventory Ratio	0.224***	0.362***	0.312***
	(4.64)	(-9.49)	(4.84)
Tangibility	-0.026***	0.023***	0.070***
	(5.69)	(3.79)	(11.04)
Size	0.010***	0.023***	0.057***
	(6.49)	(5.68)	(6.72)
Cash Flow	-0.042***	-0.156***	-0.212***
	(10.67)	(-3.43)	(-9.50)
EPS	0.117***	0.116***	0.060***
	(8.88)	(4.40)	(7.11)
WW Index	-0.002	-0.009***	-0.035***
	(-1.38)	(-4.69)	(-7.79)
Time and Industry Effects	Yes	Yes	Yes
Constant	-0.135***	-0.158***	-0.756***
	(-4.78)	(-3.46)	(-6.43)
N	42,923	42,923	42,923
Wald chi2	19608.54***	10522.52***	17796.12***
Random intercept variance	0.0041	0.01242	0.01241
Residual variance	0.0053	0.0088	0.0097
Inter-class Correlation (ICC)	0.433	0.583	0.558

Note: *Government Contracting Count* represents the number of distinct government agencies with which a firm maintains business relationships, either as a customer or supplier. This information is extracted

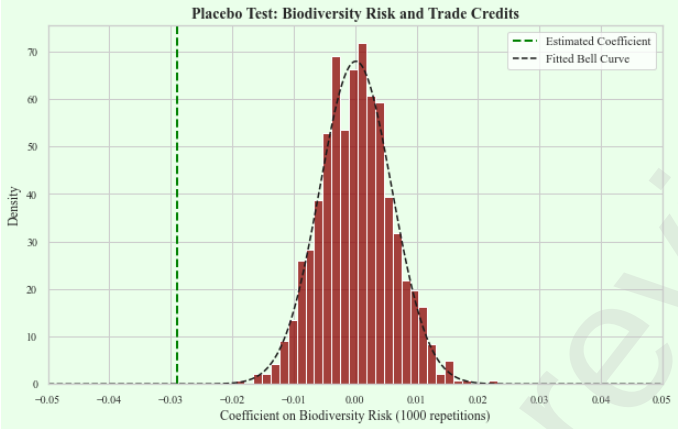
from the information of firms top five suppliers and customers. The interaction term *Biodiversity Risk* × *Government Contracting Count* is of primary interest in our analysis, as it captures the conditional effect of government involvement on the relationship between biodiversity risk exposure and debt choices. Reported values represent z-statistics, with significance levels denoted as *** ($p<0.01$), ** ($p < 0.05$), and * ($p < 0.1$).

Table 10. The role of geographical offshoring diversification for the role of corporate biodiversity risk exposure and debt financing choices

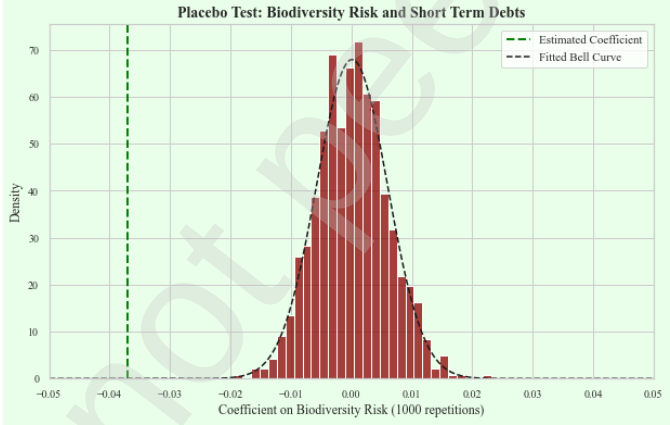
Variables	Trade Credits	Short Term Debts	Long Term Debts
	(1)	(2)	(3)
Subsidiary Count × Biodiversity Risk	0.012*	0.043***	0.051***
	(1.84)	(4.80)	(5.43)
Subsidiary Count	0.072**	0.037***	0.025***
	(2.28)	(4.76)	(3.16)
Biodiversity Risk	-0.053***	-0.013***	-0.015***
	(-2.86)	(-5.28)	(-5.80)
Sales Growth	0.002***	0.005***	0.005***
	(5.47)	(7.28)	(9.26)
ROA	-0.117***	-0.485***	-0.528***
	(13.52)	(-3.13)	(-4.72)
Inventory Ratio	0.224***	0.362***	0.313***
	(4.57)	(9.52)	(4.87)
Tangibility	-0.026***	0.026***	0.072***
	(5.79)	(4.31)	(11.41)
Size	0.010***	0.025***	0.059***
	(5.90)	(7.84)	(4.81)
Cash Flow	-0.040***	-0.157***	-0.213***
	(-7.29)	(-8.78)	(-5.41)
EPS	0.117***	0.118***	0.061***
	(8.75)	(4.64)	(3.81)
WW Index	-0.002	-0.009***	-0.035***
	(-1.48)	(-4.66)	(-9.71)
Time and Industry Effects	Yes	Yes	Yes
Constant	-0.124***	-0.237***	-0.817***
	(-4.38)	(-5.17)	(-17.70)
N	42,923	42,923	42,923
Wald chi2	19602.78***	10506.97	17801.41
Random intercept variance	0.0041	0.0126	0.0125
Residual variance	0.0054	0.0088	0.0097
Inter-class Correlation (ICC)	0.433	0.587	0.561

Note: Prior studies commonly use the total number of countries from which firms source inputs as a proxy for geographical offshoring diversification. However, firms in emerging markets such as India and China often provide limited disclosure regarding their input purchases across foreign markets. In contrast, these firms routinely report information on their overseas affiliated entities. Consistent with a strand of literature that employs the number of foreign subsidiaries as a measure of offshoring breadth (Hsu et al., 2015; Xiao & Yu, 2024; Zhong et al., 2025), we adopt the total number of a firm's overseas subsidiaries to estimate its geographical offshoring diversification. The interaction term *Biodiversity Risk* × *Subsidiary Count* is of primary interest in our analysis, as it captures the conditional effect of geographical offshoring diversification on the relationship between biodiversity risk exposure and debt choices. Reported values represent z-statistics, with significance levels denoted as *** ($p<0.01$), ** ($p < 0.05$), and * ($p < 0.1$).

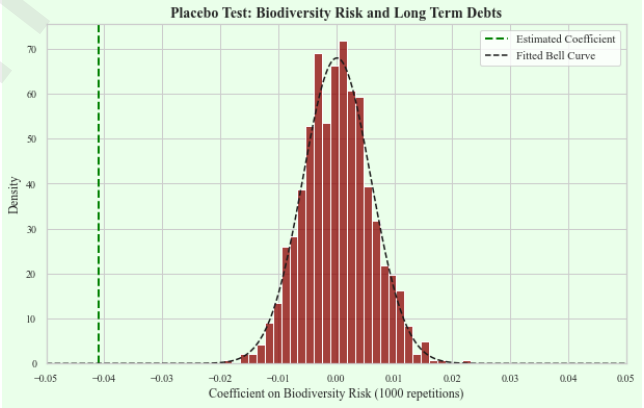
Figures



Panel A: Randomized Biodiversity Risk and Trade Credits



Panel B: Randomized Biodiversity Risk and Short-Term Debts



Panel C: Randomized Biodiversity Risk and Long-Term Debts

Figure 1. Randomized corporate biodiversity risk exposure and debt financing choices