# Nature Transition Risk*

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**Abstract**

We investigate how investors assess transition risks arising from the discretionary regulatory mandates for nature conservation. We focus on the UN Biodiversity Conference in Kunming, China, a policy shock signaling heightened political commitment to protection. During the conference, firms exhibited negative abnormal stock returns on average. Using a machine learning approach, we identify historical nature-related subsidies to capture firm-level variations in expectations of mandated conservation engagement, beyond measuring corporate environmental (ecological) impacts. This metric negatively correlates with returns during the conference, particularly for firms with high operational volatility, and those in regions with limited fiscal flexibility and stringent conservation pressures. Investor concerns primarily stem from policy uncertainty, without positive earnings expectations from conservation. Our findings underscore the role of authoritative discretion in shaping nature transition risks.

**Keywords:** Biodiversity Finance, Discretionary Regulation, Subsidy, China.
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# 1 Introduction

Nature is deteriorating at an unprecedented pace, leading to a severe decline in natural assets and ecosystem services essential for business operations and societal well-being (WWF, 2020, 2024). Growing concerns over this crisis have accelerated global efforts to protect and restore biodiversity, with the public sector serving as the primary transition catalyst in practice (IPBES, 2019, 2020; Karolyi & Tobin-de la Puente, 2023; Flammer *et al.*, 2025; Chen *et al.*, 2024).[1] Meanwhile, regulatory changes promote awareness of biodiversity-related risks in the private sector (Garel *et al.*, 2024; Giglio *et al.*, 2025), while how transition expectation impacts firm value remains underexplored.

In contrast to the clearly defined and measurable targets for addressing climate crisis (e.g., the 1.5 °C goal, carbon neutrality), biodiversity issues lack standardized and widely accepted evaluation metrics (Metrick & Weitzman, 1998; Gjerde *et al.*, 2025; Roeder & Utz, 2025).[2] In addition, unlike climate change, which is often marked by extreme weather events, biodiversity loss tends to unfold gradually and receives less public awareness (Avise *et al.*, 2008; Mammides & Campos-Arceiz, 2025). As a result, there is insufficient attention and significant divergence among stakeholders regarding conservation performance and transition pathways.[3] The formation of market-based compensation mechanisms is therefore hindered, preventing firms engaged in nature transition from realizing value comparable to those in climate actions (Karolyi & Tobin-de la Puente, 2023). Conversely, this lack of standardized metrics gives regulators broad *discretion* in requiring firms to invest in conservation.[4] Such a transition exposes firms to considerable policy uncertainty and unprofitable investments stemming from evolving conservation mandates, thereby introducing a novel and underexplored dimension of risk: *nature transition risk*.

The dynamics of China's financial market during the 15th United Nations Biodiversity Conference of the Parties to the Convention on Biological Diversity, held in Kunming, in October 2021 (the Kunming COP15) provide us an ideal research setting. COP15 marks a milestone in global nature conservation policy, unprecedentedly strengthening political consensus and commitments among countries. More salient for China, President Xi Jin-

[1] These efforts primarily include public initiatives, such as biodiversity-focused Conferences of the Parties (COP) and the Taskforce on Nature-related Financial Disclosures. Notably, in December 2022, nearly 200 governments endorsed the Kunming-Montreal Global Biodiversity Framework, pledging ambitious goals to halt and reverse nature loss by 2030.

[2] For instance, comparing the economic impacts of changes in panda populations in China versus vulture populations in India (Frank & Sudarshan, 2024) is inherently complex, illustrating that "simplicity is not a defining feature of biodiversity" (Karolyi & Tobin-de la Puente, 2023).

[3] For example, A survey in UK shows 83% of respondents were concerned about climate change, while only 49% concerned about biodiversity issues, and 31% were entirely unaware (Starling Research, 2023). Similarly, Gjerde *et al.* (2025)'s survey indicates 50% of companies perceive investor prioritization of climate topics, compared to just 3% for nature-related concerns.

[4] Conserving nature and biodiversity requires not only scaling back production to mitigate harm but also investing in restoration (e.g., planting) to reverse loss trends—efforts that public funding alone cannot fully support (Flammer *et al.*, 2025; Karolyi & Tobin-de la Puente, 2023; Chen *et al.*, 2024).

ping made a formal commitment to transition at this conference.[5] In China, government wields formidable capacity to coordinate resources and ensure compliance (Edin, 2003; Liu *et al.*, 2015), enabling effective enforcement of its green initiatives (Greenstone *et al.*, 2021; Chen *et al.*, 2024), shaping private sector's behaviors. Meanwhile, state capacity enhances government discretion, causing firms with similar environmental impacts to face varied regulatory pressures (Cai *et al.*, 2016; Buntaine *et al.*, 2024). Correspondingly, investors in this market are highly responsive to political signals (Liu *et al.*, 2017), with decisions largely driven by regulatory preferences (Fisman *et al.*, 2014) rather than solely corporate fundamentals. Such institutional features could lead the Kunming COP15 to trigger heightened expectations of corporate nature transition risks in this host country.[6]

We first document that China recorded the globally highest internet attention to the Kunming COP15. Meanwhile, analysis of daily stock trading data of non-financial firms listed on the Shanghai and Shenzhen exchanges reveals negative abnormal returns, on average, around the conference, consistent with investors' concerns about changes in government conservation mandates.

We then construct a novel dataset measuring firms' exposure to nature transition risks based on the history of receiving nature-related subsidies. This approach leverages the insight that, due to the lack of standardized biodiversity metrics and a large biodiversity financing gap (Karolyi & Tobin-de la Puente, 2023), governments assign corporate conservation tasks with significant discretion after reinforcing their protection commitments. First, governments tend to impose greater conservation demands on firms with incentive-compatible mechanisms. Subsidies serve as a prevalent and highly discretionary tool to advance social objectives (Cingano *et al.*, 2025).[7] In China's policy system, subsidies not only provide critical funding (Chen *et al.*, 2008), but also enhance firms' reputation capital through government support (Allen *et al.*, 2005). This creates strong incentives for firms to maintain such ties by assuming social responsibilities, including sustainability-linked duties (Lee *et al.*, 2017), thus reducing their resistance to nature transition policies.

Second, to optimize policy objectives, governments tend to favor firms with specialized expertise, as these entities are better equipped to achieve targeted goals (Gailmard & Patty, 2012). Subsidies are typically allocated to specific projects with explicit texts explaining the allocation rationales, allowing stakeholders to realized the corresponding

[5] Xi highlighted the importance of biodiversity for humanity, urged international cooperation to build a shared future for all life on Earth, supported a "Post-2020 Global Biodiversity Framework," pledged 1.5 billion CNY to the Kunming Biodiversity Fund to aid conservation in developing countries, and outlined China's planned policy reforms (`https://www.gov.cn/xinwen/2021-10/12/content_5642048.htm`).

[6] We note that these institutional properties support the advantages of leveraging the Kunming COP15 and Chinese markets for identification. However, the inherent feature of nature transition, characterized by significant government discretion can provide valuable insights for managing such risks globally.

[7] Subsidies are more flexible than equity investments or tax instruments (Lee *et al.*, 2014) and are nearly universal among listed firms, unlike government procurements, which cover less than one-third Chinese listed firms (Branstetter *et al.*, 2023; Yu *et al.*, 2024). This makes subsidies a prominent instrument in China's policy toolkit, particularly in its environmental transition (Wang *et al.*, 2026).

competencies of subsidized firms (Fang *et al.*, 2023; Wang *et al.*, 2026). Overall, firms with a history of receiving subsidies for nature-related projects are likely to be prioritized for transition tasks, given their revealed conservation expertise and aligned incentives with government, resulting in greater risk exposure expected around the Kunming COP15.

We analyze subsidy project description texts disclosed in corporate annual reports. Using a fine-tuned BERT model, we classify a subsidy as nature-related if it pertains to one of five key drivers of biodiversity loss and ecosystem collapse (IPBES, 2019): land and sea use, organism exploitation, pollution, climate change, or species invasion. The methodology accords with mainstream authoritative frameworks, including the Kunming Declaration and the Global Biodiversity Framework, which aligns with emerging regulation-related concerns stemming from COP15 conference.

We validate the metric with several methods, including evaluating the prediction performance of the model, identifying key terms that contribute the most to each nature-related sub-category, and examining the distribution of subsidies in certain dimensions. The results align with intuition. For instance, Agriculture, Forestry, Animal Husbandry, and Fishery sector received the highest average nature-related subsidies, while the Education sector had the lowest. In addition, our metric displays significant heterogeneity at the firm level. Nature-related subsidies are not highly correlated with a series of alternative environmental (ecological) risk metrics, including text-based indicators (Giglio *et al.*, 2025; Sautner *et al.*, 2023; Li *et al.*, 2024), ESG ratings, and environmental (ecological) footprints surrounding firms. Thus, our measure constructed from the perspective of regulatory conservation task allocation preferences, based on a deep learning approach, could capture underexplored variations in nature transition risk exposure.

We document that firms receiving higher annual level of nature-related subsidies prior to the Kunming COP15 experienced larger stock price decreases around the conference. This negative relationship holds after controlling for firm fundamentals, industry-specific features, and regional characteristics, as well as other aforementioned environmental (ecological) risk metrics, in regression tests. Analysis of subsidy sub-categories shows that those tied to climate change drivers are the least significant, consistent with the notion that knowledge emphasized by previous commitments, such as the Paris Agreement, may already be partially priced in before the Kunming COP15.

Theoretically, the political commitments of Kunming COP15 may update investors' expectations on earnings from conservation investments, or raise discount rates owing to uncertainties around unfinalized policies and corresponding business shifts. We further analyze how stock performance correlates with cross-sectional factors tied to these valuation concerns. We find that the negative relationship between nature-related subsidies and stock returns around the Kunming COP15 is more pronounced in firms with higher earnings or cash flow volatility, but does not vary significantly with corporate earning levels. These findings suggest that investors are primarily concerned with regulatory

uncertainty, while do not anticipate extra profits from corporate engagement in nature conservation, notwithstanding potential government subsidies. The rationale is further supported by our tests showing that historical nature-related subsidies lack relevance with changes in analysts' earnings forecasts around the conference, but are significantly positively correlated with increased stock return volatility.

The above findings implicitly assume that authorities are homogeneous in their incentives to promote transition. We further relax this assumption, recognizing that, under central commitments, local governments vary in their conservation needs and the extent to which they pressure firms to bear transition burden. We document that the negative relationship between nature-related subsidies and stock returns is stronger for firms headquartered in cities with lower fiscal flexibility. This suggests investors perceive that resource-constrained regulators are less able to fund conservation directly, shifting greater investment burdens onto firms. Moreover, the negative correlation is more pronounced in cities with larger protected area coverage, as well as less biodiversity improvement over the years prior to the Kunming COP15, consistent with expectations of higher conservation obligations in these regions. These results confirm that investor concerns about transition risk primarily stem from anticipated forced internalization of nature-related social cost.

Finally, we find that some real outcomes of strengthened biodiversity conservation commitments have emerged following the Kunming COP15. Firms are more likely to reference "biodiversity" in their sustainability development reports or corporate social responsibility reports after the policy change. Moreover, firms with a history of receiving more nature-related subsidies exhibit a greater propensity to engage in such biodiversity-related reporting. This ex-post evidence also helps validate that our firm-level indicator effectively captures expectations of firms' subsequent nature-related engagement.

This paper contributes to the emerging literature on biodiversity risks and financial markets. Giglio *et al.* (2025) analyze 10-K filing texts and find inadequate pricing of biodiversity risks. Giglio *et al.* (2024) model economic and asset price effects of biodiversity loss. Garel *et al.* (2025) document that firm-level nature dependence, measured by ENCORE materiality ratings, correlates with higher downside risk. Hoepner *et al.* (2023) and Xin *et al.* (2025) examine the informativeness of biodiversity in ESG ratings, while Xiong (2023) additionally considers global risks associated with biodiversity incidents. Arlt *et al.* (2024), Deng & Lin (2025) and Nguyen *et al.* (2025) expand discussions to the banking activities. Garel *et al.* (2024) and Coqueret *et al.* (2025) introduce the "corporate biodiversity footprint" (CBF) from Iceberg DataLab to quantify firms' biodiversity impacts. Notably, Garel *et al.* (2024) documents that high-CBF firms faced stock value declines post-Kunming Declaration and higher premiums in the long term, attributing this to anticipated biodiversity regulations or litigation. Similar pricing patterns also emerge in other markets (Guidolin & Pedio, 2025; Soylemezgil & Uzmanoglu, 2024).

Beyond such environmental (ecological) impacts frameworks widely applied in climate finance literature (e.g. Bolton & Kacperczyk, 2021, 2023; Zhang, 2025; Seltzer *et al.*, 2022; Hsu *et al.*, 2023), we emphasize how the absence of clear-defined, widely-accepted and comparable evaluation of biodiversity grants governments broad regulatory discretion in corresponding transition, resulting in firms with similar impacts on nature facing different regulatory requirements. From such complementary perspective of discretionary task assignment, we use past nature-related subsidies received to capture firms' exposure to government conservation mandates, showing variations underexplored by existing measurements and offering fresh insights into unique features of nature transition.[8] Moreover, while providing evidence from a large emerging market with institutional advantages in capturing variations in political commitments and discretion, we believe that the idea of regulatory preference has strong generalizability and external validity.[9]

This paper also relates to the emerging literature on blended biodiversity finance (Flammer *et al.*, 2025; Cao *et al.*, 2025; Poyser, 2025; Kotchen & Vogt, 2023). From a static perspective, public compensations can encourage corporate proactive participation in conservation. However, dynamically, limited profit expectations of regulatory discretion and policy uncertainty can reduce the perceived value of private investments, hindering the mobilization of financial resources essential for transition. Our findings indicate the complexity and challenges in policy tool design for nature conservation.

This paper also sheds light on the economic impact of nature conservation. Previous research has shown that conserving biodiversity enhances agricultural productivity (Frank *et al.*, 2024), improves public health (Frank & Sudarshan, 2024; Frank, 2024), mitigates climate change and natural disasters (Isbell *et al.*, 2015; Rizzi, 2022; Taylor & Druckenmiller, 2022; Liu *et al.*, 2025), improves amenity (Cornaggia *et al.*, 2025; Han *et al.*, 2024) and aids drug development (Rausser & Small, 2000). However, biodiversity conservation also incurs costs, including indirect expenses like increased unemployment (Ferris & Frank, 2021), production cutback (Akbari *et al.*, 2025), land (or real estate) discount (Bahrami *et al.*, 2024; Frank *et al.*, 2025) and public financing interests (Chen *et al.*, 2024). Some studies integrate these benefits and costs to develop optimal conservation strategies (e.g., Brock & Xepapadeas, 2003; Strassburg *et al.*, 2020). Our study explores transition risk from conservation task expected by firms, suggesting that such risk has been incorporated into investment decisions and reflected in asset prices. We also provide evidence on corporate real engagement including biodiversity-related reporting.

[8] Our within-country analysis also mitigates institutional or cultural endogeneity concerns prevalent in cross-country studies by focusing on a single-country sample. Furthermore, our methodology extends to smaller listed firms, which are often excluded from environmental footprint assessments due to limited public information disclosure of carbon emissions or biodiversity impacts. This broader coverage enhances the generalizability of our estimates. Additionally, measuring ecological impact accounts for potential biases in impact model design, such as sensitivity to model assumptions and parameter settings, which is less concerned in constructing our nature-related subsidies.

[9] In other words, we use an appropriate empirical context to explore an idea with general implications.

The rest of this paper is structured as follows. Section 2 shows the overall market response to the Kunming COP15. Section 3 outlines the construction and validation of our corporate nature transition risk exposure metrics. Section 4 examines the firm-level pricing patterns associated with nature transition risk. Section 5 discusses the underlying valuation considerations of investors. Section 6 explores corporate real biodiversity-related actions. Section 7 concludes.

## 2 The Kunming COP15 Conference and market reactions

### 2.1 The Policy Shock

The COP15 conference is widely dubbed a "Paris moment for biodiversity," with its biodiversity framework drawing parallels to the milestone climate transition commitments of the 2015 Paris Agreement. As its first phase, the Kunming COP15 conference hosted the highest-level leaders' summit in the history of the UN Convention on Biological Diversity in October 12, 2021.[10] Over 100 contracting parties adopted the Kunming Declaration, which stated that "putting biodiversity on a path to recovery is a defining challenge of this decade ... requiring strong political momentum to develop, adopt and implement an ambitious and transformative post-2020 global biodiversity framework ..." The declaration further committed to enhancing government decision-making, legal frameworks, and action plans for conservation and sustainable use of biodiversity.[11]

For stakeholders with interests in China, Kunming COP15 conference conveyed significant additional regulatory messages. As the host country, China actively promoted the negotiation of the Global Biodiversity Framework. In addition, President Xi Jinping attended the conference and delivered speeches in October 12, proposing increased investment, greater resource mobilization, and conservation scope expansion.[12] Overall, during Kunming COP15, the Chinese central government has made a robust political commitment to intensifying biodiversity conservation, attracting considerable public attention. Figure 1 lists the five countries with the highest surge in Google search index following the two weeks of Kunming COP15 opening. The index in China was notably much higher than that of the other countries. This aligns with the pattern of a significant global lack of media coverage on COP15 and nature transition, outside of the host country, as documented in Mammides & Campos-Arceiz (2025).[13] Figure 2 illustrates the fluctuation in

[10] Ten heads of state or government from China, Russia, Egypt, Türkiye, France, Costa Rica, Kyrgyzstan, Papua New Guinea, and the United Kingdom, along with UN Secretary-General António Guterres, attended, while 125 ministerial-level representatives held focused discussions.

[11] See the document details in: https://www.cbd.int/doc/c/df35/4b94/5e86e1ee09bc8c7d4b35aaf0/kunmingdeclaration-en.pdf

[12] See: https://www.idcpc.org.cn/english2023/ttxw_5749/202212/t20221229_159133.html.

[13] Mammides & Campos-Arceiz (2025) point out that global attention to COP15 was far lower than to entertainment news events (e.g., coverage of Taylor Swift) during the same period.

the search volume index on China's largest search engine, Baidu, revealing that public interest in these topics peaked around the time of the COP15 conference. These patterns, contrasted with the trends observed in other countries' interest in biodiversity events, in which COP15 did not represent a peak (e.g., Giglio *et al.*, 2025)[14], support the substantial impact of this event and potential changes in investor perceptions in China.

### 2.2 Constructing Cumulative Abnormal Returns

We employ the event study approach to assess the stock market reactions to the Kunming COP15. The market model used to calculate abnormal returns is as follows:

$$R_{i,t} = \alpha_i + \beta_i R_{M,t} + \epsilon_i \tag{1}$$

where $R_{i,t}$ is the return on stock $i$ on day $t$ and $R_{M,t}$ is the value-weighted market return on day $t$.[15] For each firm, we estimate the model over a pre-event period and obtain the estimated coefficients $\hat{\alpha}_i$ and $\hat{\beta}_i$. We calculate the abnormal return ($AR_{i,\tau}$) based on these coefficients, the realized market returns ($R_{M,t}$) and realized individual firm returns ($Ret_{i,t}$) over the event window, as $AR_{i,\tau} = R_{i,\tau} - (\hat{\alpha}_i + \hat{\beta}_i R_{M,\tau})$. Then we measure the cumulative abnormal return $CAR_i$ by summing up the abnormal returns for each day in the event window for each firm (i.e., $CAR_i = \sum_\tau AR_{i,\tau}$). Specifically, we choose a six-month estimation window (i.e., March 1 to August 31, 2021) and a five-day event window (i.e., five trading days starting from October 12, 2021) in our baseline estimation.[16]

We collect stock return data on firms listed and traded in the A-share market of Shanghai and Shenzhen Exchange from the China Stock Market and Accounting Research Database (CSMAR). Our sample includes all non-financial listed firms with available data for at least one year and traded in the A-share market in the Chinese mainland as of Kunming COP15. The financial sector is excluded because their accounting standards of financial statements are not comparable to those of non-financial firms.

### 2.3 Sign and Magnitude of Market Response

Due to the particularly positive externalities and long-term benefits associated with biodiversity conservation efforts (Simpson *et al.*, 1996), the Kunming COP15 may raise concerns among investors regarding potential short-term negative impacts on businesses. The substantial biodiversity financing gap cannot be fully met by public capital alone, ne-

[14] Giglio *et al.* (2025) analyze the news texts in the New York Times, finding that biodiversity coverage intensity was lower than that of climate risk, with no significant rise around the Kunming COP15.

[15] The empirical results presented in this paper remain consistent if we replace the measure of market return in the market model with the equal-weighted market return.

[16] On October 12, 2021, the Kunming COP15 Leaders Summit officially opened, and President Xi Jinping's speech was delivered on the same day. Additionally, we excluded firms with fewer than 120 day observations within the estimation window.

cessitating increased involvement from the private sector (Karolyi & Tobin-de la Puente, 2023). Thus, although the government pledged at Kunming COP15 to increase direct public compensation in biodiversity conservation, it is challenging to completely offset corporate transition risk exposure. Meanwhile, the Kunming COP15 primarily focused on broad objectives, with specific micro-policy details yet to be finalized by each country, leaving uncertainty about future policies and complicating profit predictions. Furthermore, retail investors — who make up a large share of China's stock market—tend to react more negatively to such policy shocks (Hu & Wang, 2022; Tan *et al.*, 2023). As a result, the nature transition policy shock might lead to a reduction in stock prices.

Consistently, the summarized results presented in the first row of Table 1 reveal negative values of the CAR for both mean (around -0.953%) and median CAR (around -1.254%), while over 65% of the observations are negative in our baseline sample. The magnitude of this effect is comparable to that of significant political shocks documented in previous studies (Liu *et al.*, 2017; Fisman *et al.*, 2014).[17]

# 3 Quantifying Firm-level Nature Transition Risk Exposure

## 3.1 Construction of Nature-related Subsidy

To measure firm-level exposure to nature-related transition risks — particularly variations in anticipated government conservation mandates with discretion — we develop a textual analysis model to identify nature-related subsidies (NRS) from subsidy project descriptions mandatorily disclosed in corporate annual reports (Wang *et al.*, 2026), using the following steps:

*Step 1: Define the key domains of transition concerns based on authoritative sources.*

We begin by reviewing key official documents, including the Kunming Declaration, the GBF, and reports from the International Platform on Biodiversity and Ecosystem Services (IPBES, 2019). These authoritative materials consistently identify five key domains related to biodiversity loss: (i) land and sea use, (ii) organism exploitation, (iii) pollution, (iv) climate change, and (v) species invasion. We employ this classification standard in the following analysis. Our classification approach differs from the domains used by previous studies, such as only covering land use, greenhouse gas (GHG) emissions, water pollution, and air pollution. We include additional biodiversity-specific issues, such as organism exploitation and species invasion, to better match the range of nature transition. Besides, our definition aligns with authoritative documents, enhancing its relevance

[17] Specifically, Liu *et al.* (2017) documents that the average CARs for Chinese market stocks during the 2012 Chinese political turnover risk event ranged from -1% to -2%, while between 50% and 75% of the sampled firms experienced negative CARs during this period. Fisman *et al.* (2014) focuses on the adverse shocks to Sino-Japanese relations in 2005 and 2010 and found the average CARs for Chinese and Japanese market stocks during these shock events ranged from 2% to -6%.

for stakeholders assessing transition risks.[18]

*Step 2: Train a fine-tuned BERT model for multi-label classification*

To identify nature-related subsidy, we employ a supervised machine learning approach. First, we construct a manually annotated training dataset by research assistants with expertise in ecological policy to label subsidy descriptions based on the definitive descriptions of five biodiversity-related domains in IPBES (2019). Using this dataset, we fine-tune a pre-trained BERT model for multi-label classification, which outputs probability scores (0–1) for each biodiversity domain. A subsidy is classified as nature-related if its probability exceeds 0.5 for at least one domain. More details regarding the sample construction process can be seen at Appendix A.

*Step 3: Construct firm-level indicator datasets*

After analyzing and labeling individual subsidies, we aggregate them by firms to calculate the average annual number of nature-related subsidies received prior to the Kunming COP15 (specifically, from 2016 to 2020 in the following empirical analysis).

## 3.2 Validation

### *3.2.1 The Classification Accuracy of the BERT-based Fine-Tuned Model*

To evaluate the BERT model's performance in this specific classification task, we analyze its predictive capabilities using multiple metrics. As shown in Table IA1, the model achieves an overall precision of 92.92%, recall of 93.77%, and F1-score of 93.34%. For individual classes, the F1-scores were: "Land and sea use" (88.61%), "Organism exploitation" (89.32%), "Pollution" (89.96%), "Invasive species" (95.18%), and "Climate change" (89.74%). All F1-scores exceeded 89%, demonstrating that the fine-tuned BERT model delivers satisfactory prediction accuracy for nature-related subsidy categories.

### *3.2.2 Face Validity*

To demystify the "black box" of deep learning models, we employ the SHAP (SHapley Additive exPlanations) method to reveal the decision-making mechanism. Specifically, we tokenize the subsidy text and generate values representing each token's contribution to the predicted probability. Then we aggregate these values to obtain the distribution of each term's contribution to the text being predicted as belonging to a specific domain. For example, as shown in Figure IA1, the text "research and substitution of endangered

[18] Climate change threaten species' survival and ecosystem functions, causing damage to biodiversity (e.g., Willis & Bhagwat, 2009). The Kunming Declaration and the CBF both emphasize the challenges of coordinating governance between climate change and biodiversity (e.g.,"optimizing the co-benefits and synergies of financing for biodiversity and climate crises.") Our incorporating climate change into indicator construction aims to comprehensively describe all risk exposures related to nature transition, consistent with existing literature studying sub-factors like greenhouse gases (e.g., Garel *et al.*, 2024; Coqueret *et al.*, 2025). Furthermore, our following tests reveal that among all biodiversity sub-items, the climate one had the weakest correlation with CARs during Kunming COP15.

medical herbs" is only associated with the "organism exploitation" domain (prediction probability: 76.89%) and not with other domains (prediction probabilities all below 50%). Within the "organism exploitation" domain, the word "endangered" has a SHAP value exceeding 50%, while "medical herbs" contributes over 20%, indicating that these two terms contribute the most in the labeling.

To further evaluate the contribution of all words in predicting NRS-biodiversity relevance, we utilize the Term Frequency-Inverse Document Frequency (TF-IDF) metric by the following steps: (1) segmenting subsidy project description texts into word sequences. (2) generating a TF-IDF feature matrix with a maximum of 1,000 features to control vocabulary size. (3) training a logistic regression model to assess each word's contribution to target category, where regression coefficients indicate word importance. (4) extracting and ranking the top 100 most significant words, compiling them into a table with importance weights, and visualizing results via word clouds and bar plots.

Using this method, we obtain key terms for predicting certain nature-related labels. Figure 3 presents the English translations of the most influential terms contributing to each sub-field label, which aligns closely with intuition. For land and sea use, terms related to agriculture and water conservancy are most prominent. Organism exploitation is characterized by terms associated with breeding, processing, and biological characteristics. For pollution, energy use and healthy lifestyles are key, while climate change is primarily linked to energy, electricity, and emissions. Finally, invasive species are most strongly connected to control measures and biological characteristics.

### *3.2.3 Industry Variation*

Table 2 reveals the distribution of average annual nature-related subsidies per firm across industries. We find that Agriculture, Forestry, Animal Husbandry, and Fishery (4.029), Electricity, Heat, Gas, and Water Supply (2.505), and Mining (1.898) rank highest, reflecting their strong policy linkage to nature transition. Given their direct dependence and impact on ecosystems, these sectors' elevated subsidy levels imply greater future conservation task assignments enforced by governments. Meanwhile, Water Conservancy, Environment and Public Facilities Management (1.453) also feature prominently, consistent with active government engagement in fields of infrastructure. These sectors, closely collaborating with governments, are more likely to face additional investment mandates related to ecological restoration — such as wetland rehabilitation and pollution control — potentially increasing their transition obligations.

Overall, the distribution of nature-related subsidies reflects a "nature-policy" duality — a combination of firms' biodiversity relevance and their alignment with government conservation mandates. While benefiting from fiscal support, firms may face greater transition challenges as political commitments to biodiversity improvement strengthen.

### *3.2.4 Comparison with Alternative Text-based Approaches*

Based on the perspective of discretionary task assignment by governments, we document that our nature-related subsidy indicator, developed through a deep learning approach, can identify incremental information variations compared to existing methods for constructing environmental risk indicators in our context.

At the subsidy project level, Figure IA2 shows that our approach identifies around 13% of subsidies from 2016 to 2020 as related to nature. In contrast, dictionary-based methods based on the translated keywords in previous studies — for instance, biodiversity-risk dictionary by Giglio *et al.* (2025) — capture approximately 0.03% of the subsidies.[19]

At the firm level, we apply such dictionary-based approaches to construct measures from corporate annual report texts, and examine their correlation with our nature-related subsidy metric. Specifically, consistent with our empirical setup, we construct a cross-sectional dataset and calculate the average annual number of nature-related subsidies received by each firm from 2016 to 2020. Then we analyze the MD&A session of corporate annual reports and calculate the average value of each firm's biodiversity risk metrics consistent with Giglio *et al.* (2025), climate change exposure metrics consistent with Sautner *et al.* (2023) and climate risk metrics consistent with Li *et al.* (2024), from 2016 to 2020.[20] For robustness, we also replicate the indicators using firms' ESG reports texts.[21]

Moreover, in addition to textual analysis, previous studies employ ratings and impact measures to proxy corresponding corporate risks. For the former, we collect ESG scores and environmental sub-scores from two leading Chinese ESG rating agencies, Sino and Wind, in 2020.[22] For the latter, we use geography-based data to measure average value of human modification of terrestrial ecosystems (Theobald *et al.*, 2025) and human footprints (Wildlife Conservation Society, WCS), the average value of carbon dioxide emissions (the logarithm of total amount and the intensity measured by the ratio of emissions to sales) and average pollutant concentrations (including PM2.5 and sulfur dioxide) from 2016 to 2020,[23] within a certain radius of firms' location, which serves as imperfect, yet full-sample, proxies for local environmental (ecological) footprints.[24]

[19] Details on the dictionary and indicator construction are provided in Appendix A.3.

[20] These methods were originally applied to 10-K texts or earnings call transcripts in their respective studies. Since Chinese listed firms concentrate their key information in the MD&A section and China lacks a systematic earnings call database, we focus on MD&A text data from annual reports.

[21] Typically named corporate social responsibility reports or sustainability reports.

[22] Domestic agencies offer more comprehensive coverage and more accurate, market-preferred information on Chinese corporations (Chen *et al.*, 2025).

[23] CO2 data is from the Emissions Database for Global Atmospheric Research (EDGAR). Other pollution data is from NASA. See at: https://edgar.jrc.ec.europa.eu/ and https://disc.gsfc.nasa.gov/datasets/M2TMNXAER_5.12.4/summary?keywords=M2TMNXAER_5.12.4.

[24] Few firms in our sample provide actual environmental impact data, complicating large-sample analyses. Indeed, measuring corporate environmental footprints remains a frontier research challenge, which indicates that our full-sample measurement approach based on subsidy disclosure might be more aligned with practical decision-making currently.

Table IA2 presents that correlations between our machine-learning-based nature transition exposure metric and alternative risk metrics are all below 0.21. Among these, the "E" (Environmental) component of ESG ratings and the dictionary-based transition risk indicators exhibit stronger correlations with nature-related subsidies than with other metrics within their categories.

# 4 Firm-level Nature Transition Risk Valuation

Based on the negative result of the overall market response to Kunming COP15, we next examine the relationship between firms' historical receipt of nature-related subsidy projects and their CARs during the Kunming COP15 period.

## 4.1 Univariate Tests

We first conduct a univariate test by categorizing the sample into three distinct groups—low, middle, and high—based on the terciles of average annual number of nature-related subsidies received by firms from 2016 to 2020. For each group, we compute the mean of CARs. Moreover, we test the difference in returns between the two extreme groups by regressing CARs on an intercept and an indicator variable that equals one if the observation is from the group with the largest value of the risk exposure metric, and zero if it is from the smallest-value group. We use two-way clustering (by city and industry) to calculate standard errors, which accounts for within-sector and within-region correlations, and maintain consistency with the following multivariate regression analysis.

The results in Panel A of Table 3 indicate that CARs are negative across all groups and decrease monotonically with the annual average level of nature-related subsidies in the past five years. The difference between the two extreme groups (High - Low) is statistically significant at the 5% level, reaching approximately the value of -0.633%. The median total market value and meadian circulation market value for firms in our sample is 5.688 and 4.828 billion CNY, respectively.[25] At this scale, there is an additional wealth loss of about 36.005 for mean-size firms or 30.561 million CNY for median-size firms with the heaviest expected transition burden compared to those with the slightest anticipated obligations during the event window. Thus, the results are not only statistically significant but also economically meaningful.

## 4.2 Baseline Regressions

To further control other factors associated with cross-sectional stock returns, we complement our analysis with multivariate regression tests to further substantiate our claims. The specification is as follows:

[25] The exchange rate between CNY and U.S. dollar was between 6:1 and 7:1 around the Kunming COP15.

$$CAR_i = \beta Nature\text{-}related\ subsidies_i + \gamma Z_i + \mu_k + \rho_c + \epsilon_{i,c,k} \quad (2)$$

where $i$ denotes firm, $c$ denotes city, and $k$ denotes industry. $CAR_i$ denotes the cumulative abnormal return of firm $i$ around the Kunming COP15, which could be obtained according to methodologies in Section 2.2. *Nature-related subsidies*$_i$ represents the average annual number of nature-related subsidies received by firm $i$ before the Kunming COP15 (from 2016 to 2020), which is obtained according to methodologies in Section 3.1. $Z_i$ represents firm-level characteristics, including size, leverage, book-to-market ratio, and state ownership. $\mu_k$ represents industry fixed effects. $\rho_c$ represents city fixed effects. $\epsilon_{i,c,k}$ represents the error term. Standard errors in estimations are clustered at the industry and city levels. We collect firm data from the CSMAR. Table A1 provides the detailed definitions of all the variables.

Panel B of Table 3 reports the baseline regression estimates for Equation (2). Column (1) shows the naive correlation between the level of past nature-related subsidies received by firms and their corresponding CARs during Kunming COP15. In Columns (2)-(4), we augment the model with industry fixed effects, city fixed effects and firm-level controls. Across all specifications, the point estimates are consistently negative and statistically significant at standard levels, with their magnitudes remaining stable. These results further suggest that investors assign lower valuations to firms when they are expected to take on more mandated nature conservation tasks following the Kunming COP15.

### 4.3 Sub-category Analysis

Table 4 provides further details on the performance of subsidies identified within nature-related sub-fields. The core explanatory variables in Columns (1)-(5) represent the average annual number of subsidy projects received from 2016 to 2020 related to land and sea use, organism exploitation, pollution, climate change and species invasion, respectively.[26] Column (6) simultaneously examine the effects of subsidies related to all the five sub-categories.

We find that the level of subsidies related to all the five drivers of biodiversity loss documented in mainstream authoritative frameworks had negative impacts on stock returns around the Kunming COP15. In particular, the effect is more pronounced for biodiversity-specific domains that had been less emphasized in pre-COP15 stages, such as land use, organism over-exploitation and species invasion. The Kunming COP15 has significantly increased their importance in the decision-making processes of governments, businesses, and other stakeholders. In contrast, subsidies related to climate change had less significant negative pricing influence during the conference. This might be because climate issues have been continuously emphasized since events including the Kyoto Pro-

[26] Subsidies related to invasive species are not winsorized in regression analysis their limited number.

tocol and the Paris Agreement, while the primary focus of the Kunming COP15 was biodiversity and nature capital conservation. Although climate change is highly related to biodiversity loss crisis, it was not the unique concern of this conference, providing less new information to the market. Thus, the results of these sub-categories not only confirm the pricing of nature transition risk during Kunming COP15, but also show that the Chinese financial market responded rationally to new information.

## 4.4 Robustness Checks

### *4.4.1 Alternative specifications*

We examine various alternative specifications for robustness checks.

First, we consider potential confounding effects of general subsidy level. Our results should reflect expectations on firms' nature transition risk correlated to past nature-related subsidies received, rather than general political connections or misallocation associated with subsidies (e.g., connected but less efficient firms getting subsidies). Table A2 extends baseline specification by including the average annual number of total subsidies received by firms from 2016 to 2020. The results show that the coefficient of total subsidies is positive, indicating that general subsidies might enhance firm performance. Meanwhile, the nature-related subsidies coefficient remains significantly positive and increases in magnitude after controlling for total subsidies. This result supports that past nature-related subsidies capture additional variations tied to firms' expectations of engaging in future government conservation initiatives, reinforcing our "nature-policy" duality framework.

Second, we test alternative measures for cumulative abnormal returns around the Kunming COP15 and the level of past nature-related subsidies received. Table A3 uses market-adjusted abnormal returns (i.e., the difference between individual stock return and value-weighted market return), while Table A4 employs average annual amount of nature-related subsidies from 2016 to 2020 (scaled by firm value). All results remain robust.

### *4.4.2 Considering alternative environmental metrics*

We now consider whether the relationship between past nature-related subsidies and stock returns around the Kunming COP15 can be explained by alternative environmental risk metrics discussed in Section 3.2.4. Table IA3, Table IA4, and Table IA5 respectively present our findings. These tables build upon Column (4) of Panel B of Table 3 by sequentially adding various control variables to the regressions. These controls include: (i) the average value (2016-2020) of indicators derived from dictionary-based textual analysis of corporate annual report MD&A and ESG reports,based on Giglio *et al.* (2025), Sautner *et al.* (2023), and Li *et al.* (2024), respectively); (ii) firms' 2020 ESG scores from Sino and Wind (both overall ESG scores and environmental sub-scores); and (iii) local

ecological/environmental footprint measures during 2016-2020, including the WCS human influence index, index measuring human modification of territorial ecosystems (Theobald *et al.*, 2025), logarithm of average CO2 emissions, average intensity (emissions per sales), and average concentrations of PM2.5 and sulfur dioxide within a 5-kilometer radius of the firm.[27] The results consistently show that the inclusion of these alternative metrics does not significantly alter the sign or magnitude of the nature-related subsidy coefficient. These robust findings strengthen our analysis in that Section 3.2.4, underscoring that our measure provides incremental information regarding nature transition risk beyond the "impact framework".

## 5 Mechanism

We have observed that Kunming COP15 led to a significant drop in stock prices, particularly for firms expected to face increased conservation mandates. These firms are identified as those operating in biodiversity-related domains and demonstrating high policy compliance, proxied by the number of nature-related subsidies previously received. In Appendix B, we provide a case of a representative firm to further demonstrate that nature-related subsidies are strongly associated with both a firm's expertise in nature conservation and its close government ties. Additionally, firms with a high number of such subsidies prior to the Kunming COP15 are indeed likely to undertake more new conservation tasks post-event, while exhibiting lower returns during the event period.

We argue that Kunming COP15 marked a turning point of pricing nature transition risk. It signaled a significant escalation in China's political commitment to biodiversity conservation, highly likely to shift from a model primarily driven by direct public investment (Chen *et al.*, 2024) to one involving large-scale mandated engagement from the corporate sector. From a corporate perspective, this shift presents several challenges: while COP15 elevates expectations for transition intensity, significant uncertainty surrounds the government's subsequent concrete measures, potential policy dynamic shifts, and unforeseen disruptions to business operations due to internal resource reallocation for conservation efforts, likely leading to a substantial increase in firms' discount rates.

In addition, the ability of firms to achieve net benefits from participating in conservation remains questionable. Issues like the difficulty in defining property rights and monetizing or internalizing benefits due to externalities, coupled with a lack of public and market attention to biodiversity performance and existing divergences, suggest that even with potential compensatory government favors, firms engaging in ecological protection could incur additional costs without guaranteeing positive net returns. These notions suggest that their expected cash flows from biodiversity investments may not be positive.

[27] Our findings remain consistent for 1km, 2km, 10km, and 20km radius in Table IC6.

To offer more insights into how the market values nature transition risk, this section further explores such mechanism hypothesis by expanding our baseline specification.

### 5.1 FIRM-LEVEL HETEROGENEITY

We first investigate whether firms with differing operation characteristics experienced distinct market reactions during Kunming COP15, even under similar expected pressures from nature transition obligations. Specifically, our analysis focuses on firms' fundamental profitability and cash-generating abilities, considering heterogeneity in both the level (the first moment) and volatility (the second moment).

Table 5 presents firm-level valuation heterogeneity tests. Columns (1)-(3), building on Equation (2), incorporate the standard deviations of firms' return on assets (ROA), return on equity (ROE), and cash flow (normalized by total assets) over the five years preceding the event (i.e., 2016 - 2020), along with their interaction terms with the centered pre-shock level of nature-related subsidies. The results indicate that the market reacted more negatively to firms with higher volatility (i.e., larger standard deviations for corresponding indicators). Theoretically, volatility makes firms more vulnerable to default under external negative shocks (Merton, 1974). Besides, firms with unstable earnings typically possess less robust business models and weaker risk management, hindering their adaptation to evolving policies. Volatility also complicates predictions of future performance (Dichev & Tang, 2009). As previously discussed, nature conservation is an emerging issue, which poses new challenges for both corporate and investor decision-making. Our findings therefore reflect the market's heightened concern about whether volatile firms can adapt their business models to nature transition pressures.

Columns (4)-(5) analyze the means of firms' ROA and ROE over the same five-year pre-event period. We observe no statistically significant valuation differences among firms with varying levels of profit-generating ability. This outcome could underscore the inherent complexity of nature conservation tasks. Successfully managing biodiversity investments may present a new challenge for firms, where traditional business success may not directly translate to this emerging sustainability domain. Intriguingly, Columns (6) shows that firms with higher cash-flow generating levels exhibit a significantly weaker negative relationship between past nature-related subsidies and returns around the Kunming COP15. This to some extent aligns with the intuition regarding risk resilience capacity.

Collectively, our findings on firm-level heterogeneity are consistent with the notion that the nature transition appears to be a government-led initiative with discretionary resource allocation, where the private sector lacks experience in responding, struggles to generate positive returns from new ecological investments, and finds it difficult to hedge against the inherent uncertainties of the transition.

### 5.2 Changes in valuation-related factors

We then directly examine variations in factors tied to the valuation model to further illuminate investors' considerations — uncertainty versus earnings expectations. Specifically, we use the change in stock price volatility before and after the Kunming COP15 to capture the former, and the change in analysts' earnings forecasts to capture the latter.

We capture firm-level stock-return volatility using two metrics: the change in the standard deviation of returns ($\Delta$ *Return vol st.d*) and the change in the range of returns ($\Delta$ *Return vol range*) for each firm. Both metrics compare the period from October 12 to November 12, 2021, to the average of the same seasonal period from 2016 to 2020. As shown in Table 1, firms in our sample experienced increased stock price volatility following the Kunming COP15, as evidenced by the pronounced positive cross-sectional averages for both $\Delta$ *Return vol st.d* and $\Delta$ *Return vol range*.

The first two rows in Panel A of Table 6 report the univariate test results for the change in corporate stock price volatility before and after the Kunming COP15. The grouping and statistical testing methods are consistent with Section 4.1. We find that $\Delta$ *Return vol st.d* and $\Delta$ *Return vol range* both increase monotonically with firms' exposure to natural transition risk. The difference between the two extreme groups (High - Low) is statistically significant at the 1% level. This positive relationship remains robust in the formal multivariate regression tests: Columns (1)–(2) in Panel B show that after controlling for firm-specific characteristics, industry features, and regional endowments, firms with greater natural transition risk still exhibit higher increases in stock price volatility following the Kunming COP15. This is consistent with the notion that the lack of unified measurement for biodiversity leads to high governmental discretion, considerable future policy uncertainty, and significant analytical divergence.

Furthermore, for each firm, we calculate the difference between the mean of all EPS forecasts from August 1 to August 31, 2021, and that from October 12 to November 11, 2021, and standardized this difference using the stock price on August 31, 2021. We consider forecasts for earnings in 2022 and 2023 . Descriptive statistics in Table 1 reveal a major downward revision in earnings forecasts by analysts following the Kunming COP15, evidenced by the negative cross-sectional averages for $\Delta$ *Forecast EPS 2022* and $\Delta$ *Forecast EPS 2023*. Meanwhile, Panel B of Table 6 show that firms expected to be mandated more conservation engagement did not achieve significantly higher earnings forecasts (both statistically and economically). All the results indicate that the market generally believes that, even with potential government compensation and support in many aspects, investing in natural transition initiatives remains unprofitable for firms.

### 5.3 REGIONAL HETEROGENEITY IN TRANSITION BURDEN

Our prior discussions on political commitment and enforcement are based on that the extent of conservation mandates primarily hinges on interactions between firms and one general authority. In reality, the government-firm relationship is intricate. Central government commitments rely on local government execution, and these local entities vary widely in their available resources and the severity of local ecological issues. Consequently, the transition burden imposed on firms can differ significantly across regions, leading to disparate transition risks even for firms with similar expertise and political ties.

We investigate local fiscal conditions. Specifically, we calculate the average difference between local governments' general budget expenditures and revenues (in million CNY) from 2016 to 2020. This difference is then normalized by GDP (in billion CNY), population (in thousand), and fiscal revenue (in million CNY). Higher values of these metrics indicate less flexibility for local governments to allocate additional discretionary funds towards new conservation initiatives. We incorporated these fiscal indicators, and their interactions with pre-shock nature-related subsidies, into our baseline model. city-level data are all obtained from National Bureau of Statistics and local statistical yearbook. Columns (1)-(3) of Table 7 show a significantly negative interaction coefficients. The market seems to believe that governments with weaker fiscal flexibility have less ability to compensate or directly invest, pushing more future transition burden onto firms. This finding aligns with observed heterogeneity in blended finance (Flammer *et al.*, 2025).

We also consider heterogeneity in local nature conditions and associated transition pressure. On one hand, we collect maps for National Parks and National Nature Reserves in China from the Ministry of Ecology and Environment. By matching these with administrative border data, we calculate the proportion of these protected areas within each city. We argue that cities with larger protected areas are likely to face more extensive conservation tasks.[28] Columns (4)-(5) of Table 7 support this, showing that the interaction coefficients between protected area size and subsidies remain significantly negative.

On the other hand, we collect a citizen science dataset from the China Bird Report Center that compiles detailed birdwatching reports (Meng *et al.*, 2025; Chen *et al.*, 2024). We calculate the difference in bird observations (both individual number and species number) between the period of the forth quarter of 2015 to the third quarter of 2016 and the forth quarter of 2019 to the third quarter of 2020, normalized by total administrative area (in square kilometers). Higher values for the metrics represent less improvement (or greater deterioration) in local ecology over the past years, implying a greater need for future conservation investment. As expected, Columns (6)-(7) of Table 7 show that the interaction coefficients between the measures and subsidies remain significantly negative.

[28] National Parks, formally announced by President Xi at the Kunming COP15, represent China's highest-level protected areas, while National Nature Reserves have long been the most strictly regulated (Chen *et al.*, 2024) in the country.

Overall, the results in Table 7 complement our mechanism arguments in Section 5.1 and Section 5.2, confirming that the ultimate source of firms' nature transition risks stems from anticipated government-mandated conservation investments by firms.

## 6 Further discussions on corporate real actions

In addition to financial outcomes, it is important to recognize the real impact of the nature transition initiatives on corporations. We investigate changes in managers' willingness to disclose biodiversity-related information in corporate communications around the Kunming COP15. Specifically, we gathered all available corporate ESG reports — sustainability reports and corporate social responsibility reports for listed firm in the A-share market of China. We employ a textual analysis approach and count the frequency of the term "biodiversity" within these reports. The rationale behind this approach is that when firms mention biodiversity more frequently in their reports, they are likely to have a greater focus on biodiversity issues in their business strategies and operations.

Figure 4 illustrates the number of corporate reports containing the keyword "biodiversity," as well as the proportion of these reports relative to the total number from 2010 to 2023. Notably, there is a substantial increase in attention to biodiversity by listed firms in 2021. This trend indicates a systemic shift towards incorporating biodiversity considerations into managerial decisions following the Kunming COP15.

We then measure the changes in corporate biodiversity reporting around the Kunming COP15 using two metrics: $\Delta$*Reporting bio 2022 (2023)* is a dummy variable that equals one if the corporate ESG reports contain the keyword "biodiversity" in 2022 (2023), but not in 2020, otherwise zero. Consistent with patterns in Figure 4, Table 1 reveal a notable uptick in firms disclosing their biodiversity information following the Kunming COP15, with positive cross-sectional averages for $\Delta$*Reporting bio 2022 (2023)*.

Panel A of Table 8 reports univariate test results examining the role of firm-level nature transition exposure metrics. The methodology mirrors that in Section 4.1. We find that $\Delta$*Reporting bio 2022* and $\Delta$*Reporting bio 2023* increase monotonically with firms' exposure to natural transition risk, with the gap between high- and low-exposure groups statistically significant at the 1% level. This positive correlation holds in multivariate regressions: Panel B show that, after controlling firm-specific traits, regional attributes, and sectoral features, firms with greater nature transition exposure exhibit a markedly higher probability of biodiversity disclosure following the Kunming COP15.

These findings support that our nature-related subsidy measure could efficiently capture firm-level variations in future conservation engagement and nature transition risk. Moreover, the increased disclosure of biodiversity-related information possibly reflects not only heightened managerial awareness of biodiversity issues but also potential adjustments in firms' actions to deal with sustainability issues.

## 7 Conclusion

We document the significant impact of regulatory mandates for nature conservation, as evidenced by the negative abnormal stock returns of Chinese firms during the Kunming COP15. By using a machine learning approach to identify historical nature-related subsidies received, we show that firms receiving more of these subsidies faced heightened nature transition risks and decreased stock valuations around the conference period. These risks primarily stem from policy uncertainty and expectations of non-profitability associated with conservation efforts. Firms characterized by higher volatility in profitability and cash flows, as well as those operating in regions with limited fiscal flexibility and stringent conservation pressures, experienced more pronounced market penalties. Finally, firms exposed to greater nature transition risk showed a higher propensity to disclose biodiversity-related information in the aftermath of the event.

It is particularly noteworthy given that Kunming COP15 represented a significant diplomatic platform where China, as the host country, demonstrated robust political commitment toward global nature conservation. This commitment was exemplified through China's instrumental role in facilitating negotiations for the Global Biodiversity Framework, further reinforced by President Xi Jinping's articulation of specific national biodiversity transition objectives. As we have explained, in the context of China's political economy, where state decisions greatly influence both economic development and sustainability transitions, this high-level political signaling regarding biodiversity priorities may have substantive implications for corporate strategic considerations. However, the negative returns suggest that the financial market may primarily focus on the costs and uncertainties associated with the forthcoming transition, rather than being encouraged by the anticipated increase in public investments and a more positive outlook for sustainable development. Our finding preliminarily implies potential financial frictions during the nature conservation transition, arising from conflicts of interest between the public and private sectors, especially in emerging markets (Flammer *et al.*, 2025; Chen *et al.*, 2024).

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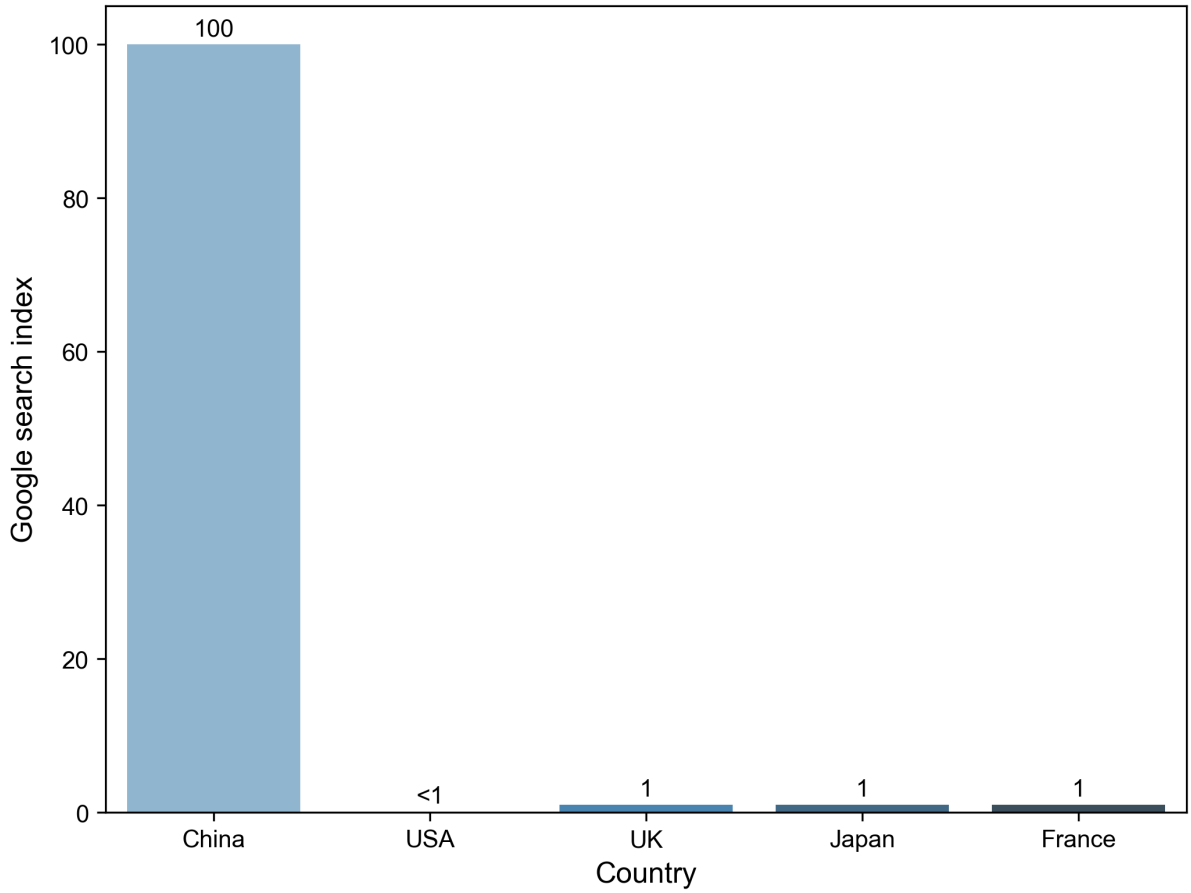
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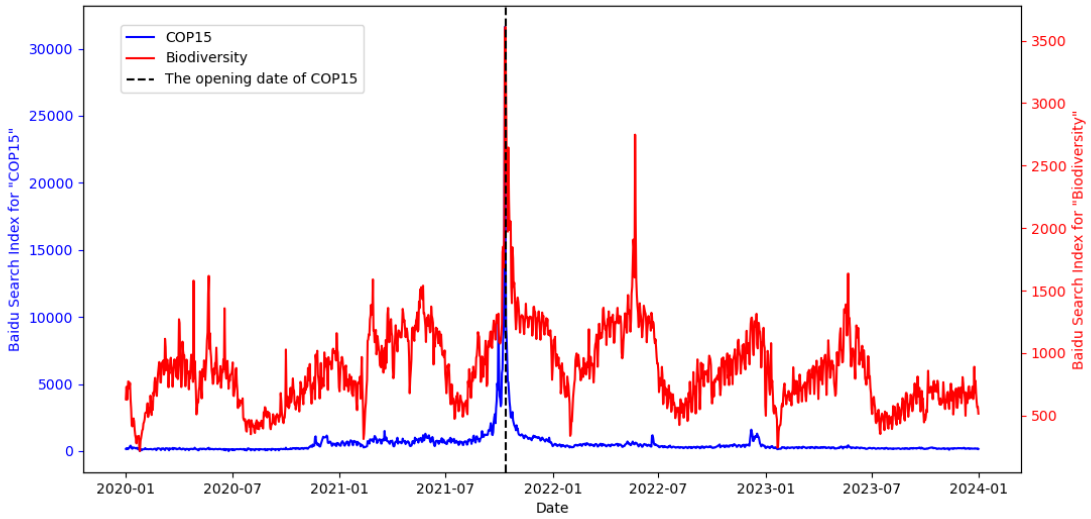
## Figures and Tables

Figure 1: Google search index for "COP15" across countries



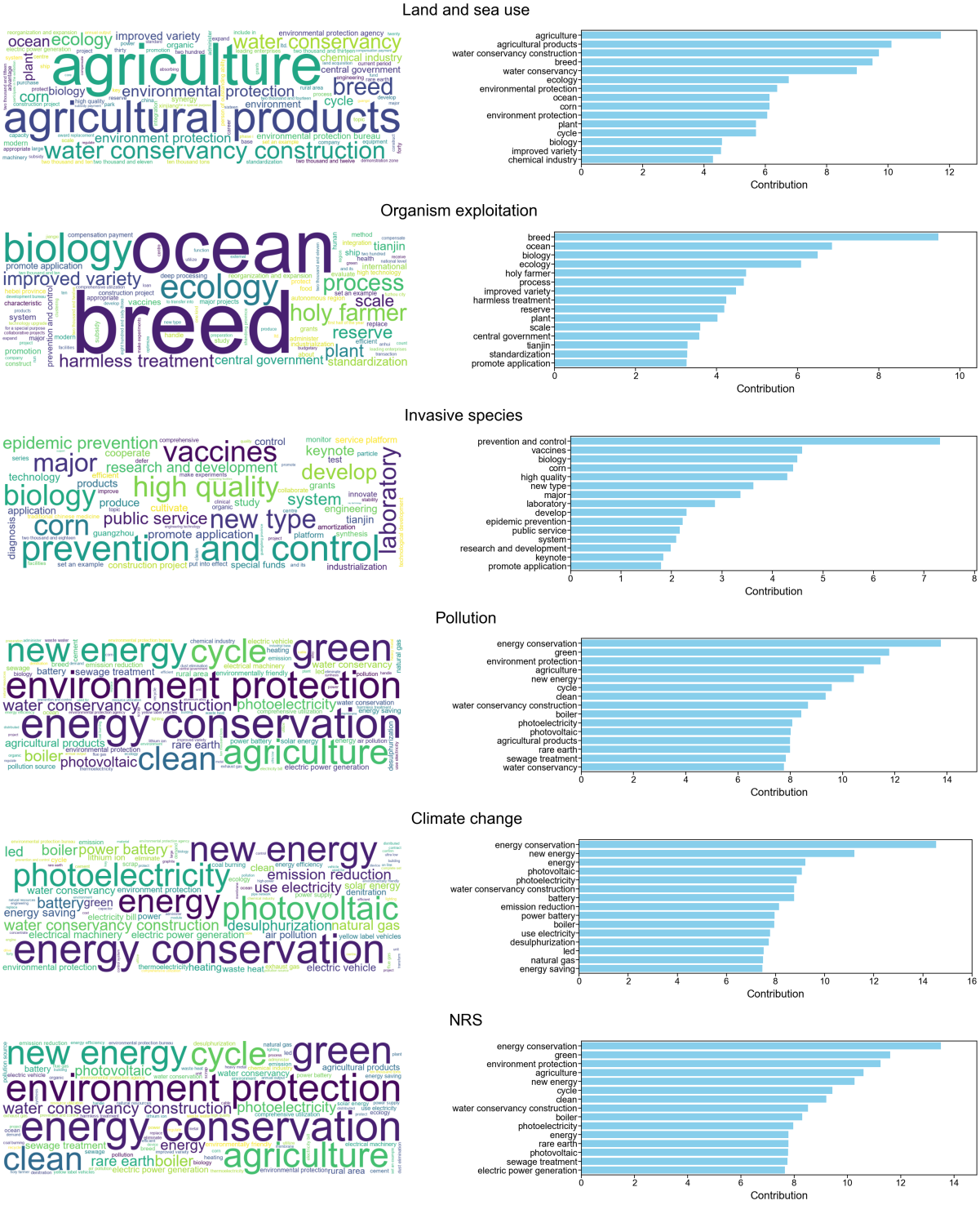

**Notes:** This figure shows countries with sizable Google search index values of "COP15" in the two weeks since the opening of COP15 in Kunming.

FIGURE 2: BAIDU SEARCH INDEX FOR "COP15" AND "BIODIVERSITY"



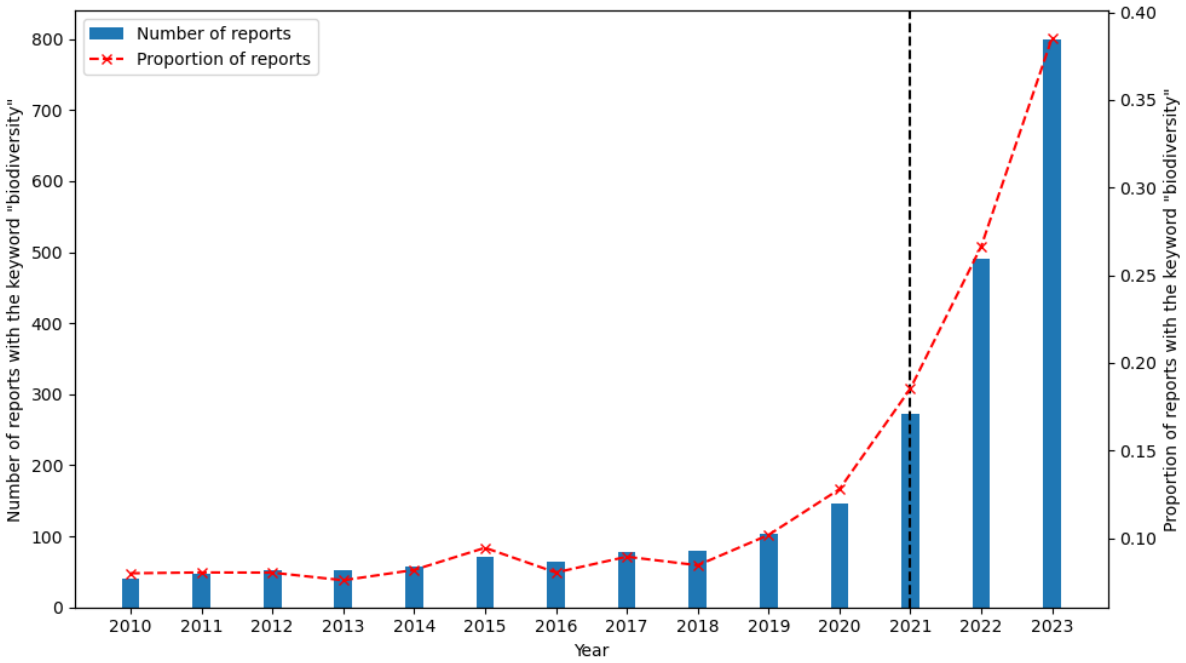

**Notes:** This figure shows the trend of Baidu search index. The blue solid line represents the search index for the keyword "COP15," while the red solid line represents the search index for the keyword "biodiversity." The black dashed line indicates the opening date of the Kunming COP15.

Figure 3: Terms with significant contribution to predicting nature-related subsidy




**Note:** The figure consists of word clouds on the left and contribution rankings on the right for the nature-related subsidy (NRS) and its five sub-categories: land and sea use, organism exploitation, pollution, climate change, and species invasion. In the word clouds, the size of each word reflects its contribution to the corresponding category. On the right, the top 15 highest-contributing words for each category are listed in descending order of their contribution scores. Contribution is measured using the Term Frequency–Inverse Document Frequency (TF-IDF) approach.

Figure 4: The number of corporate ESG reports related to "biodiversity"




**Notes:** This figure shows the number of corporate ESG reports (i.e., corporate social responsibility reports or sustainable development reports) containing the keyword "biodiversity," as well as the proportion of these reports relative to the total number of ESG reports. The blue bar represents the number of reports, while the red dashed line represents the proportion of these reports relative to the total number of reports. The black dashed line indicates the year COP15 in Kunming was held.

Table 1: Summary Statistics

| | Obs | Mean | St.D | P25 | P50 | P75 |
|---|---|---|---|---|---|---|
| CAR (%) | 3564 | -0.953 | 3.897 | -3.491 | -1.254 | 1.103 |
| CAR_ma (%) | 3564 | -0.484 | 4.097 | -3.195 | -0.943 | 1.708 |
| Nature-related subsidies | 3564 | 1.163 | 1.840 | 0.000 | 0.400 | 1.400 |
| NRS - land and sea use driven | 3564 | 0.157 | 0.325 | 0.000 | 0.000 | 0.200 |
| NRS - organism exploitation driven | 3564 | 0.029 | 0.096 | 0.000 | 0.000 | 0.000 |
| NRS - pollution driven | 3564 | 1.107 | 1.745 | 0.000 | 0.250 | 1.400 |
| NRS - climate change driven | 3564 | 0.687 | 1.088 | 0.000 | 0.200 | 0.800 |
| NRS - species invasion driven | 3564 | 0.005 | 0.140 | 0.000 | 0.000 | 0.000 |
| ln(Size) | 3564 | 15.554 | 1.053 | 14.761 | 15.390 | 16.295 |
| Leverage | 3564 | 0.398 | 0.188 | 0.239 | 0.394 | 0.543 |
| B/M | 3564 | 0.559 | 0.280 | 0.331 | 0.520 | 0.766 |
| SOE | 3564 | 0.293 | 0.455 | 0.000 | 0.000 | 1.000 |
| Earnings volatility - ROA | 3156 | 0.025 | 0.020 | 0.010 | 0.018 | 0.035 |
| Earnings volatility - ROE | 3156 | 0.045 | 0.039 | 0.017 | 0.031 | 0.061 |
| Cash flow volatility | 3149 | 0.064 | 0.036 | 0.034 | 0.057 | 0.091 |
| ROA | 3564 | 0.047 | 0.035 | 0.020 | 0.044 | 0.073 |
| ROE | 3564 | 0.073 | 0.053 | 0.039 | 0.075 | 0.110 |
| Cash flow | 3564 | 0.031 | 0.051 | 0.001 | 0.016 | 0.040 |
| Δ Forecast EPS_2022 (%) | 1190 | -0.160 | 0.673 | -0.368 | -0.017 | 0.137 |
| Δ Forecast EPS_2023 (%) | 1185 | -0.143 | 0.833 | -0.410 | -0.012 | 0.225 |
| Δ Return vol_st.d (bps) | 3490 | 18.948 | 68.810 | -34.675 | 13.375 | 69.100 |
| Δ Return vol_range (bps) | 3490 | 75.771 | 245.781 | -110.170 | 68.592 | 265.047 |
| Fiscal inflexibility1 | 3564 | 0.049 | 0.027 | 0.040 | 0.040 | 0.046 |
| Fiscal inflexibility2 | 3564 | 3.984 | 1.078 | 3.871 | 3.871 | 4.009 |
| Fiscal inflexibility3 | 3564 | 0.648 | 0.449 | 0.514 | 0.514 | 0.554 |
| Protected area proportion | 3564 | 0.014 | 0.021 | 0.000 | 0.003 | 0.019 |
| EX-ante biodiversity loss1 | 3344 | -0.007 | 0.020 | -0.007 | 0.000 | 0.003 |
| EX-ante biodiversity loss2 | 3344 | -0.026 | 0.054 | -0.049 | -0.000 | 0.005 |
| Δ Reporting bio_2022 (%) | 3564 | 7.632 | 26.554 | 0.000 | 0.000 | 0.000 |
| Δ Reporting bio_2023 (%) | 3564 | 13.973 | 34.676 | 0.000 | 0.000 | 0.000 |

**Notes:** This table reports summary statistics for the main variables used in the paper. Our initial sample includes all non-financial listed firms publicly traded in the A-share market with data available in China. All variables are defined in Table A1.

Table 2: Nature-related subsidy: Cross-industry distribution

| **CSRC industry classification** | **Natural-related subsidy (mean)** |
|---|---|
| Agriculture, Forestry, Animal Husbandry, and Fishery | 4.029 |
| Electricity, Heat, Gas and Water Supply | 2.505 |
| Mining | 1.898 |
| Water Conservancy, Environment and Public Facilities Management | 1.453 |
| Manufacturing | 1.287 |
| Conglomerate | 1.250 |
| Health and Social Work | 1.000 |
| Transportation, Storage and Post | 0.996 |
| Accommodation and Catering Services | 0.914 |
| Scientific Research and Technical Services | 0.675 |
| Construction | 0.669 |
| Wholesale and Retail Trades | 0.652 |
| Leasing and Business Services | 0.497 |
| Real Estate | 0.433 |
| Culture, Sports and Entertainment | 0.343 |
| Information Transmission, Software and Technology Services | 0.310 |
| Education | 0.222 |

**Notes:** This table reports the average number of nature-related subsidies per firm (2016-2020) for each industry in our sample, using the China Securities Regulatory Commission (CSRC) classification. Industries are ranked in descending order by this average.

Table 3: Nature-related subsidies and returns around Kunming COP15

| **Panel A: Univariate tests** | Low | Middle | High | High-Low |
|---|---|---|---|---|
| CAR (%) | -0.673<br>(-6.506) | -0.923<br>(-7.780) | -1.306<br>(-11.103) | -0.633<br>[-2.467] |

| **Panel B: Multivariate regressions** | CAR | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | -0.145** | -0.125*** | -0.088*** | -0.082*** |
| | (0.054) | (0.027) | (0.025) | (0.026) |
| ln(Size) | | | | 0.259*** |
| | | | | (0.081) |
| Leverage | | | | 1.573*** |
| | | | | (0.505) |
| B/M | | | | -2.169*** |
| | | | | (0.211) |
| SOE | | | | -0.246 |
| | | | | (0.209) |
| Industry FE | No | Yes | Yes | Yes |
| City FE | No | No | Yes | Yes |
| Adjusted $R^2$ | 0.004 | 0.049 | 0.065 | 0.088 |
| Obs | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the impacts of past nature-related subsidies (NRS) received on the cumulative abnormal returns (CAR) around the Kunming COP15. CAR is calculated based on the market model of Equation (1), over the five-day window starting from October 12, 2021. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Panel A reports univariate tests comparing CAR across groups with low, middle, and high NRS. T-statistics in parentheses are based on portfolio method. T-statistics in brackets are based on standard errors clustered at the city and industry level. Panel B reports regression results based on the specification of Equation (2), with CAR as the dependent variable. Column (1) includes only NRS, while Columns (2)-(4) progressively add industry fixed effects, city fixed effects and firm-level controls. Detailed definitions of variables are presented in Table A1. Standard errors in parentheses are clustered at the city and industry level; ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Table 4: Nature-related subsidies and returns around Kunming COP15: Sub-categories

| | CAR | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Nature-related subsidies - land and sea use driven | -0.940*** | | | | | -0.729*** |
| | (0.215) | | | | | (0.175) |
| Nature-related subsidies - organism exploitation driven | | -2.912** | | | | -1.651* |
| | | (1.071) | | | | (0.897) |
| Nature-related subsidies - pollution driven | | | -0.089*** | | | -0.126 |
| | | | (0.029) | | | (0.073) |
| Nature-related subsidies - climate change driven | | | | -0.036 | | 0.267** |
| | | | | (0.045) | | (0.116) |
| Nature-related subsidies - species invasion driven | | | | | -0.791** | -0.440 |
| | | | | | (0.325) | (0.282) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.092 | 0.091 | 0.088 | 0.087 | 0.087 | 0.094 |
| Obs | 3564 | 3564 | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports regression results estimating the impact of each past nature-related subsidy (NRS) sub-category received on cumulative abnormal returns (CAR) around the Kunming COP15. The dependent variable, CAR, is calculated using the market model as defined in Equation (1), over a five-day window starting from October 12, 2021. Columns (1)-(5) include the average annual number of nature-related subsidies received from 2016 to 2020, specifically for the driver domains of land and sea use, organism exploitation, pollution, climate change, and invasive species, respectively. Column (6) simultaneously regresses on all sub-categories of NRS. All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Table 5: Nature-related subsidies and returns around Kunming COP15: Firm-level heterogeneity

| Dependent variable | CAR | | | | | |
|---|---|---|---|---|---|---|
| Firm trait (Z) | Earnings volatility - ROA | Earnings volatility - ROE | Cash flow volatility | Earnings - ROA | Earnings - ROE | Cash flow |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Nature-related subsidies × Z | -3.534*** | -1.675** | -0.966** | 0.147 | 0.591 | 0.883*** |
| | (1.117) | (0.622) | (0.332) | (0.525) | (0.422) | (0.250) |
| Nature-related subsidies | -0.099*** | -0.096*** | -0.090*** | -0.081*** | -0.073** | -0.073** |
| | (0.024) | (0.024) | (0.026) | (0.027) | (0.027) | (0.025) |
| Firm Traits (Z) | Yes | Yes | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.089 | 0.090 | 0.088 | 0.087 | 0.088 | 0.088 |
| Obs | 3140 | 3140 | 3140 | 3564 | 3564 | 3564 |

**Notes:** This table reports regression results estimating how the impact of past nature-related subsidies (NRS) on cumulative abnormal returns (CAR) around the Kunming COP15 varies with firm-level conditions related to earnings and cash flow. The dependent variable, CAR, is calculated using the market model as defined in Equation (1), over a five-day window starting from October 12, 2021. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Columns (1)-(6) augment the specification of Column (4) in the Panel B of Table 3 by including a firm-level fundamental indicator (Z) and its interaction term with NRS. Specifically, Columns (1)-(3) examine operation volatility (using the standard deviation of ROA, ROE and cash flow, from 2016 to 2020 in percentage, respectively). Columns (4)-(6) examine the average value of ROA, ROE and cash flow, respectively. ROA (ROE) is calculated as the ratio of annual profits to total assets (equity) in percentage. Cash flow is calculated as the ratio of annual cash flow to total assets. To make the NRS coefficient comparable with the results in Table 3, all interaction terms of the firm trait variables Z are centered (mean-normalized). All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

TABLE 6: NATURE-RELATED SUBSIDIES AND VALUATION-RELATED FACTORS

**Panel A: Univariate tests**

| | Low | Middle | High | High-Low |
|---|---|---|---|---|
| Δ Return vol_st.d (bps) | 5.274<br>(2.772) | 21.125<br>(9.955) | 32.542<br>(16.619) | 27.267<br>[8.067] |
| Δ Return vol_range (bps) | 35.228<br>(5.240) | 79.574<br>(10.293) | 118.296<br>(16.769) | 83.068<br>[6.716] |
| Δ Forecast EPS_2022 (%) | -0.197<br>(-6.473) | -0.158<br>(-4.390) | -0.118<br>(-3.325) | 0.079<br>[2.427] |
| Δ Forecast EPS_2023 (%) | -0.196<br>(-5.236) | -0.130<br>(-2.970) | -0.089<br>(-1.984) | 0.108<br>[3.192] |

**Panel B: Multivariate regressions**

| Dependent variable | Δ Return vol_st.d | Δ Return vol_range | Δ Forecast EPS_2022 | Δ Forecast EPS_2023 |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | 2.851*** | 9.025*** | -0.013 | -0.007 |
| | (0.710) | (2.998) | (0.008) | (0.009) |
| Controls | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.182 | 0.140 | 0.062 | 0.068 |
| Obs | 3490 | 3490 | 1137 | 1130 |

**Notes:** This table reports the impacts of past nature-related subsidies (NRS) on factors related to investors' pricing considerations around the Kunming COP15. NRS is the total number of nature-related subsidies received from 2016 to 2020. Δ Return vol st.d (range) is the difference between the standard deviation (range) of stock return from October 12 to November 11, 2021 and the mean standard deviation (range) of the same seasonal period across 2016-2020. Δ Forecast EPS 2022 (2023) is the change in analysts' earnings forecasts per share (EPS) divided by the stock price in August 31, 2021 in percentage for year 2022 (2023), while the change in analysts' EPS forecasts is the difference between the mean EPS forecast from August 1 to August 31, 2021 and that from October 12 to November 12,2021. Panel A reports univariate tests comparing Δ Return vol st.d, Δ Return vol range, Δ Forecast EPS 2022 and Δ Forecast EPS 2023 across groups with low, middle, and high NRS. T-statistics in parentheses are based on portfolio method. T-statistics in brackets are based on standard errors clustered at the city and industry level. Panel B reports regression results. In Columns (1)-(4), the dependent variable from Column (4) in Panel B of Table 3 is replaced with Δ Return vol st.d, Δ Return vol range, Δ Forecast EPS 2022 and Δ Forecast EPS 2023, respectively. All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Nature-related subsidies and returns around Kunming COP15: City-level heterogeneity

| Dependent variable | CAR | | | | | | |
|---|---|---|---|---|---|---|---|
| City trait (M) | Fiscal budget inflexibility | | | Protected area proportion | | Ex-ante biodiveristy loss | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Nature-related subsidies × M | -2.684*** | -0.106*** | -0.167*** | -2.171** | -2.791*** | -2.614** | -0.714*** |
| | (0.827) | (0.013) | (0.046) | (0.971) | (0.925) | (1.082) | (0.210) |
| Nature-related subsidies | -0.077*** | -0.082*** | -0.077*** | -0.079*** | -0.079** | -0.063** | -0.060** |
| | (0.024) | (0.024) | (0.024) | (0.025) | (0.035) | (0.022) | (0.021) |
| City Traits (M) | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.089 | 0.090 | 0.089 | 0.088 | 0.088 | 0.085 | 0.084 |
| Obs | 3564 | 3564 | 3564 | 3564 | 2272 | 3344 | 3344 |

**Notes:** This table reports regression results estimating how the impact of past nature-related subsidies (NRS) on cumulative abnormal returns (CAR) around the Kunming COP15 varies with city-level conditions. The dependent variable, CAR, is calculated using the market model as defined in Equation (1), over a five-day window starting from October 12, 2021. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Columns (1)-(7) augment the specification of Column (4) in the Panel B of Table 3 by including a city-level variable (M) and its interaction term with NRS. Specifically, Columns (1)-(3) examine fiscal budget inflexibility, using the difference between the average fiscal expenditure and fiscal revenue in million CNY (normalized by average GDP in million CNY, permanent resident population in thousand people and fiscal revenue in million CNY, respectively) of the city where the firm is located from 2016 to 2020. Columns (4)-(5) examine protected area proportion (i.e., the sum of national parks and national nature reserves area, normalized by total administrative area, of the city where the firm is located) among all cities and cities with these protected area, respectively. Columns (6)-(7) examine ex-ante biodiversity relative loss using the the difference between the number of bird speices and individual birds (in thousand) observed from the fourth quarter of 2015 to the third quarter of 2016, and that from the fourth quarter of 2019 to the third quarter of 2020 (normalized by total administrative area in kilometer), respectively. Under the full specification, the city trait variables M are absorbed by the city fixed effects. All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8: Nature-related subsidies and corporate biodiversity reporting

**Panel A: Univariate tests**

| | Low | Middle | High | High-Low |
|---|---|---|---|---|
| Δ Bio reporting 2022 (%) | 6.106 | 6.389 | 10.455 | 4.349 |
| | (9.511) | (8.200) | (11.763) | [4.490] |
| Δ Bio reporting 2023 (%) | 11.638 | 13.083 | 17.454 | 5.816 |
| | (13.535) | (12.177) | (15.829) | [4.482] |

**Panel B: Multivariate regressions**

| Estimation model | Probit | | Logit | |
|---|---|---|---|---|
| Dependent variable | Δ Reporting bio_2022 | Δ Reporting bio_2023 | Δ Reporting bio_2022 | Δ Reporting bio_2023 |
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | 0.047*** | 0.029*** | 0.091** | 0.052** |
| | (0.018) | (0.010) | (0.041) | (0.021) |
| Controls | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes |
| Pseudo $R^2$ | 0.219 | 0.199 | 0.223 | 0.199 |
| Obs | 3015 | 3270 | 3015 | 3270 |

**Notes:** This table reports the impacts of past nature-related subsidies (NRS) on corporate biodiversity reporting. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Δ Reporting bio 2022 (2023) is a dummy variable that equals one if the corporate social responsibility reports or sustainable development reports containing the keyword "biodiversity" in 2022 (2023) but not in 2020, otherwise zero. Panel A reports univariate tests comparing Δ Reporting bio 2022 (2023) across groups with low, middle, and high NRS. T-statistics in parentheses are based on portfolio method. T-statistics in brackets are based on standard errors clustered at the city and industry level. Panel B reports regression results. The dependent variable from Column (4) in Panel B of Table 3 is replaced with Δ Reporting bio 2022 in Columns (1) and (3), and Δ Reporting bio 2023 in Columns (2) and (4), respectively. Regressions in Columns (1)-(2) employ probit model (LPM), while those in Columns (3)-(4) employ logit model for robustness. All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

# Appendix

Table A1: Variable definitions

| Variable | Definition and data source |
|---|---|
| CAR | The cumulative abnormal return over the five-day event window (i.e., five trading days starting from October 12, 2021) in percentage based on the market model. Source: CSMAR. |
| $CAR_{ma}$ | The cumulative market-adjusted return over the five-day event window (i.e., five trading days starting from October 12, 2021) in percentage based on the market model. Source: CSMAR. |
| ln(Size) | The natural logarithm of the firm market value as of the week ended at September 3, 2021, in RMB yuan. Source: CSMAR. |
| Leverage | The ratio of liabilities to assets as of the end of 2020. Source: CSMAR. |
| B/M | Book-to-market ratio, constructed as the ratio of the book value to the market value of equity as of the end of 2020. Source: CSMAR. |
| SOE | A dummy variable that equals one if it is a state-owned enterprise and zero otherwise. Source: CSMAR. |
| Earning volatility - ROA | The standard deviation of the ratio of annual profits to total assets from 2016 to 2020 in percentage. Source: CSMAR. |
| Earning volatility - ROE | The standard deviation of the ratio of annual profits to total equity from 2016 to 2020 in percentage. Source: CSMAR. |
| Cash flow volatility | The standard deviation of the ratio of annual cash flow to total assets from 2016 to 2020 in percentage. Source: CSMAR. |
| ROA | The average value of the ratio of annual profits to total assets from 2016 to 2020 in percentage. Source: CSMAR. |
| ROE | The average value of the ratio of annual profits to total equity from 2016 to 2020 in percentage. Source: CSMAR. |
| Cash flow | The average value of the ratio of annual cash flow to total assets from 2016 to 2020 in percentage. Source: CSMAR. |
| Fiscal inflexibility1 | The difference between the averaged fiscal expenditure and fiscal revenue in million yuan RMB (normalized by average GDP in billion yuan RMB) of the city where the firm is located from 2016 to 2020. Source: CEIC. |
| Fiscal inflexibility2 | The difference between the averaged fiscal expenditure and fiscal revenue in million yuan RMB (normalized by averaged permanent resident population in thousand people) of the city where the firm is located from 2016 to 2020. Source: CEIC. |
| Fiscal inflexibility3 | The difference between the averaged fiscal expenditure and fiscal revenue in million yuan RMB (normalized by averaged fiscal revenue in million yuan RMB) of the city where the firm is located from 2016 to 2020. Source: CEIC. |
| Protected area proportion | The sum of national parks and national nature reserves area (normalized by total administrative area) of the city where the firm is located in 2020. Source: the Ministry of Ecology and Environment. |
| Ex-ante biodiversity loss1 | The centered difference between the number of bird species observed from the fourth quarter of 2015 to the third quarter of 2016, and that from the fourth quarter of 2019 to the third quarter of 2020 in thousand (normalized by total administrative area in kilometer) |

| | |
|---|---|
| Ex-ante biodiversity loss2 | The centered difference between the number of individual birds observed from the fourth quarter of 2013 to the third quarter of 2016, and that from the fourth quarter of 2019 to the third quarter of 2020 in thousand (normalized by total administrative area in kilometer) |
| Δ Forecast EPS 2022 | The change in analysts' earnings forecasts per share (EPS) divided by the stock price in August 31, 2021 in percentage for year 2022. The change in analysts' EPS forecasts is defined as the difference between the mean EPS forecast from August 1 to August 31, 2021 and that from October 12 to November 11, 2021. |
| Δ Forecast EPS 2023 | The change in analysts' earnings forecasts per share (EPS) divided by the stock price in August 31, 2021 in percentage for year 2023. The change in analysts' EPS forecasts is defined as the difference between the mean EPS forecast from August 1 to August 31, 2021 and that from October 12 to November 11, 2021. |
| Δ Return vol st.d | The difference between the standard deviation of stock return from October 12 to November 11, 2021 and the mean standard deviation of the same seasonal period across 2016-2020 |
| Δ Return vol range | The difference between the standard range of stock return from October 12 to November 11, 2021 and the mean standard range of the same seasonal period across 2016-2020 |
| Δ Reporting bio 2022 | A dummy variable that equals one if the corporate orporate social responsibility reports or sustainable development reports containing the keyword "biodiversity" in 2022 but not in 2020, otherwise zero |
| Δ Reporting bio 2023 | A dummy variable that equals one if the corporate orporate social responsibility reports or sustainable development reports containing the keyword "biodiversity" in 2023 but not in 2020, otherwise zero |

**Notes:** This table reports the detailed definitions of the main variables used in the paper. All variables are winsorized at the 5% and 95% levels. The exchange rate between the US dollar and the Chinese CNY was typically around 1:7

Table A2: Nature-related subsidies and returns around Kunming COP15: Additional Controls

| | CAR | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | -0.304*** | -0.239*** | -0.188*** | -0.157*** |
| | (0.094) | (0.021) | (0.028) | (0.028) |
| Total subsidies | 0.047*** | 0.032*** | 0.028*** | 0.021*** |
| | (0.014) | (0.004) | (0.006) | (0.006) |
| ln(Size) | | | | 0.249** |
| | | | | (0.089) |
| Leverage | | | | 1.533*** |
| | | | | (0.514) |
| B/M | | | | -2.160*** |
| | | | | (0.205) |
| SOE | | | | -0.227 |
| | | | | (0.218) |
| Industry FE | No | Yes | Yes | Yes |
| City FE | No | No | Yes | Yes |
| Adjusted $R^2$ | 0.011 | 0.052 | 0.067 | 0.089 |
| Obs | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the results of robustness tests by augmenting regressions in Table 3 with controlling the annual average number of all kinds of subsidies received by a firm from 2016 to 2020.

Table A3: Nature-related subsidies and returns around Kunming COP15 - Robustness tests using market-adjusted abnormal returns

| **Panel A: Univariate tests** | Low | Middle | High | High-Low |
|---|---|---|---|---|
| CAR_ma (%) | -0.297 | -0.440 | -0.740 | -0.443 |
| | (-2.716) | (-3.528) | (-5.985) | [-1.566] |

| **Panel B: Multivariate regressions** | CAR_ma | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | -0.100 | -0.079 | -0.072** | -0.089*** |
| | (0.059) | (0.056) | (0.026) | (0.026) |
| ln(Size) | | | | 0.363*** |
| | | | | (0.102) |
| Leverage | | | | 1.529*** |
| | | | | (0.500) |
| B/M | | | | -1.426*** |
| | | | | (0.189) |
| SOE | | | | -0.320 |
| | | | | (0.270) |
| Industry FE | No | Yes | Yes | Yes |
| City FE | No | No | Yes | Yes |
| Adjusted $R^2$ | 0.002 | 0.021 | 0.064 | 0.081 |
| Obs | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the results of robustness tests by replacing CAR in Table 3 with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).

Table A4: Nature-related subsidy amounts and returns around Kunming COP15

| **Panel A: Univariate tests** | Low | Middle | High | High-Low |
|---|---|---|---|---|
| CAR (%) | -0.674<br>(-6.520) | -0.797<br>(-6.273) | -1.408<br>(-12.681) | -0.734<br>[-2.996] |

| **Panel B: Multivariate regressions** | CAR | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Nature-related subsidy amount | -15.283*** | -12.040*** | -10.627*** | -6.639*** |
| | (4.317) | (1.612) | (1.610) | (2.021) |
| ln(Size) | | | | 0.221** |
| | | | | (0.078) |
| Leverage | | | | 1.642*** |
| | | | | (0.485) |
| B/M | | | | -2.135*** |
| | | | | (0.238) |
| SOE | | | | -0.236 |
| | | | | (0.210) |
| Industry FE | No | Yes | Yes | Yes |
| City FE | No | No | Yes | Yes |
| Adjusted $R^2$ | 0.010 | 0.052 | 0.068 | 0.088 |
| Obs | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the results of robustness tests by replacing NRS in Table 3 with NRS amount, which is the total amount of nature-related subsidies received from 2016 to 2020 (scaled by the firm market value as of the week ended at September 3, 2021, and multiplied by 100).

# Internet Appendix

## A Additional Details on Indicator Construction and Validation

### *A.1 Reference Text of Identifying Nature-related Domains*

We draw on IPBES (2019) and incorporate expert opinion to define the five nature- and biodiversity-related factors, as follows:

*1. Land and sea use change*

Land and sea use change refers to the conversion of land and sea cover types due to human activities, which lead to the destruction and transformation of natural ecosystems, profoundly impacting biodiversity, ecosystem functions, and climate.

*1.1 Agricultural and urban expansion*

Agricultural and urban expansion is the primary driver of land use change. Over half of Earth's terrestrial surface is covered by human activities, with agricultural expansion being the most widespread form of land cover change. Currently, more than one-third of the land is used for crop cultivation or livestock grazing, often at the expense of forests, wetlands, grasslands, and other natural land cover types.

*1.2 Fragmentation*

Changes in land cover lead to the fragmentation of natural ecosystems. Fragmentation refers to the division of large, continuous natural habitats into smaller, isolated patches. Fragmentation disrupts species migration, foraging, and reproduction, thereby increasing the risk of species extinction. Industrial logging, agricultural expansion, fires, and mining/resource extraction are the primary drivers of fragmentation.

*1.3 Landscape/seascape management intensification*

Landscape and seascape management intensification refers to the enhancement of productivity in agriculture, fisheries, aquaculture, and forestry through technological advancements and the intensive use of resources. The intensification may precipitate the gradual decline of ecosystem functionality; in extreme cases, it could initiate irreversible ecological transformations, ultimately leading to the abandonment of the deteriorated land. For example, in the livestock industry, overly dense livestock populations and inadequate herd management practices have become key contributors to pasture degradation.

*1.4 Land degradation*

Land degradation refers to the reduction or loss of biological or economic productivity and complexity in croplands, pastures, grasslands, forests, and woodlands in arid, semi-arid, and dry sub-humid areas, including soil erosion and deterioration of soil physical, chemical, biological, or economic properties.

*2. Resource exploitation*

Resource exploitation includes activities that extract biological and non-biological materials from nature. With growing population and consumption, the rate of resource

exploitation has risen significantly, profoundly impacting biodiversity and ecosystems.

*2.1 Extraction of biological and non-biological materials from nature*

The extraction of biological and non-biological materials from nature is the physical removal of living and non-living resources from their original ecosystems. Biological extraction harvests organisms or parts of them—timber felled in tropical forests, fish netted from oceans, medicinal plants collected from grasslands, or bushmeat hunted in tropical savannas—whereas non-biological extraction withdraws inanimate substances such as iron ore blasted from bedrock, petroleum drilled beneath polar seas, groundwater pumped from aquifers, or sand dredged from riverbeds for concrete.

*2.2 Freshwater extraction*

Freshwater extraction is the deliberate withdrawal of water from rivers, lakes, wetlands, and underground aquifers for human use. It takes the form of groundwater pumped by electric wells that can reach depths of hundreds of metres, surface water diverted through irrigation canals that siphon flow from entire river stretches, and reservoir releases timed to meet urban or industrial demand. Such overextraction lowers water tables, dries flood-plain wetlands that migratory birds depend on, and concentrates salts and pollutants, undermining both biodiversity and the long-term security of farms and cities that rely on the same finite resource.

*3. Pollution*

Pollution refers to the release of harmful substances into the natural environment due to human activities, negatively affecting ecosystems. It covers emissions to the air, water, and soil, the dumping or accumulation of solid waste, the artificial brightening of night skies with electric light that disrupts circadian rhythms, and the chronic intrusion of loud or persistent noise that masks animal communication.

*3.1 Atmospheric emissions*

Population growth, economic activity, and energy consumption drive anthropogenic greenhouse gas (GHG) emissions, such as carbon dioxide ($CO_2$), nitrogen oxides ($NO_x$), and sulfur dioxide ($SO_2$). These gases, once airborne, set off cascading ecological damage: $CO_2$ warms the climate, shifting habitats and stressing species already at their thermal limits, while $NO_x$ and $SO_2$ return as acid rain that leaches nutrients from soils, acidifies lakes, and weakens the calcium-rich shells and skeletons of aquatic life.

*3.2 Waterborne pollutants*

Declining water quality is primarily caused by urban sewage, industrial and agricultural runoff, erosion, salinization, oil spills, and marine dumping. Pollutants in wastewater include fecal coliforms, organic pollutants, heavy metals, and pharmaceutical residues. Agriculture is the main contributor to soil erosion and nutrient influx into freshwater, with fertilizer and pesticide use leading to eutrophication and harmful algal blooms.

*3.3 Solid waste disposal or deposition*

As global urbanization accelerates, the volume of solid waste continues to rise, with

most waste being generated in urban areas. Improper waste management not only releases greenhouse gases into the atmosphere but also contaminates soil and groundwater, posing a dual threat to ecosystems and human health. Among all waste streams, electronic and plastic waste are the fastest-growing categories. Electronic waste contains toxic substances such as heavy metals, while plastic waste — due to its extreme resistance to degradation — accumulates persistently in marine environments, becoming a new form of "oceanic invader." Carried by ocean currents, plastic fragments converge into massive concentrations, expanding at an alarming rate and endangering marine life and the stability of entire marine ecosystems.

*3.4 Soil pollution*

Soil pollution mainly stems from industrial activities, agricultural chemicals, and improper waste disposal. Common soil pollutants include heavy metals, pesticides, and industrial chemicals, which affect crop growth and quality and pose risks to human health through the food chain. Heavy metals such as lead, cadmium, mercury, and arsenic, emitted by mining, metallurgy, and chemical industries, accumulate in the soil, affecting plant growth and posing health risks to humans via the food chain. Pesticides and fertilizers used extensively in agriculture also contribute to soil pollution, with pesticide residues and heavy metals in fertilizers contaminating soil and entering water bodies through runoff, further degrading water quality. Improper waste disposal, particularly illegal dumping of industrial and municipal solid waste, also leads to soil pollution.

*3.5 Light pollution*

Light pollution refers to the negative impact of artificial light on the natural environment caused by human activities. Sources of light pollution include urban lighting, billboards, traffic lights, and building illumination. Light pollution not only hinders astronomical observations but also negatively affects ecosystems. For ecosystems, light pollution disrupts the natural behaviors and biological rhythms of flora and fauna. For example, nocturnal animals may experience disturbances in foraging, reproduction, and migration. Plant growth and flowering times may also be affected by light pollution.

*3.6 Noise pollution*

Noise pollution refers to the negative impact of excessive noise from human activities on the natural environment. Major sources include transportation, industrial activities, construction, and urban life. Noise pollution disrupts animal communication, foraging, and reproductive behaviors. For instance, birds may alter their singing patterns, affecting territory establishment and mate attraction. Underwater noise pollution in oceans, particularly from ships and industrial activities, interferes with the navigation and communication of marine mammals, impacting their foraging and reproduction.

*4. Invasive species*

Invasive species refer to species introduced to non-native environments through human activities, posing threats to local ecosystems and species. The introduction and

spread of invasive species are significant drivers of biodiversity loss. The spread of invasive species is primarily driven by expanding trade networks, increased human mobility, ongoing habitat degradation, and climate change. The detection and management costs of invasive species are exceptionally high, especially once they have established and spread.

*5. Climate change*

Climate change refers to long-term changes in the climate system caused by anthropogenic greenhouse gas emissions. Climate change has widespread impacts on nature and human, including rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events. Currently, climate change is one of the drivers of natural change, with strong direct global effects and the ability to influence other drivers.

*5.1 Sea level rise*

Global sea level rise is caused by thermal expansion of seawater and glacier melting. Since 1901, global sea levels have risen by 0.19 meters, with recent rates exceeding 3 millimeters per year. The current rate of sea level rise is faster than that experienced over the past two millennia and is likely to continue or accelerate. Sea level rise poses significant threats to low-lying coastal areas, causing flooding and land loss.

*5.2 Ocean acidification*

Ocean acidification is the decline in seawater pH due to increased anthropogenic carbon dioxide emissions. Acidification alters the biochemistry of marine ecosystems, posing significant threats to calcifying organisms such as corals and shellfish. Since the Industrial Revolution, ocean pH has dropped by over 30%. Acidification is most critical in shallow waters supersaturated with calcium carbonate, where the highest concentrations of anthropogenic $CO_2$ are found in surface layers. Ocean acidification negatively impacts marine life and functions, feeding back into climate change and potentially causing coral bleaching and structural changes in marine ecosystems.

### *A.2 Training Set Construction and Model Performance Evaluation*

To determine whether a subsidy is related to biodiversity, we manually labeled 35,000 samples. We randomly split these samples into a training set (80%) and a test set (20%). Each sample was evaluated for its relevance to the five biodiversity domains: land and sea use, organism exploitation, pollution, climate change, and species invasion. If a sample was related to any of these domains, it was labeled as 1; otherwise, it was labeled as 0.

For model training, we employed the BERT-base-chinese. This model enhances its performance in Chinese contextual tasks. We use the training set to fine-tune the model for our classification task.

After fine-tuning the model, we evaluated its predictive performance on each subdomain using the test set. The results are presented as following Table IA1.

Table IA1: Classification metrics of the BERT-based fine-tuned model

| Label | Precision | Recall | F1 Score |
|---|---|---|---|
| Nature-related subsidies | 92.92% | 93.77% | 93.34% |
| NRS - land and sea use driven | 90.89% | 86.75% | 88.61% |
| NRS - organism exploitation driven | 89.85% | 88.81% | 89.32% |
| NRS - pollution driven | 90.28% | 89.76% | 89.96% |
| NRS - species invasion driven | 93.34% | 97.18% | 95.18% |
| NRS - climate change driven | 89.49% | 90.00% | 89.74% |
| Average | 90.77% | 90.50% | 90.56% |

**Note:** This table presents classification metrics for the BERT-based fine-tuned model, detailing precision, recall, and F1 scores across various labels.

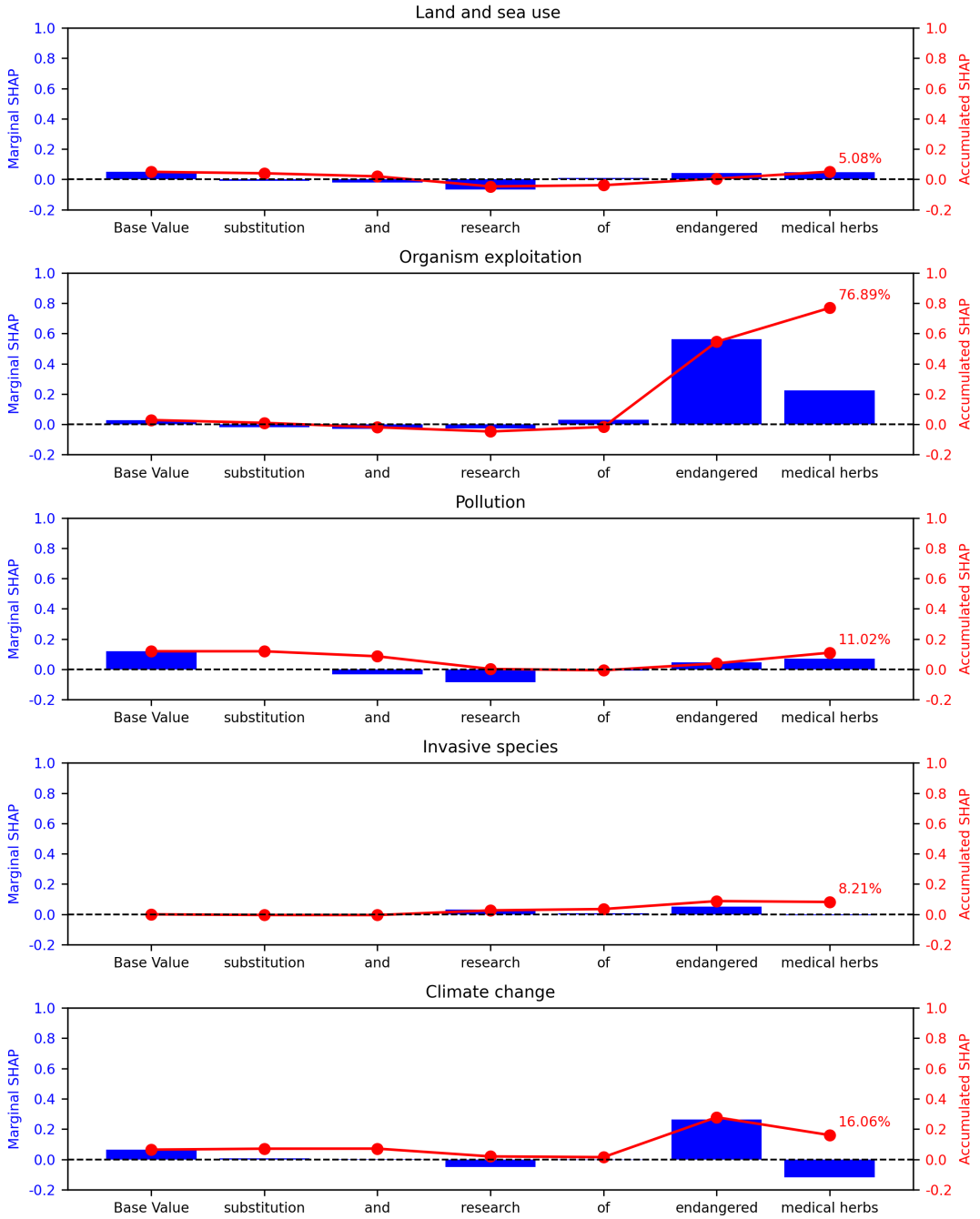
### *A.3 Additional Details on Dictionary-based Approaches for Alternative Risk Metrics*

Employing the methods of Giglio *et al.* (2025); Sautner *et al.* (2023); Li *et al.* (2024), we constructed alternative risk metrics from the text of the Management Discussion & Analysis (MD&A) within annual reports, as well as from annual ESG report texts. The metrics are calculated as followed:

1. *Biodiversity risk* (Giglio *et al.*, 2025) =
$$\begin{cases} 1 & \text{if the report contains at least two biodiversity risk sentences} \\ 0 & \text{otherwise} \end{cases}$$
2. *Biodiversity regulation risk* (Giglio *et al.*, 2025) =
$$\begin{cases} 1 & \text{if the report contains at least two biodiversity-risk sentences, and at least one of them is a biodiversity-regulation-risk sentence} \\ 0 & \text{otherwise} \end{cases}$$
3. *Climate change exposure(CCE)* (Sautner *et al.*, 2023) $= \dfrac{\text{Count of climate-related words}}{\text{Total word count}} \times 10{,}000$
4. $CCE^{opp}$ (Sautner *et al.*, 2023) $= \dfrac{\text{Count of climate opportunity-related words}}{\text{Total word count}} \times 10{,}000$
5. $CCE^{reg}$ (Sautner *et al.*, 2023) $= \dfrac{\text{Count of climate regulation-related words}}{\text{Total word count}} \times 10{,}000$
6. $CCE^{phy}$ (Sautner *et al.*, 2023) $= \dfrac{\text{Count of climate physical risk-related words}}{\text{Total word count}} \times 10{,}000$
7. *Climate risk* (Li *et al.*, 2024) $= \dfrac{\text{Count of climate risk-related words}}{\text{Text length}} \times 10{,}000$
8. *Acute climate risk* (Li *et al.*, 2024) $= \dfrac{\text{Count of acute climate risk-related words}}{\text{Text length}} \times 10{,}000$
9. *Chronic climate risk* (Li *et al.*, 2024) $= \dfrac{\text{Count of chronic climate risk-related words}}{\text{Text length}} \times 10{,}000$
10. *Transition climate risk* (Li *et al.*, 2024) $= \dfrac{\text{Count of transition climate risk-related words}}{\text{Text length}} \times 10{,}000$

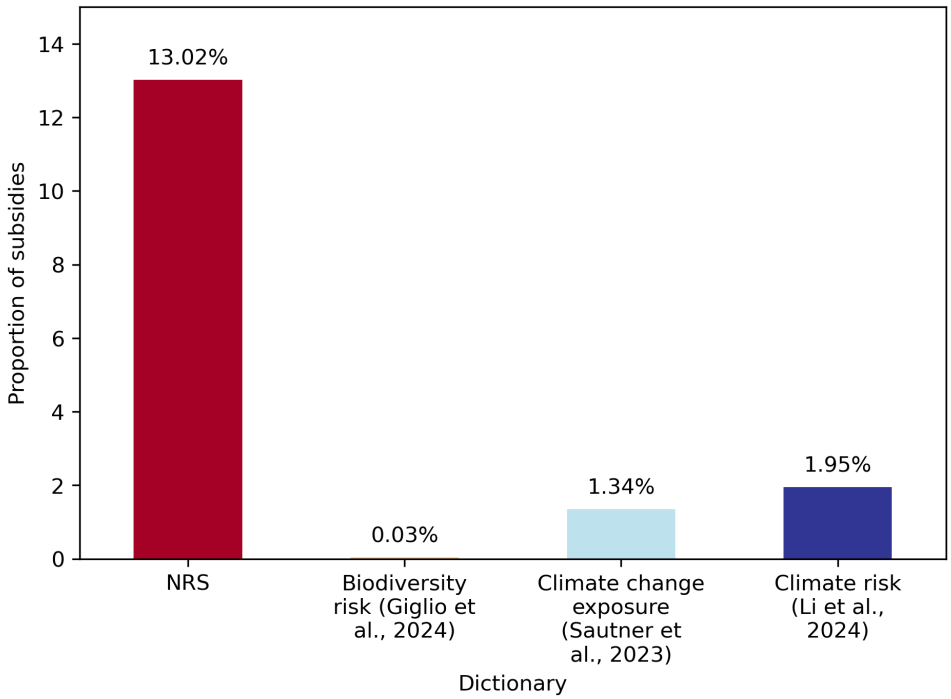
The definitions of biodiversity-related sentences, climate-related words, and climate risk-related words follow Giglio *et al.* (2025); Sautner *et al.* (2023); Li *et al.* (2024) with a translation.

FIGURE IA1: EXAMPLE FOR A SUBSIDY TEXT UNDER SHAP ANALYSIS




**Notes:** This figure shows a case study analyzing a subsidized text, visually demonstrating how each word contributes to the classification outcome through a SHAP method. The blue bar chart quantifies individual word contributions, while the red line graph tracks their cumulative impact—with the end point (e.g., 5.08%) indicating the predicted probability of the whole text being classified into the target category.

FIGURE IA2: PROPORTION OF SUBSIDIES IDENTIFIED BY OUR METHOD AND OTHER NATURE AND CLIMATE RISK DICTIONARIES




**Notes:** This figure illustrates the proportion of subsidies identified using our deep learning-based method (the red bar) compared to those identified through dictionary-based textual analysis approaches (the other three bars), including the biodiversity-risk dictionary by Giglio *et al.* (2025) (the second bar), the climate-change-exposure dictionary by Sautner *et al.* (2023) (the third bar), and the climate-risk dictionary by Li *et al.* (2024) (the fourth bar), over the period from 2016 to 2020.

Table IA2: Correlation between nature-related subsidies and other environmental / ecological indicators at firm level

| Indicator | Corr. w./ NRS |
|---|---|
| ***Biodiversity risk (text-based) metrics*** *(ref: Giglio* et al. *(2025))* | |
| Biodiversity risk - MD&A | 0.074 |
| Biodiversity risk - ESG report | 0.032 |
| Biodiversity regulation risk - MD&A | 0.025 |
| Biodiversity regulation risk - ESG report | 0.039 |
| ***Climate change exposure (text-based) metrics*** *(ref: Sautner* et al. *(2023))* | |
| Climate change exposure - MD&A | 0.206 |
| Climate change exposure - ESG report | 0.151 |
| Climate change exposure: opportunity - MD&A | 0.149 |
| Climate change exposure: opportunity - ESG report | 0.123 |
| Climate change exposure: regulation risk - MD&A | 0.165 |
| Climate change exposure: regulation risk - ESG report | 0.126 |
| Climate change exposure: physical risk - MD&A | 0.122 |
| Climate change exposure: physical risk - ESG report | 0.094 |
| ***Climate risk (text-based) metrics*** *(ref: Li* et al. *(2024))* | |
| Climate risk - MD&A | 0.132 |
| Climate risk - ESG report | 0.085 |
| Acute physical climate risk - MD&A | 0.036 |
| Acute physical climate risk - ESG report | 0.013 |
| Chronic physical climate risk - MD&A | 0.052 |
| Chronic physical climate risk - ESG report | 0.061 |
| Transition climate risk - MD&A | 0.123 |
| Transition climate risk - ESG report | 0.070 |
| ***ESG ratings*** | |
| ESG score - Sino | 0.008 |
| E score - Sino | 0.134 |
| ESG score - Wind | 0.032 |
| E score - Wind | 0.168 |
| ***Ecological/environmental impact (geography-based) metrics*** | |
| Human footprints - 5km radius | -0.099 |
| Ecosystem modification - 5km radius | -0.077 |
| ln (CO2) - 5km radius | -0.070 |
| CO2 intensity - 5km radius | -0.145 |
| PM2.5 - 5km radius | 0.102 |
| SO2 - 5km radius | -0.140 |

**Note:** This table presents correlations between nature-related subsidies and various environmental indicators, including biodiversity risk metrics from Giglio *et al.* (2025), climate change exposure metrics from Sautner *et al.* (2023), climate risk metrics from Li *et al.* (2024), ESG rating from Sino and Wind. The human footprints data is from WCS. The ecosystem modification data is from Theobald *et al.* (2025). The CO2 data is from Emissions Database for Global Atmospheric Research. The PM2.5 and SO2 data is from NASA (`https://disc.gsfc.nasa.gov/datasets/M2TMNXAER_5.12.4/summary?keywords=M2TMNXAER_5.12.4`).

Table IA3: Nature-related subsidies and returns around Kunming COP15: Other text-based environmental risk metrics

| Dep. Var | CAR | | | |
|---|---|---|---|---|
| Text Source | MD&A text | | ESG report | |
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | -0.084*** | -0.095*** | -0.084*** | -0.081*** |
| | (0.026) | (0.023) | (0.026) | (0.027) |
| Biodiversity risk | 0.810** | 1.083*** | -0.415* | -0.187 |
| | (0.353) | (0.336) | (0.216) | (0.455) |
| Biodiversity regulation risk | -2.821 | -3.818* | 4.210 | 4.636 |
| | (2.092) | (2.032) | (2.431) | (2.795) |
| Climate change exposure | | -0.032** | | 0.009 |
| | | (0.012) | | (0.016) |
| Climate change exposure - opportunity | | 0.579** | | -0.080 |
| | | (0.233) | | (0.267) |
| Climate change exposure - regulation risk | | -1.496*** | | -0.369 |
| | | (0.270) | | (0.528) |
| Climate change exposure - physical risk | | -0.160 | | -1.585 |
| | | (0.699) | | (1.614) |
| Climate risk | | 0.083 | | 0.202 |
| | | (0.071) | | (0.117) |
| Climate risk - acute physical risk | | -2.006* | | -3.189 |
| | | (1.069) | | (2.999) |
| Climate risk - chronic physical risk | | -0.215 | | -0.324 |
| | | (0.167) | | (0.191) |
| Climate risk - transition risk | | 0.201*** | | -0.113 |
| | | (0.066) | | (0.126) |
| Controls | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.088 | 0.133 | 0.088 | 0.088 |
| Obs | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the impacts of past nature-related subsidies (NRS) on the cumulative abnormal returns (CAR) around the Kunming COP15, introducing alternative environmental risk metrics. CAR is calculated based on the market model of Equation (1), over the five-day window starting from October 12, 2021. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Columns (1)-(2) augment the specification of Column (4) in Panel B of Table 3 by including biodiversity metrics according to Giglio *et al.* (2025), climate metrics according to Sautner *et al.* (2023) and Li *et al.* (2024), based on text analysis of corporate annual reports, respectively. Columns (3)-(4) replicate Columns (1) -(2) based on text analysis of corporate annual ESG reports (i.e., sustainability reports or social responsibility reports). All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table IA4: Nature-related subsidies and returns around Kunming COP15: ESG information

| | CAR | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Nature-related subsidies | -0.074** | -0.076*** | -0.076*** | -0.079*** | -0.075*** |
| | (0.026) | (0.023) | (0.025) | (0.027) | (0.025) |
| ESG score_Sino | 0.023** | 0.019 | | | 0.026* |
| | (0.008) | (0.014) | | | (0.014) |
| E score_Sino | | 0.005 | | | 0.006 |
| | | (0.012) | | | (0.012) |
| ESG score_Wind | | | -0.268*** | -0.176* | -0.302*** |
| | | | (0.068) | (0.088) | (0.094) |
| E score_Wind | | | | -0.019 | -0.006 |
| | | | | (0.020) | (0.032) |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.087 | 0.087 | 0.091 | 0.090 | 0.089 |
| Obs | 3213 | 3213 | 3564 | 3482 | 3213 |

**Notes:** This table reports the impacts of past nature-related subsidies (NRS) on the cumulative abnormal returns (CAR) around the Kunming COP15, introducing alternative environmental risk metrics. CAR is calculated based on the market model of Equation (1), over the five-day window starting from October 12, 2021. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Columns (1)-(6) augment the specification of Column (4) in Panel B of Table 3 by progressively including firm's ESG score and the environmental (E) sub-scores evaluated by Sino and Wind ESG ratings. All regressions include industry fixed effects, city fixed effects and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table IA5: Nature-related subsidies and returns around Kunming COP15: Local nature-related footprints

| | CAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Nature-related subsidies | -0.081*** | -0.082*** | -0.085*** | -0.085*** | -0.084*** | -0.085*** | -0.083*** |
| | (0.025) | (0.025) | (0.024) | (0.024) | (0.024) | (0.025) | (0.025) |
| Human footprint | 0.004 | | | | | | 0.029 |
| | (0.008) | | | | | | (0.021) |
| Ecosystem modification | | -0.005 | | | | | -0.027* |
| | | (0.005) | | | | | (0.014) |
| ln(CO2 emission) | | | 0.004 | | | | 0.027 |
| | | | (0.050) | | | | (0.101) |
| CO2 emission intensity | | | | -0.003 | | | -0.010 |
| | | | | (0.024) | | | (0.043) |
| PM2.5 | | | | | -0.211 | | -0.205 |
| | | | | | (0.137) | | (0.136) |
| SO2 | | | | | | 0.000 | 0.002 |
| | | | | | | (0.007) | (0.006) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE / City FE | Yes | Yes | Yes | Yes | Yes | Yes | No |
| Adjusted $R^2$ | 0.087 | 0.088 | 0.089 | 0.089 | 0.089 | 0.089 | 0.088 |
| Obs | 3563 | 3564 | 3014 | 3014 | 3014 | 3014 | 3013 |

**Notes:** This table reports the impacts of past nature-related subsidies (NRS) on the cumulative abnormal returns (CAR) around the Kunming COP15, introducing alternative environmental risk metrics. CAR is calculated based on the market model of Equation (1), over the five-day window starting from October 12, 2021. NRS is the average annual number of nature-related subsidies received from 2016 to 2020. Columns (1)-(7) augment the specification of Column (4) in Panel B of Table 3 by including average local environmental footprints within a 5km radius of the firm's main office address from 2016 to 2020. Columns (1)-(2) examine WCS human footprints and human modification of territorial ecosystems (Theobald *et al.*, 2025). Columns (3)-(4) examine carbon emissions (amount and intensity). Columns (5)-(6) examine pollution (PM2.5 and sulfur dioxide). Columns (7) conduct simultaneous tests. All regressions include industry fixed effects, city fixed effexts and all control variables defined in Table 3. Standard errors, reported in parentheses, are clustered at the city and industry level. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

## B Example of Fujian Jinsen

### *B.1 Overview of Corporate General Operations*

Fujian Jinsen Forestry Co Ltd, formerly Jiangle County State-Owned Forest Harvesting and Cultivation Farm, was restructured into a joint-stock company in 2007 and listed on the Shenzhen Stock Exchange in 2012 (002679). The company's primary revenue derives from the sale of forest products, mainly timber, with Chinese fir and Masson pine as the dominant species. Due to China's nationwide ban on commercial logging of natural forests, Fujian Jinsen's business model focuses on procuring tree species and cultivating forest resources for timber production.

Located in Jiangle County, Sanming City, Fujian Province, where forest coverage exceeds 80%, the company operates in a key southern Chinese forestry region. In the early 2010s, excessive logging, high proportions of artificial forests, predatory mining, and unsustainable land use led to ecosystem degradation, prompting multiple central government inspections, warnings, and accountability measures on the municipality. Since 2015, with increasing central emphasis on ecological protection, local authorities have intensified biodiversity conservation efforts.[29] In October 2021, during the Kunming COP15, the region applied for central government designation as a nature transition innovation base, further enhancing biodiversity protection measures.[30]

Based on the industrial and regional conditions, over the past decade, Fujian Jinsen's annual reports have consistently highlighted the significant impact of policy risks on its operations. Specifically, the firm engages in commercial forestry cultivation and timber sales, activities directly tied to local biodiversity conservation, while also possessing expertise in ecological restoration. Additionally, its operations involve extensive state-owned natural forests, necessitating frequent and close interactions with government entities. This creates a pronounced "nature-policy" duality, amplifying nature transition risks. As its annual report in 2021 stated:

> *"(Page 21) ..... potential localized or multifaceted policy adjustments unfavorable to commercial forestry could adversely affect the company's operations."*

Consistent with the Fujian Jinsen's risk disclosures, the firm received multiple subsidies for ecological initiatives before COP15, which enhanced the government's bargaining power in pushing the company to engage in additional nature transition task afterwards. Below, we provide descriptions of two such projects to illustrate such conservation mandates.

### *B.2 Conservation Tasks: Two Specific Projects*

*1. Conservation Project in Mountainous and Hilly Regions of Northwestern Fujian*

The Nature Conservation Project in the Mountainous and Hilly Regions of Northwestern Fujian Province, formally initiated in 2022, focuses on ecological restoration across diverse landscapes. In Jiangle County, Fujian Jinsen collaborated with local governments to employed:

[29] For example, see https://www.mee.gov.cn/gkml/hbb/bgg/201511/W020151126550511267548.pdf.

[30] The specific policy name for this nature transition innovation base is the "Green Waters and Lush Mountains are Gold and Silver Mountains" Practice and Innovation Base, aligning with President Xi Jinping's prominent doctrine on nature conservation.

(i) unmanned aerial vehicles (UAVs) for aerial planning, (ii) natural regeneration techniques, and (iii) the establishment of planted forests alongside the rehabilitation of degraded stands. Concurrently, the company engaged local communities in activities such as understory clearing and seedling planting, while providing training in silvicultural practices and Chinese herbal-crop cultivation to hundreds of villagers.

By early 2025, the project had successfully restored approximately 8,000 hectare of degraded ecosystems.[31] Fujian Jinsen, a key participant in the project, correspondingly undertook additional government-assigned ecological restoration tasks beyond its primary business operations. These responsibilities strained the company's resources, leading to fluctuations in its core business performance and constraining liquidity. In addition, although government subsidies offset a significant portion of the costs, challenges such as trade credit constraints continued to elevate operational risks for the company.

*2. Forestry Carbon-Sink Development and Carbon-Bill Trading Project*

Fujian Jinsen collaborated with local governments in Sanming City to promote the marketization of forest-based carbon sink ecological products. Key activities included issuing forest carbon bills and facilitating carbon sink transactions. To support this initiative, Fujian Jinsen established a wholly owned subsidiary, Fujian Jinsen Carbon Sink Technology Co., Ltd., responsible for: (i) conducting resource inventories, (ii) verifying ownership and consolidating land, and (iii) establishing a data management center and a carbon sink asset valuation center. Fragmented carbon sink resources were aggregated and integrated to enhance efficiency. The company also developed *the Manual for Forest Carbon Bill Development* to standardize procedures and enable carbon bills to support transactional, collateral, redemption, and offsetting functions, thereby fostering carbon financing services.

The project heavily relies on Fujian Jinsen's backstop guarantee mechanism, which involves packaging, pricing, purchasing, and, if necessary, repurchasing carbon sink assets. This approach exposes the company to market risks and financial pressures. Significant investments were required for carbon accounting systems, market-oriented operations, and cross-regional coordination, including costs for monitoring equipment, finance platform development, and administrative coordination, straining the company's resources. The backstop guarantee model increased uncertainties regarding commercial sustainability and effective risk management.

Additionally, Fujian Jinsen has collaborated with local courts and procuratorates to establish an "Eco-judicial Carbon Offset Initiative". Under this framework, the company is responsible for operating a carbon offset fund management committee and designing mechanisms such as expedited case mediation and a system for offenders to compensate for environmental damage through carbon credit purchases.[32] Such projects deliver significant social and environmental benefits, but their commercial return models remain unclear. The related investments are more likely to represent a form of corporate social responsibility rather than profit-driven initiatives.

[31] See at: https://mp.weixin.qq.com/s/8tAy0h1Zj5j_K5LC1W1MpA

[32] See at: https://www.sm.gov.cn/zw/zwxx/sjdt/202206/t20220605_1794238.htm

### *B.3 Stock Market Performance Around Kunming COP15*

In our baseline sample, Fujian Jinsen received 15 nature-related subsidies between 2016 and 2020—an average of 3 per year—far above the sample median of 0.4. Correspondingly, around the Kunming COP15 (specifically, in the five trading days after October 12, 2021), the company's cumulative abnormal return, calculated using the market model in Equation (1), reached –6.182%, well below the sample mean of –1.254%. Moreover, Fujian Jinshen did not publish any corporate social responsibility (CSR) reports from 2013 to 2021. However, since 2022, the company has annually released CSR reports, consistently highlighting its natural transition projects in collaboration with the government.[33]

These patterns are consistent with our hypothesis: Fujian Jinsen's operations are closely tied to biodiversity, leveraging significant expertise in nature conservation, while maintaining strong government ties. These factors result in substantial nature-related subsidies in earlier years. With the advent of Kunming COP15, markets anticipate heightened government emphasis on nature conservation, likely leading to increased assignments of local transition tasks to the company. This could strain its resource allocation, significantly disrupting its core business and introducing high operational uncertainty and pessimistic long-term profitability expectations, ultimately leading to a significant decline in its stock price.

[33] See more details at http://www.cninfo.com.cn/new/disclosure/stock?stockCode=002679&orgId=9900022738#latestAnnouncement

## C Robustness Tests Using Market-Adjusted Abnormal Returns

Table IC1: Nature-related subsidies and returns around Kunming COP15: Sub-categories - Robustness tests using market-adjusted abnormal returns

| | CAR_ma | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Nature-related subsidies - land and sea use driven | -1.198*** | | | | | -0.980*** |
| | (0.247) | | | | | (0.265) |
| Nature-related subsidies - organism exploitation driven | | -3.888*** | | | | -2.359*** |
| | | (1.283) | | | | (0.899) |
| Nature-related subsidies - pollution driven | | | -0.096*** | | | -0.138 |
| | | | (0.029) | | | (0.113) |
| Nature-related subsidies - climate change driven | | | | -0.021 | | 0.344** |
| | | | | (0.046) | | (0.156) |
| Nature-related subsidies - species invasion driven | | | | | -0.825** | -0.375 |
| | | | | | (0.371) | (0.268) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.087 | 0.087 | 0.081 | 0.080 | 0.081 | 0.092 |
| Obs | 3564 | 3564 | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the results of robustness tests by replacing CAR in Table 4 with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).

Table IC2: Nature-related subsidies and returns around Kunming COP15: Firm-level heterogeneity - Robustness tests using market-adjusted abnormal returns

| Dependent variable | CAR_ma | | | | | |
|---|---|---|---|---|---|---|
| Firm trait (Z) | Earnings volatility - ROA | Earnings volatility - ROE | Cash flow volatility | Earnings - ROA | Earnings - ROE | Cash flow |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Nature-related subsidies × Z | -4.097*** | -1.800** | -1.157*** | -0.691 | 0.252 | 0.737** |
| | (1.164) | (0.707) | (0.291) | (0.512) | (0.426) | (0.257) |
| Nature-related subsidies | -0.107*** | -0.102*** | -0.097*** | -0.100*** | -0.090*** | -0.081*** |
| | (0.025) | (0.024) | (0.026) | (0.026) | (0.026) | (0.026) |
| Firm Traits (Z) | Yes | Yes | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.082 | 0.082 | 0.081 | 0.083 | 0.084 | 0.081 |
| Obs | 3140 | 3140 | 3140 | 3564 | 3564 | 3564 |

**Notes:** This table reports the results of robustness tests by replacing CAR in Table 5 with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).

Table IC3: Nature-related subsidies and returns around Kunming COP15: City-level heterogeneity - Robustness tests using market-adjusted abnormal returns

| Dependent variable | CAR_ma | | | | | | |
|---|---|---|---|---|---|---|---|
| City trait (M) | Fiscal budget inflexibility | | | Protected area proportion | | Ex-ante biodiversity loss | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Nature-related subsidies × M | -2.723*** | -0.111*** | -0.172*** | -2.692** | -3.433*** | -2.943** | -0.774*** |
| | (0.762) | (0.012) | (0.042) | (1.198) | (1.093) | (1.379) | (0.229) |
| Nature-related subsidies | -0.085*** | -0.089*** | -0.084*** | -0.085*** | -0.082** | -0.069*** | -0.066*** |
| | (0.024) | (0.024) | (0.024) | (0.025) | (0.036) | (0.021) | (0.019) |
| City Traits (M) | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.082 | 0.084 | 0.082 | 0.082 | 0.083 | 0.082 | 0.082 |
| Obs | 3564 | 3564 | 3564 | 3564 | 2272 | 3344 | 3344 |

**Notes:** This table reports the results of robustness tests by replacing CAR in Table 7 with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).

Table IC4: Nature-related subsidies and returns around Kunming COP15: Other text-based environmental risk metrics - Robustness tests using market-adjusted abnormal returns

| Dep. Var | CAR_ma | | | |
|---|---|---|---|---|
| Text Source | MD&A text | | ESG report | |
| | (1) | (2) | (3) | (4) |
| Nature-related subsidies | -0.092*** | -0.116*** | -0.094*** | -0.086*** |
| | (0.027) | (0.021) | (0.027) | (0.027) |
| Biodiversity risk | 0.960* | 1.196** | -1.012*** | -0.464 |
| | (0.483) | (0.483) | (0.132) | (0.474) |
| Biodiversity regulation risk | -2.345 | -3.440 | 3.872 | 4.334 |
| | (2.168) | (2.065) | (2.237) | (2.613) |
| Climate change exposure | | -0.026** | | 0.012 |
| | | (0.011) | | (0.016) |
| Climate change exposure - opportunity | | 0.619** | | -0.196 |
| | | (0.266) | | (0.283) |
| Climate change exposure - regulation risk | | -1.521*** | | -0.646 |
| | | (0.287) | | (0.601) |
| Climate change exposure - physical risk | | -0.056 | | -2.184 |
| | | (0.710) | | (1.919) |
| Climate risk | | 0.104 | | 0.243* |
| | | (0.075) | | (0.123) |
| Climate risk - acute physical risk | | -2.294* | | -4.214 |
| | | (1.115) | | (3.613) |
| Climate risk - chronic physical risk | | -0.307* | | -0.552** |
| | | (0.172) | | (0.203) |
| Climate risk - transition risk | | 0.245*** | | -0.112 |
| | | (0.064) | | (0.116) |
| Controls | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.082 | 0.147 | 0.082 | 0.084 |
| Obs | 3564 | 3564 | 3564 | 3564 |

**Notes:** This table reports the results of robustness tests by replacing CAR in Table IA3 with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).

Table IC5: Nature-related subsidies and returns around Kunming COP15: ESG information - Robustness

| | CAR_ma | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Nature-related subsidies | -0.079*** | -0.086*** | -0.081*** | -0.084*** | -0.082*** |
| | (0.026) | (0.018) | (0.025) | (0.027) | (0.026) |
| ESG score_Sino | 0.013 | 0.001 | | | 0.011 |
| | (0.009) | (0.016) | | | (0.016) |
| E score_Sino | | 0.014 | | | 0.017 |
| | | (0.015) | | | (0.014) |
| ESG score_Wind | | | -0.401*** | -0.276** | -0.384** |
| | | | (0.084) | (0.099) | (0.134) |
| E score_Wind | | | | -0.055* | -0.050 |
| | | | | (0.030) | (0.053) |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.081 | 0.082 | 0.087 | 0.086 | 0.087 |
| Obs | 3213 | 3213 | 3564 | 3482 | 3213 |

**Notes:** This table reports the results of robustness tests by replacing CAR in Table IA4 with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).

Table IC6: Nature-related subsidies and returns around Kunming COP15: Local nature-related footprints - Robustness

| Dependent variable | CAR | | | | | CAR_ma | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Geographic radius | 1km | 2km | 5km | 10km | 20km | 1km | 2km | 5km | 10km | 20km |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Nature-related subsidies | -0.083*** | -0.082*** | -0.083*** | -0.083*** | -0.083*** | -0.085** | -0.086** | -0.086*** | -0.085*** | -0.084*** |
| | (0.026) | (0.026) | (0.025) | (0.025) | (0.025) | (0.031) | (0.030) | (0.028) | (0.027) | (0.027) |
| Human footprint | 0.022* | 0.032** | 0.029 | 0.034 | -0.006 | 0.022* | 0.030* | 0.028 | 0.029 | -0.016 |
| | (0.012) | (0.015) | (0.021) | (0.023) | (0.025) | (0.011) | (0.014) | (0.022) | (0.021) | (0.025) |
| Ecosystem modification | -0.022 | -0.029** | -0.027* | -0.025 | -0.000 | -0.026 | -0.031** | -0.031** | -0.025 | -0.001 |
| | (0.018) | (0.013) | (0.014) | (0.016) | (0.017) | (0.019) | (0.013) | (0.014) | (0.016) | (0.017) |
| ln(CO2 emission) | 0.037 | -0.027 | 0.027 | 0.024 | 0.148 | -0.117 | -0.114 | -0.061 | -0.063 | 0.107 |
| | (0.097) | (0.081) | (0.101) | (0.113) | (0.143) | (0.087) | (0.077) | (0.093) | (0.113) | (0.153) |
| CO2 emission intensity | 0.102 | 0.163 | -0.010 | -0.001 | 0.001 | 5.927*** | 1.317*** | 0.168*** | 0.039** | 0.015** |
| | (1.384) | (0.269) | (0.043) | (0.015) | (0.006) | (1.388) | (0.251) | (0.040) | (0.016) | (0.007) |
| PM2.5 | -0.216 | -0.206 | -0.205 | -0.195 | -0.202 | -0.268** | -0.263** | -0.259** | -0.247** | -0.262** |
| | (0.137) | (0.136) | (0.136) | (0.137) | (0.131) | (0.115) | (0.115) | (0.115) | (0.113) | (0.104) |
| SO2 | 0.001 | 0.002 | 0.002 | -0.000 | -0.007 | -0.001 | 0.001 | 0.001 | -0.002 | -0.009* |
| | (0.007) | (0.007) | (0.006) | (0.005) | (0.005) | (0.007) | (0.007) | (0.006) | (0.006) | (0.005) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| City FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.083 | 0.083 | 0.082 | 0.082 | 0.084 |
| Obs | 3013 | 3013 | 3013 | 3014 | 3014 | 3013 | 3013 | 3013 | 3014 | 3014 |

**Notes:** This table reports the results of robustness tests of the Column (9) in Table IC6, by replacing the geographic radius to 1km, 2km, 5km, 10km, 20km, and by replacing CAR with market-adjusted abnormal returns (i.e., the difference between individual stock return and the value-weighted market return).