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Firm-Level Nature Dependence

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Alexandre Garel
Audencia Business School
Arthur Romec
Toulouse Business School
Zacharias Sautner
University of Zurich, Swiss Finance Institute and ECGI
Alexander F. Wagner
University of Zurich, Swiss Finance Institute, CEPR and ECGI

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Abstract

We construct firm-level measures of dependence on ecosystem services (NatureDep scores) for 31,772 listed firms in 117 countries between 2010 and 2023, combining the ENCORE database with firm-level revenue information. The scores capture exposure to physical nature risks, with financial effects additionally depending on the deterioration of ecosystem services. NatureDep scores positively correlate with impact on biodiversity, are unrelated to nature-related actions disclosed in the CDP survey, are not reflected in firms' corporate disclosures, and predict BlackRock's biodiversity-related engagements. We employ the scores in two applications. First, the scores relate positively to measures of downside risk, with effects stemming mostly from high dependencies on water-related ecosystem services. Second, the scores predict nature-related incidents that arise when high nature dependence leads firms to damage nature, overuse resources, or trigger disputes with local communities. We conclude that investors started to pay attention to nature dependence, while corporate action and disclosure remain limited.

Keywords: Nature risk, biodiversity risk, nature dependence, physical risk, shareholder engagement

JEL Classifications: G12, G30, Q57

Alexandre Garel
Associate Professor
Audencia Business School
8 Road Joneliere
Nantes Cedex 3, 44312, France
e-mail: agarel@audencia.com

Arthur Romec
Associate Professor
Toulouse Business School
20, bd Lascrosses
Toulouse, 31068, France
e-mail: arthur.romec@gmail.com

Zacharias Sautner
Professor of Sustainable Finance
University of Zurich
Plattenstrasse 14
CH-8032 Zurich, Switzerland
e-mail: zacharias.sautner@bf.uzh.ch

Alexander F. Wagner*
Professor of Finance
University of Zurich
Plattenstr. 14
CH-8032 Zürich, Switzerland
phone: +41 446 343 963
e-mail: alexander.wagner@bf.uzh.ch

*Corresponding Author

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Alexandre Garel
Audencia Business School

Arthur Romec
Toulouse Business School

Zacharias Sautner
University of Zurich and Swiss Finance Institute

Alexander Wagner
University of Zurich and Swiss Finance Institute

Firm-level nature dependence

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Alexandre Garel[1,*], Arthur Romec[2], Zacharias Sautner[3,4], Alexander Wagner[3,4]

[1] Audencia Business School, Nantes, France
[2] Toulouse Business School, Toulouse, France
[3] University of Zurich, Zurich, Switzerland
[4] Swiss Finance Institute, Zurich, Switzerland

* Corresponding author: 8 Rte de la Jonelière, 44300 Nantes, France. Email: agarel@audencia.com

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1. Introduction

The loss of nature and biodiversity threatens the health and functioning of ecosystems that provide goods and services to economies.[1] In the World Economic Forum (2025)'s Global Risks Report, for example, biodiversity loss and ecosystem collapse rank as the second most severe long-term risks. Classic estimates place the annual value created by the world's biosphere in the tens of trillions of dollars (Costanza et al. 1997), and recent causal evidence shows sharp welfare losses when specific ecosystems collapse, such as the decline of vultures in India (Frank and Sudarshan 2024) or bat populations in the U.S. (Frank 2024). Given the high dependence of the economy on nature, the financial consequences of nature loss have become a concern for central bankers and regulators (NGFS 2023).

Despite the growing attention paid to the topic, our understanding of firms' dependencies on ecosystem services provided by nature, such as water supply, flood protection, or pollination, and the associated risks remains limited. A key reason lies in the challenge of quantifying these dependencies. This paper advances our understanding of nature dependence by creating, examining, and applying new firm-level measures of the extent to which a firm's business activities depend on ecosystem services.[2] Labelled NatureDep scores, the measures capture firm-level *exposure* to physical nature risks, with *risk realizations* additionally depending on the deterioration of ecosystem services. We measure a firm's aggregate nature dependence and its dependence on individual ecosystem services. Given the early stage of the nature finance literature, new metrics such as ours can help scholars and market participants better identify, price, and hedge nature dependencies and related risks (Karolyi and Tobin-de la Puente 2023; Starks 2024). Understanding the links between nature dependence, nature impact, and corporate exposure to climate risks is also critical for regulators seeking to address systemic risks from nature and climate sources.

The NatureDep scores are constructed by combining firm-level revenue data at the segment level with Dependency Materiality Ratings from the ENCORE database, which quantify

[1] "Nature" and "biodiversity" are distinct concepts but often used interchangeably. "Nature" includes living organisms (e.g., plants, or mammals) and non-living features (e.g., soil, rocks, or water). "Biodiversity" instead captures the variability among living organisms across the realms of land, ocean, freshwater, and atmosphere, though it is heavily influenced by the diversity of non-living features. Both enable ecosystem services that firms may depend on.

[2] Some work recently started to explore the risks associated with the *impact* of firms on biodiversity (e.g., Garel et al. 2024). These risks result from changes in regulation, technology, investor sentiment, or consumer preferences, as well as a misalignment of firms with actions aimed at protecting, restoring, or reducing negative impacts on nature.

the reliance of economic activities on 25 ecosystem services across three categories: (i) provisioning services (e.g., biomass provisioning, water supply); (ii) maintenance and regulation services (e.g., soil quality or pollination); and (iii) cultural services. For each ecosystem service, the dependence of an economic activity is determined by the extent to which its functionality would be lost if the ecosystem were disrupted and by the financial cost of adapting to such disruptions. We exclude cultural services because they are neither direct inputs nor enablers of production.

We create two aggregate NatureDep scores for a sample of 31,772 firms from 117 countries between 2010 and 2023. The first score, $NatureDep^{Overall}$, is the revenue-weighted average dependence of a firm's economic activities across economically relevant ecosystem services—those where disruptions would lead to functionality loss and/or financial adaptation costs. The second score, $NatureDep^{High}$, captures the possibility that nature risks arise from strong dependencies on a limited number of critical ecosystem services. Instead of averaging dependencies, this score counts the number of *high* dependencies across ecosystem services. Like for the first score, we revenue-weight the dependence on individual ecosystems and only then aggregate by counting high dependencies.[3] This score is designed not to average high and low dependencies, which enables it to capture tail risks stemming from high dependencies.

Our new scores show that firms in Pharmaceutical, Biotechnology & Life Sciences; Food, Beverage & Tobacco; and Household & Personal Products are the most nature-dependent. This reflects these sectors' high dependencies on a few key ecosystem services, such as water purification and supply for Food, Beverage & Tobacco or genetic material for Pharmaceutical, Biotechnology & Life Sciences. Despite a sizeable industry component, about half of the variation in both scores plays out at the firm level.

The NatureDep scores are positively associated with the corporate biodiversity footprint (CBF), a metric of firms' impact on mean species abundance (MSA) introduced into the finance literature by Garel et al. (2024). Hence, firms with a larger impact on nature also tend to have a greater dependence on it, implying a form of "double materiality" of nature loss. This positive

[3] Thus, if the revenues of an activity are 1 percent of total revenues and only this activity is highly dependent on an ecosystem service such as water purification, while all remaining activities are not, then $NatureDep^{High}$ is close to zero. Revenue weighting ensures that the firm's dependence on water purification will not be counted much in the measure summing the number of high ecosystem dependencies.

connection is well illustrated for firms in Food, Beverage & Tobacco, which have high average NatureDep scores—mainly because of high water dependence—and some of the largest CBFs due to significant land use in the supply chains. Despite the high correlation, we observe some divergences. For example, Pharmaceutical, Biotechnology & Life Sciences has a strong nature dependence, but is not among the top sectors with respect to its impact on nature.

$NatureDep^{Overall}$ has a correlation of about 50 percent with two ENCORE-based dependence metrics recently introduced by Iceberg Data Lab (IDL) and S&P, while the correlation of $NatureDep^{High}$ is lower at about 40 percent. A difference compared to these two metrics is that our scores are based on the most recent version of the ENCORE database, released in June 2024, whereas IDL and S&P build their current metrics on the 2018-2023 version. Major enhancements in the updated database, including coverage of value chains, may help explain the moderate correlations. Further, our scores provide a time series rather than only point-in-time data—as is the case for the S&P metric—and broader international coverage compared to IDL.

The NatureDep scores relate only weakly to nature-related actions disclosed in the CDP (formerly Carbon Disclosure Project) survey, such as the existence of board-level oversight for biodiversity-related matters or whether firms assess their biodiversity impacts and dependencies. The low correlations are not surprising given that most firms only recently began addressing nature risks. They also reflect that none of the CDP questions specifically focus on nature *dependence* or attempts to *quantify* such dependence. Firms with higher NatureDep scores do not discuss nature topics more extensively in their earnings calls: correlations between our scores and measures of biodiversity-related word counts in these calls are below 5 percent (biodiversity terms are rarely mentioned in earnings calls). However, the correlations have gradually strengthened over time and growing investor attention to nature topics may accelerate this trend (Gjerde et al. 2025).

NatureDep scores predict the likelihood of being targeted by BlackRock's biodiversity engagements. According to the asset manager, such engagements are motivated by concerns over nature-related risks (BlackRock 2024a). A one standard-deviation increase in $NatureDep^{Overall}$ raises the probability of being engaged by BlackRock by 0.45 percentage points (pp), or 56 percent relative to the unconditional probability. The finding that NatureDep scores predict BlackRock's biodiversity engagements serves as an external validation of the measures and, at the same time,

indicates that at least some large investors have begun to treat nature dependence as financially material.

We employ the NatureDep scores in two financial market applications. In our first application, we establish a link between NatureDep scores and stock market outcomes. Because nature-related risks are more likely to manifest through rare, extreme losses than through persistent return differences, we focus on downside risk in addition to average returns. While both NatureDep scores are unrelated to average stock returns, $NatureDep^{High}$—the score that emphasizes strong reliance on a few critical ecosystem services—positively correlates with downside risk measures (value at risk and lower partial moment); this risk effect is driven by firms' high dependencies on water-related ecosystem services. These results suggest that nature-related disruptions or regulatory shocks are already affecting firms with high dependencies.[4] The presence of downside risk effects implies that firms' exposures to nature risks are difficult to substitute if disrupted, consistent with the ecosystem services literature (Dasgupta 2021) or the model of Giglio et al. (2025a).

In our second application, we show that NatureDep scores are related to real outcomes as reflected in nature-related incidents. Though sudden collapses of ecosystem services are rare, we exploit that in some cases, high nature dependencies create negative impacts on nature. The reason is that intensive use of ecosystem services can heighten the likelihood of environmental damage or overuse of natural resources and may also trigger disputes with local communities. This implies that the likelihood of causing harm increases with greater nature dependence, which in turn raises the risk of litigation, remediation costs, reputational damage, or operational disruption. Using data from RepRisk, we show that nature dependence predicts the occurrence of incidents originating from impacts on ecosystems and biodiversity. Moreover, the downside risk effects of nature dependence are stronger in years with such incidents. These results provide novel evidence on the

[4] A caveat is that the evidence is indirect, as we cannot condition on specific risk realizations (e.g., collapses of certain ecosystem services or new regulations). Holding a firm's nature dependence fixed, returns should decline most strongly when risks realize. Testing this prediction is challenging due to limited local data on ecosystem conditions and locations of firms' (or their suppliers') physical assets. Because the same ecosystem may be in different conditions across locations, one would ideally connect asset location data with data on the status of ecosystems or regulations. Data would also need to indicate what business activities are conducted at a given location. These data are not yet available at scale, though we expect this to change. Using U.S. data, Akbari et al. (2025) move in this direction, by connecting establishment-level data to nature-protected areas (these data are not available internationally and by state of ecosystem service).

interconnectedness of nature dependence and impacts, illustrating how the associated physical and transition risks translate nature dependence into downside financial outcomes.[5]

We contribute to the biodiversity and nature finance literature by offering novel measures of firm-level nature dependence and illustrating how they can be applied. Though we provide a first step towards understanding nature dependence, we expect future research to improve upon our measures. As already indicated, our measures capture exposure to nature risks, rather than nature risk realizations, which also depend on the state and regulation of the ecosystems providing the services that firms depend on. Our measures also do not account for the likelihood that an ecosystem may be disrupted. Incorporating this information requires data on where firms' activities take place. The measures also do not reflect the ability of firms to adapt to any disruptions.

Our paper relates to studies examining whether investors price biodiversity transition risks that reflect the *impact* of firms on nature. Giglio et al. (2025c) construct measures of U.S. firms' biodiversity risks based on disclosures in 10-Ks to show that returns of portfolios sorted on the industry-average of those measures covary positively with biodiversity news. Garel et al. (2024) find that a biodiversity-footprint premium started to emerge after the Kunming Declaration in 2021. Coqueret, Giroux, and Zerbib (2025) show that in sectors more exposed to the double materiality of biodiversity risks, firms with a greater biodiversity footprint earn higher expected returns. Arlt et al. (2025) provide stress tests of the financial sector's resilience to transition risk. Bassen et al. (2024) study links between downside risk and biodiversity management.

Still, little finance research exists on nature *dependence*. Hoepner et al. (2023) examine infrastructure firms' dependence on biodiversity. Using our newly developed (as well as S&P's) measure, Canipek et al. (2025) find that firms with greater nature dependence have higher loan spreads. Lewis and Rizzi (2025) study how municipal bond pricing accounts for dependence on a specific ecosystem service (flood mitigation by wetlands). Colesanti Senni, Goel, and Leippold (2025) study how stock returns react to biodiversity news, and how the effect varies with nature

[5] This link can be illustrated with a case study from Tesla, which heavily depends on water for car battery production. Tesla faced months of delay for the construction of a gigafactory in Germany because NGOs filed legal procedures due to concerns over the firms' impact on declining groundwater. Within hours upon the legal filing, Tesla's shares sharply declined by over 3 percent (BloombergNEF 2023). The consequences of nature dependence itself can be illustrated for firms engaged in hydroelectric generation, a business activity with a high dependence on water flow regulation. Several firms with such power plants recently experienced operational and financial disruptions because droughts reduce the water flows needed to generate electricity.

dependence measured using data from S&P. Some studies use sector-level ENCORE data. For example, de Carvalho et al. (2023) find that firms in sectors with a greater ecosystem service dependence are more likely to disclose initiatives to protect biodiversity. The survey evidence in Gjerde et al. (2025) indicates that for around half of their sample of firms from around the world, nature dependence constitutes a financially material risk. Flammer, Giroux, and Heal (2025) study biodiversity conservation and restoration, for which assessing nature dependence helps when assessing the economic value of corporate strategies aimed at mitigating dependencies. Chen et al. (2025) study bond yield effects of biodiversity preservation rules in China, and Bahrami et al. (2025) examine the implications of biodiversity protection for the value of vacant land in the U.S.

2. Construction of NatureDep scores

In this section, we describe how we construct the NatureDep scores. Section 2.1 details the approach used to combine information on a business activity's reliance on ecosystems with segment-level revenue data. In Section 2.2, we provide summary statistics of the scores and in Section 2.3, we describe dependencies on individual ecosystem services. In Section 2.4, we illustrate the scores using case studies. Section 2.5 compares the scores with measures from data vendors.

2.1 Step-by-Step Construction of NatureDep scores

2.1.1 Ecosystem services and business activities

The NatureDep scores reflect a firm's dependence on ecosystem services. According to SEEA, the System of Environmental Economic Accounting, ecosystem services are the contribution of ecosystems to benefits used in economic and other human activities (acronyms are summarized in Appendix Table A2). Ecosystem services are grouped into: (i) provisioning services (products obtained from ecosystems); (ii) regulation and maintenance services (benefits from regulation of ecosystem processes); and (iii) cultural services. We exclude cultural services because they are neither direct inputs nor enablers of production.[6] To identify dependencies, we use the most recent version of the ENCORE database, released in June 2024.[7] This version contains dependencies for

[6] Cultural ecosystem services, such as visual amenity services, are non-relevant ecosystem services for most sample firms. We use NatureDep scores for cultural ecosystem services for placebo tests.

[7] ENCORE stands for Exploring Natural Capital Opportunities, Risks, and Exposure. The ENCORE database was designed by the UNEP Finance Initiative, UN Environment Programme World Conservation Monitoring Center, and Global Canopy. It is constructed to be decision-relevant by helping financial institutions and firms understand how

271 economic activities (based on International Standard Industrial Classifications, ISIC) across 25 ecosystem services. Listed in Supplementary Appendix A, these ecosystem services correspond to Level 1 of the SEEA–Ecosystem Accounting (SEEA-EA). The measures capture nature dependence as assessed at a global level, and they therefore neither account for the actual deterioration of an ecosystem service nor the likelihood of such deterioration. Incorporating such deteriorations would require data on the locations where business activities take place and data on the local conditions of ecosystems, both of which are not yet available at scale. One way to interpret our measures is that they capture *exposure* to nature risks, with nature risk *realizations* additionally depending on ecosystem deteriorations. A further caveat is that the ENCORE data accounts for possible adaptation efforts by firms and that they have an annual frequency that is imperfect for characterising the dynamics of living organisms.

We construct our scores for 31,772 listed firms from 117 countries from 2010 to 2023. Our sample construction starts from the universe of firms in Compustat North America and Compustat Global, from which we identify firms with a match in Refinitiv.[8] We retrieve information about firms' economic activities from Refinitiv, which provides revenue data by business segment (we drop segments with missing, zero, or negative revenues). Each segment corresponds to one or more NAICS codes, which we map to the 271 ISICs in the ENCORE data using the crosswalk file from the U.S. Census Bureau. If one NAICS code maps into several ISICs, we average the ENCORE data at the NAICS level across ISICs. The average firm has close to four NAICS codes and more than two business segments.

2.1.2 ENCORE dependency materiality ratings

The starting point for the score construction is the *Dependency Materiality Ratings* provided by ENCORE. These ratings draw, wherever possible, on quantitative environmental data and reflect the magnitude of the reliance of an economic activity on a given ecosystem service and is based on the following scale (ENCORE 2024a): *Very High, High, Medium, Low,* and *Very Low*. For each

their business activities depend on ecosystem services. The database is used, for example, by Finance for Biodiversity, an initiative of investors with about $25 trillion assets under management. ENCORE is referenced by the Taskforce on Nature-related Financial Disclosures (TNFD) and the Science Based Targets Network (SBTN).

[8] We consider common shares in Compustat only (i.e., we require that the identifier *tpci* is zero). We match the ISIN or CUSIP of a firm to its corresponding primary RIC. We obtain unique GVKEY-RIC pairs by prioritizing ISIN over CUSIP and prioritizing the first IID.

activity (ISIC group or ISIC class) and ecosystem service, ENCORE determines the rating using sector research and expert interviews that are guided by two questions:

Question 1: How significant is the loss of functionality in the economic activity if the ecosystem service is disrupted?

- **Limited**: The economic activity can continue as is or with minor modifications. (*Score = 1*)
- **Moderate**: The economic activity can continue only with important modifications (e.g., slower production or use of substitutes). (*Score = 2*)
- **Severe**: Disruption in the service provision prevents the economic activity. (*Score = 3*)

Question 2: What is the financial cost to the economic activity of adapting to the disruption of the ecosystem service?

- **Low**: Adaptation to the disruption of the ecosystem services will represent a minor cost to an average company engaging in the economic activity, which will not significantly affect the financial position of the company in the long run. (*Score = 1*)
- **Moderate**: Adaptation to the disruption in the ecosystem service will represent a relatively significant cost to an average company engaging in the economic activity, but the cost would not affect the financial viability of the economic activity for the company. (*Score = 2*)
- **Severe**: Adaptation to the disruption in the ecosystem service will have a significant effect on the financial viability of the economic activity for an average company engaging in the economic activity. (*Score = 3*)

As indicated in the box above, ENCORE assigns scores of 1 to 3 to each question's response and then sums them to obtain a total score ranging from 2 to 6. This total score is then translated into grades: 2 *(Very Low*), 3 (*Low*), 4 (*Medium*), 5 (*High*), and 6 (*Very High*).[9] Having both questions to measure nature dependence is important, as firms might be able to respond to a severe disruption caused by the loss of functionality of an ecosystem service (Question 1) at low financial cost (Question 2). For example, if wild pollinators such as bees are lost due to pesticide use, this implies a total functional loss (Question 1). However, the adaptation cost might be low if pollinator alternatives (e.g., moving bees from other regions) can be used without costly investments (Question 2). To construct NatureDep scores, we use these grades to build a *Dependence score D* at

[9] As an example, most economic activities belonging to agricultural products (except beef and dairy) have a dependence to Pollination Services that is *High* ("Production process can take place with some disruption of the ecosystem service, but the high quantity of the ecosystem service required for the production process makes this a high risk") or *Very High* ("The production process is extremely vulnerable to disruption. The degree of protection offered by the ecosystem service is critical and irreplaceable for the production process").

the ecosystem service-economic activity level, adding the value of 0 if an ecosystem service is not relevant for an activity (then there is no *Dependency Materiality Rating*). Scores of 1 do not exist.

ENCORE's *Dependency Materiality Rating*	*NA*	*Very Low*	*Low*	*Medium*	*High*	*Very High*
Dependence score (D)	0	2	3	4	5	6

As ENCORE uses in its score construction (qualitative) assessments from interviews with different experts, it has a structured process to ensure high data quality (see ENCORE. 2024a). Specifically, it uses the Delphi consensus-building method, where each economic activity–ecosystem service combination is evaluated using structured interview questions. Two researchers from different partner organizations of ENCORE (e.g., the UNEP-World Conservation Monitoring Centre [UNEP-WCMC] or IUCN) then independently assign scores. Any score mismatches are resolved through discussion between the researchers that lead to a final rating, which then undergoes review by UNEP-WCMC and external review by industry experts.

2.1.3 From ENCORE to NatureDep scores

For each individual ecosystem service covered by ENCORE, we compute a firm-level dependence score by taking the revenue-weighted average of the dependence scores for the firm's different economic activities. In cases where one business segment has multiple NAICS codes with the same revenue imputed to all of them, we average information at the business segment level. Formally, $NatureDep^{j}_{i,t}$, the dependence of firm i in year t on ecosystem service j, is calculated as:

$$NatureDep^{j}{}_{i,t} = \frac{\sum_{k=1}^{Ni,t} D_{j,k} \times R_k}{\sum_{k=1}^{Ni,t} R_k}$$

where $N_{i,t}$ is the number of segments in which firm i operates in year t, R_k are the revenues generated by segment k, and $D_{j,k}$ is the *Dependence score* of segment k on ecosystem service j.

We then construct two firm-level measures of aggregate nature dependence. $NatureDep^{Overall}$, our first score, averages dependencies of ecosystem services for which $NatureDep^{j}_{i,t}$ is greater than or equal to 1 (i.e., we exclude non-relevant ecosystem services, in order to avoid that a high dependence on an ecosystem service is compensated by the absence of dependence on other ecosystem services.):

$$NatureDep^{Overall}{}_{i,t} = \frac{\sum_{j=1}^{J} NatureDep^{j}{}_{i,t} \times 1_{\{NatureDep^{j}{}_{i,t} \geq 1\}}}{J_{i,t}}$$

where $1_{\{NatureDep^{j}{}_{i,t} \geq 1\}}$ is a function indicating that $NatureDep^{j}{}_{i,t} \geq 1$. The denominator, $J_{i,t}$, counts the number of revenue-weighted ecosystem dependence scores greater than or equal to 1.

Supplementary Appendix B illustrates the calculation using a simple example and Supplementary Appendix C provides a detailed application for Danone, a food and beverage company.

Although we exclude non-relevant ecosystem services, an implicit assumption is that a high dependence on one ecosystem service is compensated by low dependencies on other ecosystem services (i.e., a firm with very high dependence on one ecosystem service and low dependence on another one has a similar score as a firm with a medium dependence on both ecosystem services). However, nature-related dependencies may have non-linear effects that could stem from few high dependencies rather than from low or moderate dependencies on a greater number of ecosystem services. To address this issue, we construct the alternative firm-level score $NatureDep^{High}$. This measure captures the number of ecosystem services for which the firm-level, revenue-weighted dependence score is equal to or above 4. It thereby considers only high dependencies and treats moderate/small dependencies as equal; this can be justified if nature risks arise from few high dependencies only. Formally:

$$NatureDep_{i,t}^{High} = \sum_{j=1}^{21} 1_{\{NatureDep^{j}{}_{i,t} \geq 4\}}$$

where $1_{\{NatureDep^{j}{}_{i,t} \geq 4\}}$ is a function indicating that the firm-level revenue-weighted dependence score for ecosystem service *j* is equal to or above 4. Supplementary Appendix B illustrates the calculation. Note that the 4-point threshold is applied after aggregating segment-level dependence scores using revenue weights, as the indicator function builds on $NatureDep^{j}{}_{i,t} = \frac{\sum_{k=1}^{Ni,t} D_{j,k} \times R_k}{\sum_{k=1}^{Ni,t} R_k}$. Hence, if the total revenues share of an activity is just 1 percent, but this activity is highly dependent on one ecosystem service, for example on water purification (score of $D_{j,k}$ =6), while all remaining

activities are non-dependent ($D_{j,k}$=0), then $NatureDep^{High}$ is close to zero—the water purification dependence will, therefore, not be counted much in the measure.

2.2. Descriptive statistics of NatureDep scores

Table 1 reports summary statistics for $NatureDep^{Overall}$ and $NatureDep^{High}$ and dependence scores by ecosystem service. The average and median values of $NatureDep^{Overall}$ are close to 2.8, indicating that a typical firm's nature dependence is low. However, the score exhibits large variation, with values ranging from 1.57 to 4.27. The figures for $NatureDep^{High}$ indicate that the average (median) firm has 1.93 (1) high dependencies, ranging from 0 to 13. The ecosystem services on which the average firm has the highest dependence are Water Flow Regulation ($NatureDep^{Water\ Flow\ Regulation}$=3.41), Storm Mitigation (3.39), Water Supply (3.30), Flood Control (3.28), and Soil & Sediment Retention (3.13). The correlation between $NatureDep^{Overall}$ and $NatureDep^{High}$ is 0.77.

In Table 2, we report average values of both scores by industry, next to scores of industry-level dependencies on individual ecosystem services. The industries with the greatest nature dependence are Pharmaceutical, Biotechnology & Life Sciences ($NatureDep^{Overall}$=3.24), Food, Beverage & Tobacco (3.24), and Household & Personal Products (3.00). Food, Beverage & Tobacco has the highest average number of high dependencies ($NatureDep^{High}$=3.98).[10] Supplementary Appendix Figure F.1 shows that sample averages of the two NatureDep scores do not vary much over the sample period (there is a small decline in the average value of $NatureDep^{High}$).

2.3. Dependence scores at the ecosystem-service level

To describe the extent to which firms depend on certain ecosystem services, Supplementary Appendix Figure F.2 shows the percentage of firms with high dependencies (scores of ≥4) per ecosystem service. For eleven ecosystem services, there is an absence or near absence (we round to the first decimal in the figure) of firm-years with high dependencies (e.g., for Biomass Provisioning, Soil Quality Regulation, Noise Attenuation or Pollination), and for four ecosystems services between 1 percent and 10 percent of firms-years exhibit high dependencies (e.g., for Solid

[10] The low levels of nature dependence for firms in the insurance and financial services sectors may reflect that the current version of ENCORE does not yet fully capture downstream dependencies in underwriting and lending/investing activities.

Waste Remediation, Air Filtration, Genetic Material). Larger portions of our sample have high dependencies on Soil & Sediment Retention (15.6 percent of firm-years), Water Supply (25.4 percent), Storm Mitigation (30.2 percent), Water Purification (31.2 percent), Flood Control (32.3 percent), and Water Flow Regulation (38.3 percent). These figures indicate that a driver of $NatureDep^{High}$ are ecosystem services related to water cycles or flood and storm protection.

To further understand the role of dependencies on individual ecosystem services, we conduct in Supplementary Appendix Table F.1 an exploratory factor analysis that allows us to uncover latent dimensions of a firm's overall nature dependence. The goal is to reduce the high-dimensional set of service-specific scores into a smaller number of economically interpretable latent factors that capture common patterns across firms. We estimate the factor model at the firm-year level using principal factor extraction on the correlation matrix of the services.[11] We retain four factors, which together explain approximately 87 percent of the common variance, and exhibit clear economic interpretations.[12] Factor 1 (Hydrological Dependence) captures mostly firms' reliance on water-related services, such as Water Flow Regulation, Water Supply, Water Purification, or Flood Control. Factor 2 (Terrestrial and Biodiversity Dependence) reflects reliance on land-based and biodiversity-supporting services, including Biomass Provisioning, Soil Quality Regulation, or Nursery Population & Habitat Maintenance. Pollination and genetic material provision also load strongly on this factor, although their dependence scores exhibit substantial firm-specific heterogeneity (high uniqueness). Factor 3 (Noise and Sensory Regulation) isolates services that regulate local atmospheric and acoustic conditions (e.g., Noise Attenuation). Finally, Factor 4 (Climate and Rainfall Regulation) reflects dependence on global and regional climate stabilization services.

[11] We display in Supplementary Appendix Figure F.3 correlations across ecosystem-service level dependence scores using a heatmap. It shows strong correlations across dependence scores of families of ecosystem services. For instance, for water-related regulation services, the dependence scores of the sample firms display high correlations (e.g., Water Purification, Flood Control, Water Supply, Storm Mitigation, Water Flow Regulation), as it is the case for biomass-generation services (e.g., Nursery & Habitat Maintenance, Soil Quality Regulation, Biomass Provisioning, Pollination).
[12] The number of factors is selected based on the eigenvalue >1 criterion, scree plot inspection, and interpretability. To facilitate interpretability, we apply an orthogonal varimax rotation, which redistributes variance across factors and simplifies the loadings such that each service tends to load strongly on one factor and weakly on others.

2.4 Case studies on NatureDep scores

Figure 1 illustrates the NatureDep metrics based on case studies from six firms with numbers for 2022: Accenture, Danone, Hainan Mining, International Paper, Microsoft, and Unilever. Panel A shows that Danone has the highest value of $NatureDep^{Overall}$ (3.6), followed by Hainan Mining (3.5), Unilever (3.2), and International Paper (3.1). Panel B shows that Danone has a non-zero dependence on 14 ecosystem services, and a high dependence on three water-related services: Water Purification (5.8), Water Flow Regulation (5.0), and Water Supply (5.0). Further, Danone has a dependence score of 4 for three other ecosystem services, namely Flood Control, Storm Mitigation, and Solid Waste Remediation, leading to a value of $NatureDep^{High}$ that equals 6 (Panel C).

Danone's business model offers insights into the economics of these numbers. The French firm operates three segments: "Essential Dairy & Plant-based" (e.g., dairy products and plant-based food), "Specialized Nutrition" (e.g., breast milk substitutes), and "Waters" (water bottling, with brands such as Evian or Volvic). As shown in figure 1, the top-3 of Danone's six high dependencies are water-related. This is not only due to Danone's involvement in bottling drinking water but also because other activities rely on water. For example, production of milk products is highly dependent on the supply of clean water. As mentioned above, Danone's highest overall dependence is on Water Purification Services, which are ecosystem contributions to the restoration and maintenance of the chemical condition of water. These are essential ecosystem services to a producer of bottled water. Ecosystem services related to Water Supply and Water Flow Regulation are also highly relevant for the firm. According to Danone (2024), 40 percent of its water plants are in watersheds facing high water scarcity risk. Notably, Danone conducts water risk assessments to evaluate both its impact on water resources and the effects of water scarcity on its business. Hence, the firm evaluates transition (impact) and physical (dependence) risks associated with nature.

2.5 NatureDep sores and alternative measures from IDL and S&P

We compare and correlate the NatureDep scores with two alternative measures of firm-level nature dependence: IDL's Biodiversity Dependence score (*IDL BD score*) and S&P's Dependency

Composite score (*S&P DC score*) (see Supplementary Appendix D for details). We use the IDL score described in IDL (2023) and the S&P score provided at the end of 2024. IDL's score also starts from ENCORE's *Dependency Materiality Ratings*. IDL considers 21 ecosystem services covered by the 2018-2023 ENCORE database and four cultural services.[13] On top of having a different set of ecosystem services, our NatureDep scores differ from IDL's score because they apply materiality ratings of the previous ENCORE database, which considers only *direct* dependencies. By contrast, the updated version accounts for *indirect* dependencies due to downstream or upstream value chain links. At the firm level, for each ecosystem service, IDL computes its score by taking the weighted average of the dependence scores for the different sectors in which the firm operates (IDL uses slightly different scales and dependence scores before averaging). This step creates another divergence with our metric as the new ENCORE database offers more granularity for economic sectors. IDL's scores are available for 4,413 firms from 2019 to 2022, much fewer firms compared to our scores.[14] IDL currently does not offer measures focusing on high ecosystem dependencies (as we show below, high dependencies matter for the financial risk effects of nature dependence).

S&P's score captures the risks associated with nature dependencies by combining a reliance and a resilience score. The reliance score is primarily based on the *Dependency Materiality Rating* in the 2018-2023 ENCORE database. The resilience score intends to capture the capacity of ecosystems to keep providing the necessary ecosystem services. A strength of their measure is that it incorporates, at least to some extent, the state of ecosystems and the likelihood of disruptions. S&P's score does not have a time series; it is available for 18,823 firms, also much fewer compared to the NatureDep scores, in 2020 or 2021 (mostly for 2021).[15] Supplementary Appendix E summarizes differences between our score and the two alternatives.

[13] The correlation with IDL is mechanically limited because IDL also considers cultural services. The previous ENCORE version did not include cultural services and IDL carried out own assessments for them.

[14] Another difference lies in the way of aggregating the dependence scores. IDL computes an arithmetic average of ecosystem dependencies, whereas our measures seek to limit the possibility that high dependencies are compensated with very low dependencies. The sample period that we use reflects the data available at the time of the analysis.

[15] For a small portion of firms, the S&P metric is calculated using asset locations (e.g., for less than 20 percent of our sample firms). For all other firms, *sector-level* data of a firm's business activities are used. For firms where asset-level data are not used, the reliance score is exclusively based on ENCORE materiality ratings. The ecosystem state is incorporated through the resilience score. S&P assesses for firms without asset-level data in which country a "sector likely operates" (S&P Global 2024) and then applies the Ecosystem Integrity Index (Hill et al. 2022) to assess the ecosystem state (S&P applies average values across a country's area). This approach faces the challenge that ecosystems

As mentioned, both alternative metrics rely on the old ENCORE database, which does not incorporate the following improvements in the recent version (see ENCORE 2024a, 2024b):

- *Greater granularity for economic sectors:* The previous database covered 92 production processes within 152 sub-industries (based on Global Industry Classification Standard) compared to 271 economic activities based on ISIC for the updated database.
- *Updated and expanded list of ecosystem services and dependencies:* The improved version includes the 25 ecosystem services of Level 1 of the SEEA-EA. The information on dependencies has also been updated drawing on the latest scientific research and grey literature.
- *Comparability across sectors:* The materiality ratings of the new database are designed to be comparable across sectors and economic activities, which was not the case in the previous iteration. Moreover, the previous ENCORE version offered materiality ratings that were based on a qualitative assessment only (updated materiality ratings use quantitative data where available).
- *Coverage of value chains:* The old materiality ratings were based on direct potential dependencies whereas the updated version includes downstream and upstream value chain links.[16]

In Table 3, we display correlations between the NatureDep scores and the metrics from IDL and S&P.[17] $NatureDep^{Overall}$ has positive correlations with both alternative metrics (0.57 for IDL and 0.47 for S&P); for $NatureDep^{High}$ the correlations are lower. Yet, in both cases, correlations are far from perfect, in part because—unlike IDL and S&P—the NatureDep scores rely on the new version of the ENCORE database. As explained, this reflects that the updated data offer greater granularity for economic sectors, an updated and expanded list of ecosystem services and dependencies, and coverage of value chains. Overall, the comparison indicates that our measures contain unique information not spanned by other metrics. Supplementary Appendix G provides a comparison with biodiversity and physical climate risk metrics.

vary within countries and the country locations of a firm are only inferred (the S&P methodology document does not provide details on how this is done). If data on resilience scores are unavailable, S&P calculates nature dependence only based on the reliance score.

16 Though the revised ENCORE version includes value chain links, the low dependence scores for banks suggests that the coverage of value chains is imperfect.

17 Supplementary Appendix Table F.2 reports summary statistics for *IDL BD score* and *S&P DC score* (and ecosystem subscores).

3. Anatomy of NatureDep scores

In this section, we provide a more detailed anatomy of the NatureDep scores. In Section 3.1, we conduct an analysis of variance and gauge the role of measurement error in our NatureDep scores. Section 3.2 illustrates the importance of different firm characteristics for explaining variation in NatureDep scores. We analyse in Sections 3.3 and 3.4 whether corporate nature-related actions and disclosures differ depending on firms' NatureDep scores. Finally, we provide in Section 3.5 a validation of the NatureDep scores using data on BlackRock's biodiversity-related engagements.

3.1 Variance decomposition and measurement error

Using a variance decomposition, Table 4, Panel A, shows that there is a sizeable industry component in $NatureDep^{Overall}$, with industry fixed effects explaining about 45 percent of the variation. This result is intuitive given that ENCORE's *Dependency Materiality Ratings* are measured at the sector level. Compared to industry factors, country- and year-level dimensions play a modest role. Importantly, close to half of the variation in the score plays out at the firm level. The industry component in $NatureDep^{High}$ is smaller than for $NatureDep^{Overall}$, possibly because the measure focuses on extreme values rather than on the more fine-granular industry-level variation of the ENCORE ratings. Hence, the second measure better captures variation across firms.

We interpret the large share of firm-level variance as capturing economically relevant heterogeneity, but an alternative view is that it reflects measurement error (ME). We evaluate this alternative by quantifying ME in the NatureDep scores following an approach by Hassan et al. (2019) and Sautner et al. (2023), which assumes that a firm's "true" nature dependence follows a first-order autoregressive process. The approach then assumes that our scores measure this true exposure with classical ME. If an instrumental variable (IV) for the scores were available, one could back out the share of variation consisting of ME by comparing OLS and IV coefficients.[18] We implement this approach using one- and two-year lagged values of IDL's dependence score as IVs (S&P's score is only available for one firm-year). Supplementary Appendix Table F.3 shows

[18] The idea is that the IV measures true nature dependence with error. Under the i.i.d. assumption, ME in the IV is uncorrelated with that in the NatureDep scores and thus can be used to purge ME in our scores. This procedure does not assume that the IV has lower ME; all that is required is that the IV correlates with true nature dependence.

that less than 5 percent of the variation in our scores is quantified as ME. While interpreting these results with caution, they provide little evidence for strong measurement error problems.

3.2 Firm-level determinants of NatureDep scores

To better understand variation in the NatureDep scores, we examine the role of different firm-level characteristics by estimating the following regression for firm *i* in year *t*:

$$NatureDep_{i,t} = \beta_0 + \beta_1 \boldsymbol{X}_{i,t-1} + \gamma_t + \mu_j + \sigma_c + \varepsilon_{i,t} \quad (1)$$

where *NatureDep* is one of our aggregate measures of nature dependence ($NatureDep^{Overall}$ or $NatureDep^{High}$). The vector $\boldsymbol{X}$ contains (one-year lagged) firm characteristics used in other work to explain climate or biodiversity metrics (e.g., Sautner et al. 2023; Garel et al. 2024). Additionally, we include the corporate biodiversity footprint (CBF) from Garel et al. (2024) and a firm's carbon emissions, both in levels and intensities. We add fixed effects to the estimation that capture year (γ_t), industry (μ_j), and country (σ_c) shocks. Standard errors are clustered at the firm level. Supplementary Appendix Table F.4 reports summary statistics for the regression variables.

Table 4, Panel B, presents the regression estimates. Columns 1 to 4 explain $NatureDep^{Overall}$ and Columns 5 to 8 $NatureDep^{High}$ (the sample size varies across columns as data on the CBF and on carbon emissions are only available for parts of the sample). The strongest and most consistent correlation with the NatureDep scores comes from asset tangibility (*PPE/Total assets*): firms that operate with relatively more physical assets also have greater dependence on nature. This finding is plausible given that many ecosystem services relate to production processes and to regulation and maintenance (e.g., flood mitigation and storm mitigation), all of which relate to fixed assets. In Columns 1 and 5, firm size correlates positively with the NatureDep scores, possibly because larger firms have more economic activities, which in turn creates dependencies on more ecosystem services (when accounting for the CBF and emission levels, the size effect is subsumed by these variables). The number of segments correlates negatively with the NatureDep scores, suggesting that, holding size constant, greater diversification reduces nature dependence. The market-to-book ratio negatively relates to $NatureDep^{Overall}$, which may reflect that growth opportunities contribute less to nature dependence than assets in place.

Notably, in Column 2, a firm's CBF *positively* correlates with $NatureDep^{Overall}$, implying that firms that have larger impact on nature also have greater dependence on it—this correlation is also present in Column 6 for $NatureDep^{High}$. The association implies that greater dependence on ecosystem services can be associated with a higher likelihood of damaging the environment (we explore this channel in Section 4.2). The CBF is available for fewer firms and only for the years from 2018 to 2022. To illustrate this link, consider firms that are highly *dependent* on groundwater such as Tesla for battery production or Danone for water bottling. Such firms also have a strong negative *impact* on regional water levels, because they heavily consume water in their production processes. In the food sector, many firms additionally impact nature negatively because of pressures related to land use; this typically occurs through the supply chain, in the case of Danone through the farming of cows for milk production (see Garel et al., 2024).

Figure 2 visualizes the strong correlation between nature dependence and impact. In Panel A, we plot the industry-level averages of $NatureDep^{Overall}$ and *Ln(CBF)*, and in Panel B, the same averages between $NatureDep^{High}$ and *Ln(CBF)* (calculated over the years 2018-2022). The figures show that Food, Beverage & Tobacco—of which Danone is a constituent—is placed in the extreme top-right corner of both panels. While the overall correlation is high, figure 2 also illustrates some divergences. For example, Pharmaceutical, Biotechnology & Life Sciences has a strong nature dependence, but is not among the top sectors with respect to its nature impact.

Returning to Table 4, Panel B, the level and intensity of carbon emissions positively correlate with nature dependence, an effect that may stem from many high-emitting firms having strong dependencies on certain ecosystem services. For example, as shown in Table 2, firms operating in either Energy or Utilities locate in the top 5 of a sector ranking based on the dependence on Soil & Sediment Retention. These two sectors also rank high for Flood Control and Water Flow Regulation. The high correlation suggests that issues related to climate change and nature are heavily intertwined (in line with Giglio et al. 2025b).

3.3 Corporate nature action and NatureDep scores

We examine whether corporate actions on nature issues differ across firms based on their NatureDep scores. To measure nature action, we analyse firms' voluntary responses to the CDP questionnaire (CDP was formerly called Carbon Disclosure Project). CDP, a nonprofit supported

by institutional investors, requests information from over 10,000 firms on actions related to climate and, more recently, biodiversity risks. A total of 2,317 sample firms responded to seven biodiversity-related questions in the 2023 questionnaire:

- *(C15.1) Is there board-level oversight and/or executive management-level responsibility for biodiversity-related matters within your organization? [Yes/No]*
- *(C15.2) Has your organization made a public commitment and/or endorsed any initiatives related to biodiversity? [Yes/No]*
- *(C15.3) Does your organization assess the impacts and dependencies of its value chain on biodiversity? [Yes/No]*
- *(C15.4) Does your organization have activities located in or near to biodiversity-sensitive areas in the reporting year? [Yes/No]*
- *(C15.5) What actions has your organization taken in the reporting year to progress your biodiversity-related commitments? [Yes (there is an action)/No]*
- *(C15.6) Does your organization use biodiversity indicators to monitor performance across its activities? [Yes/No]*
- *(C15.7) Have you published information about your organization's response to biodiversity-related issues for this reporting year in places other than in your CDP response? [Somewhere/No publications]*

We use answers to these questions to identify which firms pay more attention to biodiversity or seek to improve their disclosures. Specifically, we create dummy variables coding for positive answers ("actions") to the questions. We then relate these variables to NatureDep scores as of 2022. Table 5, Panel A, reports descriptive evidence on the answers (we also report NatureDep scores for this CDP sample). While 69 percent of the firms answering to CDP disclose biodiversity-related information (C15.7), only 22 percent assess the impact and dependencies of their value chains on biodiversity (C15.3), and just 27 percent use biodiversity indicators (C15.6). In Table 5, Panel B, we display the correlations between the NatureDep scores and the variables coding for positive answers to the CDP questions. The NatureDep scores have positive but small correlations with nature-related actions. Correlations are highest for the questions on whether firms have activities located in or near biodiversity-sensitive areas (0.16 for $NatureDep^{Overall}$ and 0.09 for $NatureDep^{High}$ respectively), and whether firms use biodiversity indicators to monitor performance across their activities (0.14 and 0.07, respectively). The low correlations are not surprising given that most firms only recently started to address nature issues. Additionally, they

may reflect that the CDP questions are neither specific to nature dependence nor quantify how a firm's activities depend on nature. [19]

3.4 Corporate nature disclosures and NatureDep scores

We analyse earnings calls to explore whether firms with higher nature dependence disclose more information on nature-related issues. Earnings calls are corporate events, in which analysts listen to management and ask questions about a firm's current and future developments. A benefit of earnings calls is that they are available for firms around the world, which is well suited since we develop our scores for an international sample. We collect earnings call transcripts from Refinitiv Street Events from 2018 to 2023 and link earnings calls in year *t+1* (four quarters) to NatureDep scores in year *t*. We identify biodiversity-related text using the dictionary developed by Giglio et al. (2025c). *ConfCall (%)* is the ratio of biodiversity-related mentions scaled by the total number of words in an earnings call. *ConfCall (count)* is the number of mentions of biodiversity-related words in earnings calls. Table 6, Panel A, shows that biodiversity issues are rarely discussed in earnings calls (e.g., the average number of biodiversity-related mentions is less than one [0.11]).[20]

Table 6, Panel B, displays correlations between the NatureDep scores and the frequency or number of biodiversity terms in earnings calls. The correlations are low (less than 0.05), indicating that many firms with high NatureDep scores do not discuss biodiversity issues. Nevertheless, Table 6, Panel C, shows that the correlations gradually increased over time. A growing demand from investors for biodiversity information may contribute to this trend, which will likely accelerate in the future as more investors are requiring nature-related information for their own disclosures, risk management, or their clients (Gjerde et al. 2025).

3.5 Investor engagement and NatureDep scores

As a validation of our measure, we explore whether investors actively engage with firms that are highly dependent on nature as part of their nature-related engagement strategies. If so, this would

[19] For example, Question C15.3 treats together biodiversity impacts and dependencies, and Question C15.6 does not separate indicators along the impact and dependency dimensions. Further, the questions do not *quantify* nature or biodiversity dependence. These limitations come with the broader caveat that CDP disclosure is voluntary.
[20] Less than 5 percent of the calls in our sample contain at least one biodiversity term, consistent with Garel et al. (2024).

indicate that market participants perceive such dependence as relevant for firm value or risk. We analyse data from BlackRock, the world's largest asset manager, to assess whether NatureDep scores predict the likelihood of shareholder engagement on biodiversity. BlackRock is increasingly concerned about nature-related risks and views natural capital as an investment issue (BlackRock 2024a). As part of its stewardship activities, BlackRock engages firms on biodiversity issues as it believes this nature dimension can affect the long-term returns of firms with material exposures.[21] The asset manager uses data from ENCORE to identify nature dependence of firms (BlackRock 2024c).

We collect data on BlackRock's biodiversity engagements from its 2023 Stewardship Reports (BlackRock 2024b), in which the investor discloses the firms it engages with on biodiversity issues. A total of 52 firms have been engaged by BlackRock since 2023, and we list these firms in Supplementary Appendix Table F.5. The nature dependence of these firms is much higher for these firms than for our baseline sample (e.g., average number of high dependencies is 2.73 versus 1.93 in the baseline sample). We then estimate the following regression to test whether firm *i* is more likely to be targeted by BlackRock if it has higher nature dependence:

$$BiodivEng_i = \beta_0 + \beta_1 NatureDep_{i-1} + \beta_2 \boldsymbol{X}_i + \mu_j + \sigma_c + \varepsilon_i \qquad (2)$$

where *BiodivEng* equals one if a firm receives a biodiversity engagement from BlackRock, and zero otherwise. *NatureDep* is one of our measures of nature dependence (as of 2022) and $\boldsymbol{X}$ is a set of lagged firm-level control variables. We obtain the engagement data and the control variables from Derrien et al. (2025a), who study BlackRock's climate engagements. We account for industry (μ_j) and country (σ_c) fixed effects. Summary statistics are reported in Supplementary Appendix Table F.6.

Table 7 shows that both NatureDep scores are significant predictors of BlackRock's engagement efforts. In Column 1, a standard-deviation increase in $NatureDep^{Overall}$ raises the

[21] BlackRock's decision to engage firms might also be influenced by biodiversity impact considerations, but its definition of biodiversity issues suggests that dependencies are the most relevant consideration. BlackRock provides the following definition of biodiversity issues: *"Biodiversity refers to the variety and abundance of life on earth, which is essential to a healthy ecosystem and the services it provides. Biodiversity loss can pose financially material risks to companies in certain sectors."* Even if some engagements are driven by impact consideration, nature dependencies can still be a partial driver of the associated risks, as we illustrate in Section 4.2..

probability of being engaged by BlackRock by 0.45pp, or 56 percent relative to the unconditional probability. The statistical significance for $NatureDep^{High}$ is weaker than for $NatureDep^{Overall}$, possibly because Blackrock, for its target identification, relies on metrics that focus more on the average dependence than on the number of high dependencies.

These results suggest that some major investors have begun to consider nature dependence as a relevant financial factor informing their engagement decisions.[22] Our results should be interpreted with caution given that BlackRock only recently started to engage firms on biodiversity issues and only targets a small fraction of its portfolio firms.

4. Applications of NatureDep scores

In this section, we apply the NatureDep scores to different settings. Section 4.1 analyses whether nature dependence is associated with average stock returns and measures of downside risk. Section 4.2 examines whether high nature dependence is associated with nature-related incidents and asks whether downside risk is more pronounced when such incidents occur.

4.1 NatureDep scores and downside risk

Engagement may affect the long-term value of the engaged firms, but it does not necessarily imply that nature dependence is priced into securities. To evaluate pricing implications, we examine whether NatureDep scores are related to market-based measures of risk and return.

Conceptually, it is unclear how any pricing effects may materialize, if at all. On the one hand, the low prevalence of nature topics in financial disclosures, and the low correlations thereof with our scores, may imply that nature dependencies do not generate financially material risks. This may be because risk realizations are not significant enough or because firms hedge against them. On the other hand, Gjerde et al. (2025) illustrate that for a substantial number of firms, nature dependencies have become relevant financial factors, and associated risks have started to

[22] In Supplementary Appendix Table F.7, we re-estimate our regressions after controlling for S&P's nature dependence score (*S&P DC score*), to evaluate whether our scores contain incremental information content. While *S&P DC score* does not predict BlackRock's engagement decision, $NatureDep^{Overall}$ continues to be a statistically significant predictor ($NatureDep^{High}$ continues to have a positive effect, but this effect is estimated with more noise, probably because the sample size is much smaller when we restrict the estimation to firms covered also by S&P). The sample is reduced by too much to meaningfully estimate a similar regression for *IDL BD score*.

materialize. Nature dependence can affect returns if ecosystem services relevant to a firm's operations stop or deteriorate in their ability to function. Financial risks may also arise from regulatory shocks, such as when regulations restrict or increase the cost of accessing important ecosystem services. A greater nature dependence can also increase the likelihood of damaging the environment, and the resulting reparation, litigation, or reputation costs may depress returns (consistent with this argument is the high correlation between the NatureDep scores and the CBF). For all these channels, the timing of effects is hard to predict, and effects may also be non-linear.

A further consideration is that nature-related risks are likely to manifest through rare, extreme losses rather than persistent return differences. Consistent with this conjecture, we find no evidence in Supplementary Appendix Table F.8 that our NatureDep scores correlate with average stock returns. Hence, if market-based risk effects of nature dependence exist, they should concentrate in the left tail of the distribution. The presence of any downside risk effects would be consistent with studies showing that environmental risks have downside risk components (Hoepner et al. 2024; Ilhan, Vilkov, and Sautner 2021). We test for such effects by linking measures of downside risk for firm *i* in month *m* of year *t* with our NatureDep scores in year *t–1*:

$$Downside\ risk_{i,m,t} = \beta_0 + \beta_1 NatureDep_{i,t-1} + \beta_2 \boldsymbol{X}_{i,t-1} + \mu_{jcm} + \varepsilon_{i,m,t} \qquad (3)$$

where *Downside risk* measures downside risk of firm *i* in month *m* of year *t*. We follow Hoepner et al. (2024) and focus on two measures constructed from daily returns: (i) value at risk (*VaR*), measured as the worst daily return during a month; and (ii) the second-order lower partial moment (*LPM*), calculated as the square root of the semi-variance below 0 percent.[23] *NatureDep* measures nature dependence of firm *i* in year *t–1*. ***X*** contains firm characteristics and in some regressions *Ln(CBF)*. Regressions include industry-by-country-by-time fixed effects (μ_{jcm}) to identify effects from variation across firms in the *same* industry and the *same* country at the *same* point in time (year-month). This ensures that effects do not originate from localized industry shocks. We cluster

[23] For the *VaR* measure, we require at least 15 trading days with non-missing returns per month. We multiply the variable by -1 so that higher values indicate greater downside risk. Because it captures the worst daily outcome in a typical 20-day month, the measure is approximately equivalent to a 5 percent value-at-risk and can be interpreted as a simple, empirical proxy for conditional VaR (expected shortfall).

standard errors at the year-month and firm level. Supplementary Appendix Table F.9 reports summary statistics.

In Table 8, Panel A, we report results without and with *Ln(CBF)*; as mentioned before, the sample declines with the additional control variable. Overall, there is no evidence that a firm's average nature dependence, $NatureDep^{Overall}$, relates to *VaR* or *LPM*. By contrast, $NatureDep^{High}$ positively and significantly predicts both downside risk measures, irrespective of whether we control for *Ln(CBF)*. The effects are modest, however. In Column 2, a one standard-deviation increase in $NatureDep^{High}$ increases *VaR* by 0.03 (3 basis points, or roughly 0.6 percent relative to its mean of 4.71 percent), corresponding to about 1 percent of the standard deviation. For comparison, this effect is roughly the same order of magnitude as that of leverage (debt-to-assets) and about one-tenth the magnitude of profitability or market volatility, suggesting that nature dependence contributes to downside risk, but less than core financial characteristics. We visualize these results in figure 3, where we report binned scatter plots of the relation between $NatureDep^{High}$ and *VaR* or *LPM*. Supplementary Appendix Figure F.4 shows that effects do not originate from a single year. With respect to the ecosystem-level drivers of these results, Supplementary Appendix Table F.10 shows that the downside risk effects stem mainly from high dependencies on Water Purification, Flood Control, Storm Mitigation, and Water Flow Regulation.[24] A conclusion is that nature dependencies create non-linear effects stemming from a high reliance on certain ecosystem services, rather than from low or moderate dependencies on a greater number of services.[25] As $NatureDep^{High}$ better captures extreme effects of nature dependence, it is plausible that downside risk effects arise primarily for this construct. This interpretation is supported by the ecosystem services literature (Dasgupta 2021) and the economic model by Giglio et al. (2025a), both of which suggest that the loss of one ecosystem service is difficult to substitute through increased use of other factors.

[24] In the table, we estimate versions of Eq. (3) in which we replace NatureDep with a series of indicator variables that each reflect a high dependence on a specific ecosystem service (i.e., the dependence score is greater than or equal to 4). To have sufficient variation in the estimations, we require these indicator variables to be populated for at least 5 percent of the sample; this is the case for eight ecosystem services.

[25] Recall that for the latter measure, firms with a high dependence on one ecosystem service and a low dependence on another one end up with similar aggregate dependencies as firms with medium dependence on these two ecosystem services. Non-linear effects can arise if ecosystems have tipping points.

In Table 8, Panel B, our conclusions are reinforced after replacing our dependence measures with those from S&P and IDL: neither *IDL BD score* nor *S&P DC score* significantly predict downside risk. These non-results are plausible because the alternative metrics do not pick up extreme exposures (S&P does not explicitly count the number of high dependencies but uses a non-linear aggregator to allow high dependencies to contribute more to nature-related risks).

In Table 8, Panel C, we provide further insights into the economics of nature dependence by leveraging two dimensions of cross-sectional heterogeneity. First, we study whether the downside risk effects vary with the diversification of a firm. For a given level of dependence, a benefit of diversification is that it provides hedging for any given shock. However, diversification may also constitute a source of risk exposure if it creates new dependencies. We explore these competing views by estimating a version of Eq. (3) in which we interact $NatureDep^{High}$ with *High diversification*, which equals one if a firm has at least three business segments (strictly above the median value of 2). Columns 1 and 2 show that diversified firms unconditionally have lower values of *VaR* and *LPM*. However, diversification neither amplifies nor reduces the effect of nature dependence on downside risk. Second, we examine whether the downside risk effects are stronger if a firm's asset base consists primarily of tangible assets. We expect stronger effects because, as documented earlier, many ecosystem services relate to the production of products. We explore this question by interacting $NatureDep^{High}$ with *High tangibility*, which equals one if a firm's asset tangibility (PPE over assets) is high (top quartile) (we exclude *PPE/Total assets* from $\boldsymbol{X}$). Columns 3 and 4 show that the risk effects are particularly strong when firms operate with many tangible assets.

In Table 8, Panel D, we conduct robustness and placebo tests. In Columns 1 and 2, we address the concern that firms with extreme nature dependence have higher downside risk because of more concentrated activities (i.e., our results would reflect a general risk driver). To deal with this issue, we control for the Herfindahl-Hirschman Index (HHI) of a firm's segment revenues. $NatureDep^{High}$ continues to be positively and significantly related to downside risk, though the effect's magnitude declines. The HHI has a strong positive and significant association with *VaR* and *LPM*, indicating that less diversified firms are more exposed to the realization of downside risk (confirming the evidence from Table 8, Panel C). In Columns 3 and 4, we control for *Ln(Scope 123 emissions)* because, as shown earlier, emissions are related to nature dependence. The effects

for $NatureDep^{High}$ continue to hold when controlling for this measure of climate transition risk exposure, though the sample size shrinks substantially (results are similar if we use emission intensities). In Columns 5 and 6, we report placebo tests which use a nature dependence measure constructed for a firm's dependence on cultural ecosystem services. As mentioned earlier, business operations rarely depend on cultural ecosystems, and even if they do, any dependencies should not generate financially material effects.[26] Indeed, $PlaceboNatureDep^{High}$ is unrelated to *VaR* or *LPM*.

In Supplementary Appendix Table F.11, we provide a series of further robustness checks. In Columns 1 and 2, we show that our results for $NatureDep^{High}$ are unaffected if we two-way cluster standard errors at the country-by-time and industry-by-time levels. Results are also unaffected if we cluster standard errors at country-by-year-month, industry-by-year-month, firm and country-by-year-month, or firm and industry-by-year-month levels (not reported). In Column 3, results are unaffected for an alternative definition of *LPM*, which focuses on returns below the monthly mean (instead of below zero). Finally, in Columns 4 to 7, we evaluate the sensitivity of our results to how we map segment activities and high dependencies. Specifically, we consider whether results change if we winsorize segment weights at the 1 percent level or cap the counted high dependencies at six. The estimates show that these refinements do not affect our results (the same holds if we winsorize at the 5 percent level or cap at seven high dependencies).

Overall, our results suggest that while nature dependence is not priced in average returns, it is associated with heightened vulnerability to extreme negative return outcomes.[27]

4.2 NatureDep scores and nature-related incidents

[26] According to ENCORE, all dependencies on cultural ecosystem services were assigned a *Very High* materiality rating. However, ENCORE also notes that "*further building of consensus in the scientific community is needed on how these types of ecosystem services on how to assess the full scope of economic activities' dependencies on these services.*"

[27] We also examine announcement returns around five biodiversity-related regulatory events: (i) the Kunming Declaration and (ii) the Montreal Agreement (both jointly established a global biodiversity framework); (iii) the passage of the EU Nature Restoration Law, approved after an unexpected shift in Austria's position in the EU Environment Council; (iv) the Trump Administration's announcement of substantial weakening of the U.S. Endangered Species Act; and (v) the Biden Administration's subsequent reversal of these changes. In Supplementary Appendix Table F.12, we find no systematic differences in announcement returns by NatureDep score for each of these events. An interpretation is that the events had differential return effects on firms that offset each other: for some firms, markets view them as imposing costs (e.g., imposing compliance burdens) while for others they consider them as reducing risk (e.g., protecting critical ecosystems on which firms rely).

Direct, sudden collapses of ecosystem services are extremely rare, making it difficult to observe financial consequences through such events. Yet, we can exploit that physical risks related to nature dependencies and transition risks due to nature impacts are often intertwined (this is different in the case of climate risks). The reason is that the intensive use of the services provided by an ecosystem can increase the risk of polluting it, overusing its resources, or entering into conflict with local communities. Reflecting such interconnections, we showed in Section 3.2 that NatureDep scores strongly correlate with the CBF, which captures a firm's negative impact on nature. Such impacts can trigger regulatory action, reputational damage, litigation, or operational disruptions, all of which can reduce firm value. Supplementary Appendix H lists case studies, including the previously mentioned Tesla case, that illustrate such effects. We therefore examine whether NatureDep scores predict the occurrence of nature-related incidents.

We measure nature-related incidents using RepRisk's database of ESG controversies. RepRisk is a primary data source to identify ESG-related incidents and prior work shows that such incidents are met with negative return reactions (e.g., Derrien et al. 2025b, Akey et al., 2024, Hoepner et al. 2024, Gantchev et al. 2022, Glossner 2021, Kölbel et al. 2017). RepRisk does not have a *unique* tag for "nature incidents", though a highly related category is Impacts on Ecosystems and Biodiversity (RepRisk classifies incidents into 28 issue categories). In addition, some other categories are potentially nature-related, though less directly, according to RepRisk (2024)'s data descriptions: Animal Mistreatment; Climate Change, GHG Emissions, and Global Pollution; Impacts on Communities; Local Pollution; Overuse and Wasting of Resources; and Waste Issues. These categories are noisier as RepRisk does not identify whether incidents therein arise specifically because of nature impacts or dependencies. To identify events that are likely financially important, we focus on incidents with medium or high severity and medium to high source reach. We aggregate the incident information to the firm-year level and create for each issue category an indicator that equals one if at least one incident occurred (see Supplementary Appendix Table F.13 for summary statistics).

In Supplementary Appendix Figure F.5, we provide descriptive evidence based on correlations. We find positive links between our NatureDep scores and nature-related incidents, especially for incidents related to Impacts on Ecosystems and Biodiversity. Dependencies related to water, biomass provisioning, and soil ecosystem services also relate to more frequent incidents.

More formally, we regress for firm i and year t the measures of incident occurrence on the NatureDep scores:

$$Nature\text{-}related\ incident^{Incident\ Issue}_{i,t} = \beta_0 + \beta_1 Nature\ Dep_{i,t-1} + \beta_4 \boldsymbol{X}_{i,t-1} + \mu_{j,t} + \sigma_{c,t} + \varepsilon_{i,t} \quad (4)$$

where $Nature\text{-}related\ incident^{Incident\ Issue}$ equals one if at least one nature-related incident issue occurred in year t. $NatureDep$ measures nature dependence in $t-1$ (we multiply the coefficient and standard error by 100 to ease interpretation), and $\boldsymbol{X}$ contains firm characteristics. $\mu_{j,t}$ are industry-by-year and $\sigma_{c,t}$ country-by-year fixed effects. Standard errors are clustered by time and firm. We use a linear probability model because this model handles standard error clustering and fixed effects well (Angrist and Pischke 2009); logistic regression provides similar results.

In Table 9, Panels A and B, we report results using the different nature-related incidents variables. For both NatureDep scores, we find that firms with a higher nature dependence experience significantly more incidents that originate from impacts on ecosystems and biodiversity. In Panel A (Panel B), such incidents are 0.44pp (0.30pp) more likely for a standard-deviation increase in $NatureDep^{Overall}$ ($NatureDep^{High}$), implying a probability that is 11 percent (7 percent) higher than the baseline rate. For both scores, incidents related waste issues are also significantly more likely for firms with higher dependencies. In Panels A and B, we also report a placebo test examining the relation between the NatureDep scores and governance-related incidents. We find such incidents to be unrelated to our scores, which is plausible given that governance incidents should *not* directly originate from firms exploiting or appropriating natural resources.

If incidents are realizations of nature-related tail risk, then the previously documented downside risk effects should be more pronounced in years when such incidents occur. We test this prediction by estimating whether our NatureDep scores are more strongly related to downside risk in years with such incidents. Table 9, Panel C, provides evidence consistent with this prediction: the coefficient on $NatureDep^{High}$ is about four times larger in firm-years with ecosystem and biodiversity impact incidents than in firm-years without such incidents (however, the difference is not statistically significant at conventional levels).

Overall, it appears that firms with high nature dependence are more likely to experience incidents linked to nature impacts, and the relationship between nature dependence and downside risk is somewhat stronger in years when such incidents occur. These findings suggest that nature-related incidents provide a concrete, observable mechanism through which nature dependencies can translate into the tail risk effects documented in Section 4.1.

5. Conclusion

Despite the growing attention to nature risks, our understanding of firms' dependencies on nature and ecosystem services remains limited. In this paper, we develop, analyse, and apply new firm-level measures, NatureDep scores, that quantify the extent to which a firm's business activities depend on ecosystem services, serving as metrics of firm-level *exposure* to physical nature risks (with financial effects due to *risk realizations* additionally depending on the deterioration of ecosystem services). Firms with the highest nature dependence operate in Pharmaceutical, Biotechnology & Life Sciences, Food, Beverage & Tobacco, and Household & Personal Products. Firms with a larger impact on nature also have greater dependence on it. NatureDep scores show little correlation with nature actions as disclosed in the CDP survey. Additionally, firms with high nature dependence do not extensively discuss nature topics in earnings calls. However, NatureDep scores predict BlackRock's biodiversity-related engagements. In two applications, we demonstrate that our scores are positively associated with measures of downside risk (driven largely by high water-related dependencies), and predict nature-related ESG incidents. We conclude that investors have started to pay attention to nature dependence, while corporate action and disclosure remain limited. One takeaway of our results is that by using our measures, investors can identify firms that are most exposed to physical nature risks and consider ways to address these risks using divestment (exit) or engagement (voice). Likewise, firms that start to reduce their nature dependencies by mitigating or hedging the associated risks may see financial market benefits, especially if investor awareness of physical nature risks increases further.

Our paper contributes to the literature by offering a novel firm-level measure of nature dependence that is available at scale. While we take an initial step toward quantifying and understanding nature dependencies, we anticipate that future research will refine and enhance our measures. Linking geospatial data on firms' asset locations with localized measures of ecosystem

service conditions appears particularly promising. Additionally, further research could explore how nature-related shocks propagate through supply chains and how firms adapt to their nature dependencies. Refining our tests on the financial implications of nature dependence (using more granular data) would also be valuable. Finally, an area for future research is the development of easy-to-use dependence metrics that firms can leverage to meet upcoming disclosure requirements.

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Supplementary material

Supplementary material is available at Review of Finance online.

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Conflicts of interest

A.G. has been a member of the scientific committee of Iceberg Data Lab (2024) and currently serves on the scientific committee of the biodiversity fund launched by a French consortium of institutional investors. Z.S. is on the sustainability council of Lampe Asset Management and a Regular Research Visitor at the ECB.

Data availability

The data underlying the article's empirical analyses are publicly available from the sources listed in the article. Most of these sources require a paid subscription, but our understanding is that any researcher who wishes to purchase any of the data may freely do so.

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Appendix Table A1. Variable definitions

Variable	Definition	Source
Acute physical climate risk	Share of earnings call conversations that is centred on acute physical climate risk.	Li et al. (2024)
BiodivEng	Equals one if BlackRock has engaged a firm on biodiversity issues since 2023 (Q1-Q2-Q3), and zero otherwise.	BlackRock, Derrien et al. (2025a)
Biodiversity risk count	Equals one if a 10-K statement contains at least two sentences related to biodiversity, and zero otherwise.	Giglio et al. (2025c)
Biodiversity risk count negative	Counts the number of negative biodiversity sentences minus the number of positive sentences.	Giglio et al. (2025c)
BlackRock stake	Fraction of a firm's shares held by BlackRock inferred based on institutional ownership data from Refinitiv aggregated across BlackRock's funds.	Derrien et al. (2025a)
BlackRock portfolio share	Total value of a company's shares held by BlackRock divided by BlackRock portfolio value.	Derrien et al. (2025a)
Capex/Total assets	Capital expenditures scaled by total assets. Winsorized at 1 and 99 percent levels.	Refinitiv
CDP Actions (C15.5)	Codes the response to the CDP question: "What actions has your organization taken in the reporting year to progress your biodiversity-related commitments?". Answer coded as one if "Yes" and zero if "No". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
CDP Commitment (C15.2)	Codes the response to the CDP question: "Has your organization made a public commitment and/or endorsed any initiatives related to biodiversity". Answer coded as one if "Yes" and zero if "No". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
CDP Indicators (C15.6)	Codes the response to the CDP question: "Does your organization use biodiversity indicators to monitor performance across its activities?". Answer coded as one if "Yes" and zero if "No". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
CDP Location (C15.4)	Codes the response to the CDP question: "Does your organization have activities located in or near to biodiversity-sensitive areas in the reporting year". Answer coded as one if "Yes" and zero if "No". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
CDP Disclosure (C15.7)	Codes the response to the CDP question: "Have you published information about your organization's response to biodiversity-related issues for this reporting year in places other than in your CDP response?". Answer coded as one if a source is provided and zero if the answer is "No publications". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
CDP Oversight (C15.1)	Codes the response to the CDP question: "Is there board-level oversight and/or executive management-level responsibility for biodiversity-related matters within your organization?". Answer coded as one if "Yes" and zero if "No". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
CDP Value chain (C15.3)	Codes the response to the CDP question: "Does your organization assess the impact of its value chain on biodiversity?". Answer coded as one if "Yes" and zero if "No". Value is missing if the answer is "Question not applicable" or empty.	CDP 2023
Chronic physical climate risk	Share of the earnings calls conversation that is centred on chronic physical climate risk.	Li et al. (2024)
ConfCall (%)	Biodiversity-related mentions scaled by the total number of words in an earnings call.	Refinitiv Street Events
ConfCall (count)	Counts the number of mentions of biodiversity-related words in an earnings call.	Refinitiv Street Events
Debt/Total assets	Total debt scaled by total assets. Winsorized at 1 and 99 percent levels.	Refinitiv
Governance-related incident$^{All\ Incidents}$	Equals one if at least one incident pertaining to governance occurred in the year, and zero otherwise.	RepRisk
High diversification	Equals one if the number of segments equals three or more (strictly above the median value of 2), and zero otherwise.	Refinitiv
High tangibility	Equals one if a firm's asset tangibility (PPE over assets) is high (top quartile), and zero otherwise.	Refinitiv
HHI Revenue shares	Sum of the squared revenue shares per segment.	Refinitiv
IDL BD score	Biodiversity Dependence (BD) Score of IDL. Computation starts from ENCORE's *Dependency Materiality Rating*. IDL considers 21 ecosystem services covered by the 2018-2023 version of the ENCORE database and four cultural ecosystem services. At the firm level, for each ecosystem service, IDL computes the BD score by taking	IDL

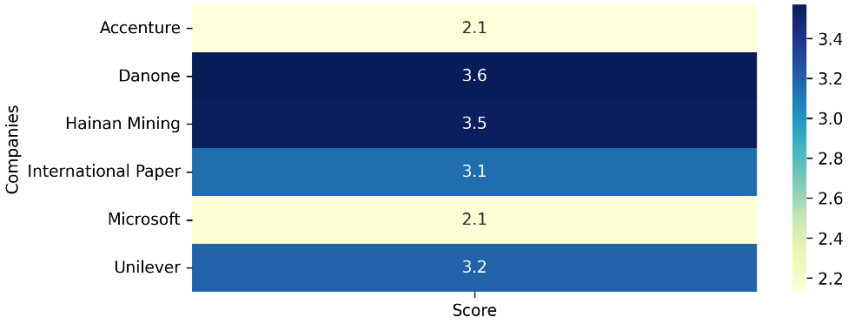
	the weighted average of the dependence scores for the different sectors in which the firm operates.	
Ln(# segments)	Natural logarithm of the number of business segments plus one.	Refinitiv
Ln(CBF)	Natural logarithm of the Corporate Biodiversity Footprint of IDL, multiplied by minus one. Winsorized at 1 and 99 percent levels.	Iceberg Data Lab
Ln(Scope 123 emissions)	Natural logarithm of the level of Scope 1, 2, and 3 carbon emissions. Winsorized at 1 and 99 percent levels.	Trucost
Ln(Scope 123 intensity)	Natural logarithm of the intensity of Scope 1, 2, and 3 carbon emissions (emissions scaled by sales). Winsorized at 1 and 99 percent levels.	Trucost
Ln(Total assets)	Natural logarithm of total assets. Winsorized at 1 and 99 percent levels.	Refinitiv
LPM	Second-order lower partial moment calculated as the square root of the variance of the negative daily returns over a given month. Winsorized at 1 and 99 percent levels.	Refinitiv
Market/Book ratio	Market capitalization scaled by book value of equity. Winsorized at 1 and 99 percent levels.	Refinitiv
Momentum 12M	Cumulated monthly returns over the last 12 months. Winsorized at 1 and 99 percent levels.	Refinitiv
MSCI Biodiversity Land Use Exposure	Score that aims to capture three risks for firms: (i) loss of license to operate; (ii) litigation by landowners and other affected parties; and (iii) increased costs of land protection and reclamation. It assesses firms based on their business segment and geographic exposures, for which it generates separate subscores that are then combined into an overall score. MSCI scores a firm's biodiversity and land use exposure on a 0-10 scale, with 10 corresponding to the highest and 0 to the lowest risk.	MSCI
NatureDep^{Overall}	Mean revenue-weighted dependence to ENCORE ecosystem services (excluding cultural ecosystem services). We only consider ecosystem services for which the segment-revenue-weighted dependence score is greater than or equal to 1.	Refinitiv, ENCORE
NatureDep^{High}	Number of revenue-weighted dependence scores to ecosystem services greater than or equal to 4.	Refinitiv, ENCORE
Nature-related incident$^{Animal\ Mistreatment}$	Equals one if at least one nature-related incident pertaining to animal mistreatment occurred in the year, and zero otherwise. According to RepRisk, this category covers "the torture, mistreatment or abuse of animals, through experiments, husbandry, trophy hunting, etc."	RepRisk
Nature-related incident$^{Climate\ Change,\ GHG\ Emissions,\ and\ Global\ Pollution}$	Equals one if at least one nature-related incident pertaining to climate change, GHG emissions, and global pollution occurred in the year, and zero otherwise. According to RepRisk, this category includes "pollution, mainly atmospheric, that has negative impacts beyond the surroundings in which the emissions occur."	RepRisk
Nature-related incident$^{Impacts\ on\ Ecosystems\ and\ Biodiversity}$	Equals one if at least one nature-related incident pertaining to impacts on ecosystems and biodiversity occurred in the year, and zero otherwise. According to RepRisk, this category covers "impacts of company activities on the condition of ecosystems, population size of species, and variability within species, between species and of ecosystems."	RepRisk
Nature-related incident$^{Local\ Pollution}$	Equals one if at least one nature-related incident pertaining to local pollution occurred in the year, and zero otherwise. According to RepRisk, this category covers "pollution into air, water, and soil that has a primarily local effect, including oil spills, etc."	RepRisk
Nature-related incident$^{Overuse\ and\ Wasting\ of\ Resources}$	Equals one if at least one nature-related incident pertaining to overuse and wasting of resources occurred in the year, and zero otherwise. According to RepRisk, this category covers "This issue refers to a company's overuse, inefficient use or waste of renewable and non-renewable resources, such as energy, water, commodities, etc."	RepRisk
Nature-related incident$^{Waste\ Issues}$	Equals one if at least one nature-related incident pertaining to waste issues occurred in the year, and zero otherwise. According to RepRisk, this category includes "inappropriate disposal or handling of waste from the company's production processes or projects, as well as waste trafficking."	RepRisk
Nature-related incident$^{Impacts\ on\ Communities}$	Equals one if at least one nature-related incident pertaining to impacts on communities occurred in the year, and zero otherwise. According to RepRisk, this category includes "activities of a company that leads to problems or worries for a community, such as a village or town or a group of people with common interests, values, preferences, social background, etc."	RepRisk
Physical climate exposure	Counts the frequency with which certain climate change bigrams occur in the earnings call transcript, scaled by the total number of bigrams in earnings calls.	Sautner et al. (2023)
Physical climate negative sent	Counts the relative frequency of physical climate change bigrams that occur in the vicinity of negative tone words in earnings calls.	Sautner et al. (2023)
Physical climate overall sent	Counts the relative frequency of physical climate change bigrams that occur in the vicinity of negative and positive tone words in earnings calls.	Sautner et al. (2023)

Physical climate positive sent	Counts the relative frequency of physical climate change bigrams that occur in the vicinity of positive tone words in earnings calls.	Sautner et al. (2023)
Physical climate risk	Counts the relative frequency of climate change bigrams mentioned in the same sentence as the word "risk" or "uncertainty" in earnings calls.	Sautner et al. (2023)
PlaceboNatureDep^{High}	Number of dependence scores to cultural ecosystem services greater than or equal to 4.	Refinitiv, ENCORE
PPE/Total assets	Net property, plant, and equipment scaled by total assets. Winsorized at 1 and 99 percent levels.	Refinitiv
ROA	Return on assets. Winsorized at 1 and 99 percent levels.	Refinitiv
S&P Biodiversity impact	Score constructed as a significance-weighted and condition-adjusted area footprint of an asset or firm's operations. The total area of the ecosystem occupied by a business activity can be adjusted for the degree to which its integrity is reduced, as well as the degree to which it is ecologically significant, thereby expressing the impact of different business activities on a common scale. This provides a measure of the equivalent area in hectares of the most pristine and significant ecosystems where integrity is reduced to zero.	S&P 2023
S&P DC score	Score constructed as the aggregate of the composite ecosystem services dependency scores of the 21 ecosystem services from the exploring natural capital opportunities, risks and exposure (ENCORE) knowledge base (Natural Capital Finance Alliance 2022) for the production process of an asset or firm combined into a single asset or firm-level dependency score, from 0 (no dependency) to 1 (high dependency).	S&P 2023
Standard deviation 12M	Standard deviation of the monthly returns over the last 12 months. Winsorized at 1 and 99 percent levels.	Refinitiv
Stock return	Monthly stock return. Winsorized at 1 and 99 percent levels.	Refinitiv
Stock return 1y	12-month cumulative stock returns. Winsorized at 1 and 99 percent levels.	Derrien et al. (2025a)
VaR	Value at risk calculated as the lowest daily return of the month, which can be interpreted as the 5 percent VaR. We multiply the variable by -1. Winsorized at 1 and 99 percent levels.	Refinitiv

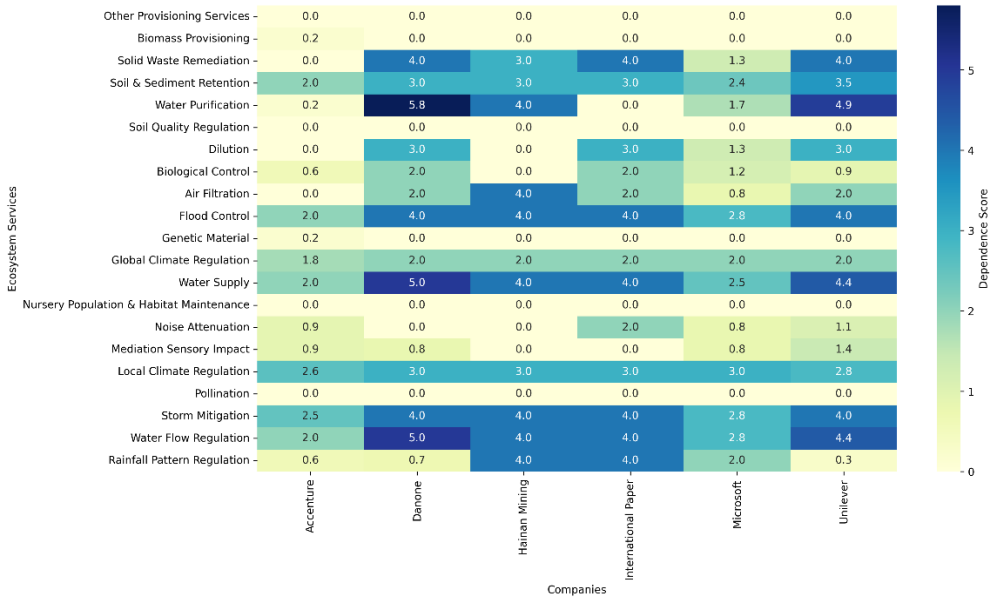
Appendix Table A2. List of acronyms

Acronym	Definition
CBF	Corporate Biodiversity Footprint
CDP	Carbon Disclosure Project
ENCORE	Exploring Natural Capital Opportunities, Risks, and Exposure
ESG	Environmental, Social, and Governance
GHG	Greenhouse Gases
GICS	Global Industry Classification Standard
HHI	Herfindahl–Hirschman Index
IDL	Iceberg Data Lab
IDL BD	Iceberg Data Lab Biodiversity Dependence
IUCN	International Union for Conservation of Nature
ISIC	International Standard Industrial Classification
IV	Instrumental Variable
LPM	Lower Partial Moment
ME	Measurement Error
MSA	Mean Species Abundance
NatureDep	Nature Dependence
NAICS	North American Industry Classification System
NGFS	Network for Greening the Financial System
PPE	Property, Plant, and Equipment
RIC	Refinitiv Instrument Code
ROA	Return on Assets
S&P DC	Standard & Poor's Dependency Composite
SBTN	Science Based Targets Network
SEEA	System of Environmental Economic Accounting
SEEA-EA	System of Environmental Economic Accounting Ecosystem Accounting
TNFD	Taskforce on Nature-related Financial Disclosures
UNEP-WCMC	United Nations Environment Programme-World Conservation Monitoring Centre
VaR	Value at Risk

Panel A: Case study firms: *NatureDep*^{Overall}



Panel B: Case study firms: Nature dependence by ecosystem service



Panel C: Case study firms: *NatureDep*^{High}

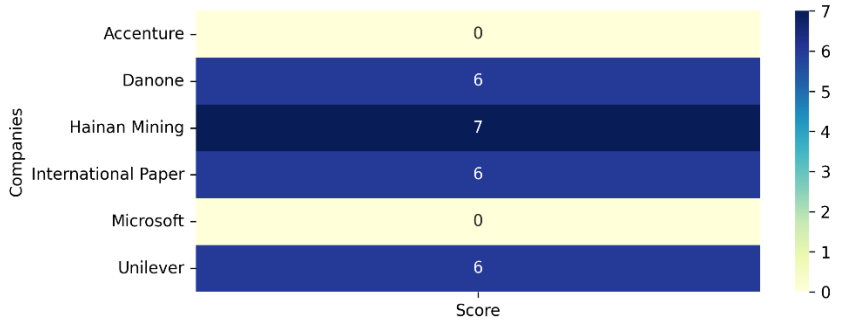
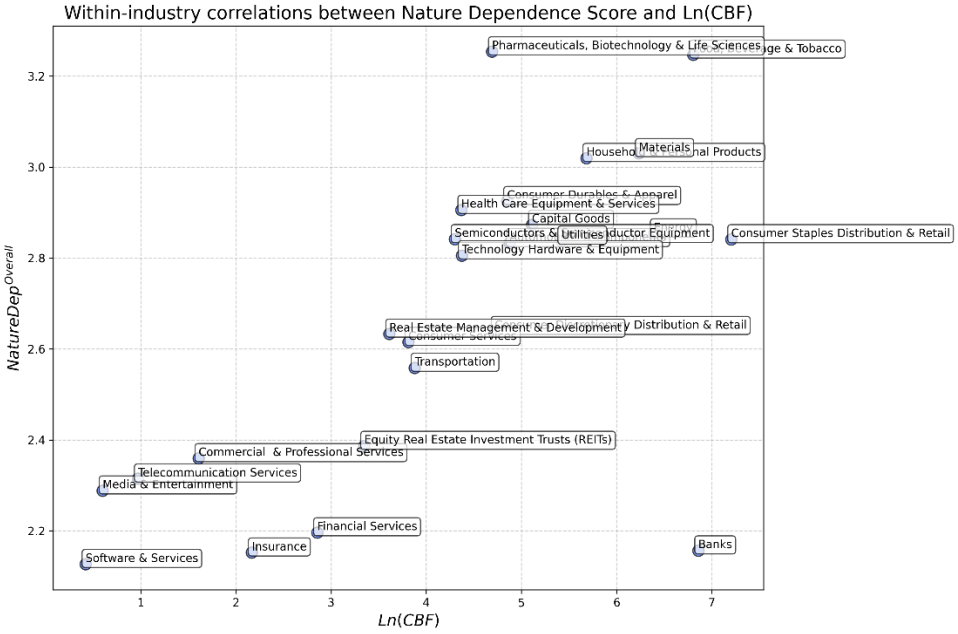


Figure 1. Illustration of NatureDep scores: Case studies.

Note: These figures provide illustrations of nature dependence of selected firms. The reported figures refer to the year 2022. Appendix Table A1 provides variable definitions.

Panel A: *NatureDep*^{Overall} and *Ln(CBF)*



Panel B: *NatureDep*^{High} and *Ln(CBF)*

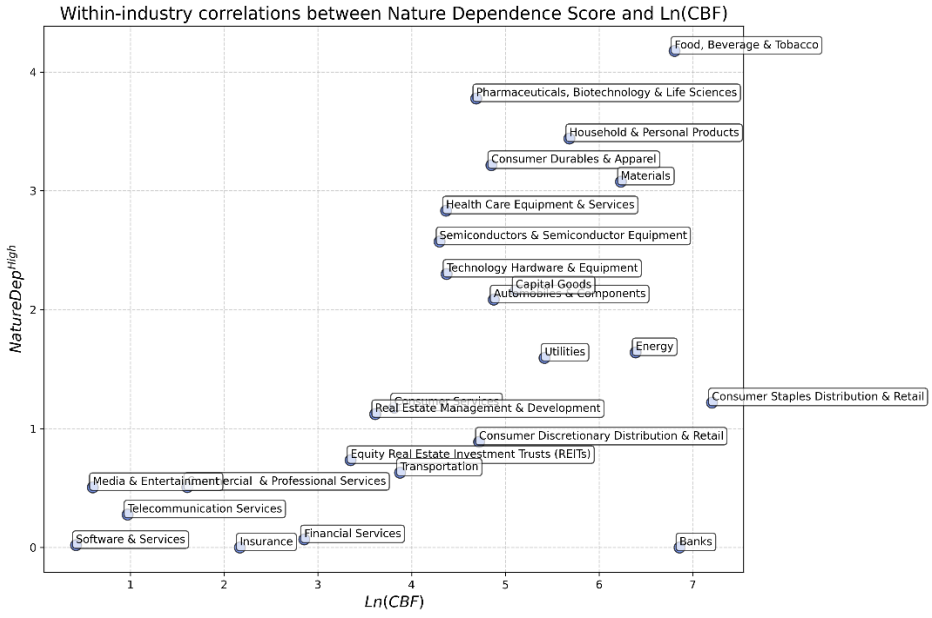
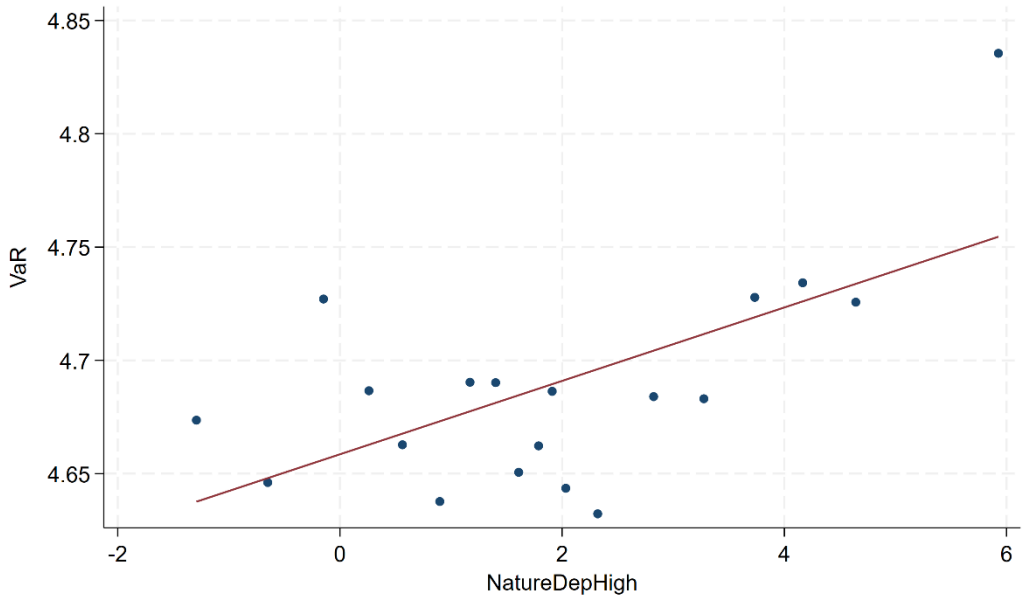


Figure 2. Correlation between NatureDep scores and the corporate biodiversity footprint.

Note: These figures document in Panel A the correlations between *NatureDep*^{Overall} and *Ln(CBF)* and in Panel B between *NatureDep*^{High} and *Ln(CBF)* by industry (GICS industry). *Ln(CBF)* is the corporate biodiversity footprint from Garel et al. (2024). For each industry, the correlation is constructed from firm-level scores. Appendix Table A1 provides variable definitions.

Panel A: *NatureDep*^{High} and *VaR*



Panel B: *NatureDep*^{High} and *LPM*

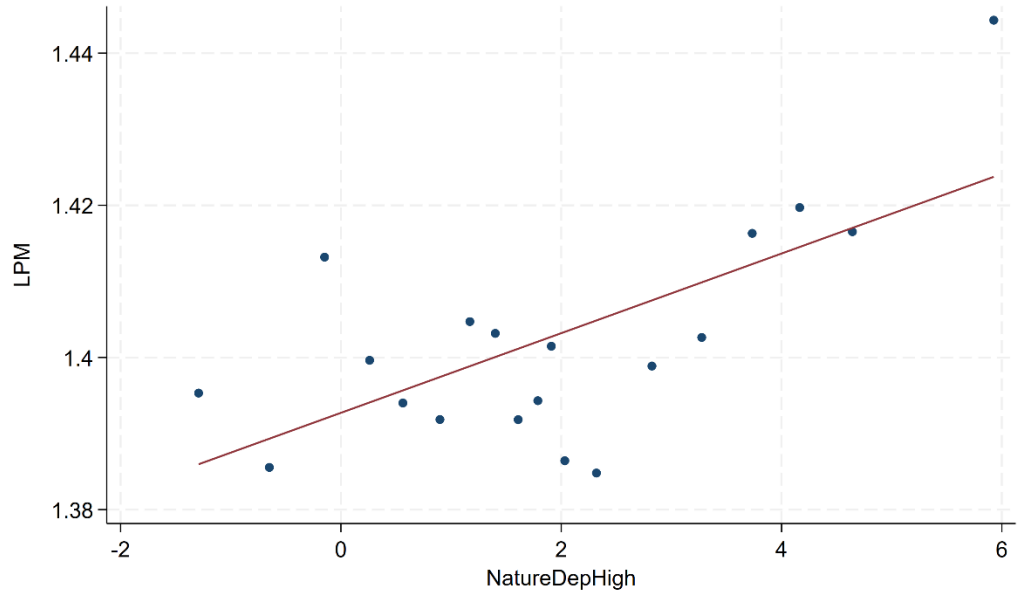


Figure 3. Binned scatter plots for NatureDep scores and downside risk.

Note: These figures document in Panel A binned scatter plots for the regression-estimated relation between *NatureDep*^{High} and *VaR* and in Panel B between *NatureDep*^{High} and *LPM*. The plots are based on 20 bins and after absorbing industry-by-country-by-time fixed effects. Appendix Table A1 provides variable definitions.

Table 1. Descriptive statistics for NatureDep scores.

Note: This table presents descriptive statistics at the firm-year level for the aggregate nature dependence scores as well as for the measures of the dependence on individual ecosystem services. The sample consists of listed firms from around the world between 2010 and 2023. Appendix Table A1 provides variable definitions.

Variables	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
$NatureDep^{Overall}$	248,394	2.75	0.44	1.57	2.40	2.80	3.04	4.27
$NatureDep^{High}$	248,394	1.93	2.25	0.00	0.00	1.00	4.00	13.00
$NatureDep^{Other\ Provisioning\ Services}$	248,394	0.14	0.46	0.00	0.00	0.00	0.00	4.00
$NatureDep^{Biomass\ Provisioning}$	248,394	0.10	0.35	0.00	0.00	0.00	0.00	3.00
$NatureDep^{Solid\ Waste\ Remediation}$	248,394	1.69	1.46	0.00	0.00	1.72	3.00	6.00
$NatureDep^{Soil\ \&\ Sediment\ Retention}$	248,394	3.13	0.72	0.00	2.84	3.00	3.55	5.00
$NatureDep^{Water\ Purification}$	248,394	2.44	1.93	0.00	0.03	2.76	4.00	6.00
$NatureDep^{Soil\ Quality\ Regulation}$	248,394	0.03	0.19	0.00	0.00	0.00	0.00	4.00
$NatureDep^{Dilution}$	248,394	1.37	1.24	0.00	0.00	1.38	2.73	4.00
$NatureDep^{Biological\ Control}$	248,394	0.64	0.79	0.00	0.00	0.11	1.32	4.00
$NatureDep^{Air\ Filtration}$	248,394	1.40	0.87	0.00	0.67	1.80	2.00	5.00
$NatureDep^{Flood\ Control}$	248,394	3.28	0.83	2.00	2.42	3.60	4.00	5.00
$NatureDep^{Genetic\ Material}$	248,394	0.22	0.81	0.00	0.00	0.00	0.00	6.00
$NatureDep^{Global\ Climate\ Regulation}$	248,394	2.21	0.57	0.00	2.00	2.00	2.11	5.00
$NatureDep^{Water\ Supply}$	248,394	3.30	0.88	2.00	2.47	3.50	4.00	5.00
$NatureDep^{Nursery\ Population\ \&\ Habitat\ Maintenance}$	248,394	0.02	0.11	0.00	0.00	0.00	0.00	2.00
$NatureDep^{Noise\ Attenuation}$	248,394	1.25	0.84	0.00	0.31	1.57	2.00	4.00
$NatureDep^{Mediation\ Sensory\ Impact}$	248,394	1.07	0.86	0.00	0.04	1.14	2.00	4.00
$NatureDep^{Local\ Climate\ Regulation}$	248,394	2.94	0.30	0.00	3.00	3.00	3.00	4.00
$NatureDep^{Pollination}$	248,394	0.02	0.19	0.00	0.00	0.00	0.00	3.00
$NatureDep^{Storm\ Mitigation}$	248,394	3.39	0.70	2.00	3.00	3.62	4.00	5.00
$NatureDep^{Water\ Flow\ Regulation}$	248,394	3.41	0.89	2.00	2.61	3.76	4.00	5.00
$NatureDep^{Rainfall\ Pattern\ Regulation}$	248,394	1.88	1.43	0.00	0.79	2.00	2.56	6.00

Table 2. NatureDep scores by industry.

Note: This table reports scores for nature dependence and the dependence on the different ecosystem services by industry (GICS industry). The data reports mean values aggregated from firm-level data to the industry level.

GICS industry	$NatureDep^{Other\ Provisioning\ Services}$	$NatureDep^{Biomass\ Provisioning}$	$NatureDep^{Soil\&Waste\ Remediation}$	$NatureDep^{Soil\ and\ Sediment\ Retention}$	$NatureDep^{Water\ Purification}$	$NatureDep^{Soil\ Quality\ Regulation}$	$NatureDep^{Dilution}$	$NatureDep^{Biological\ Control}$	$NatureDep^{Air\ Filtration}$	$NatureDep^{Flood\ Control}$	$NatureDep^{Genetic\ Material}$	$NatureDep^{Global\ Climate\ Regulation}$	$NatureDep^{Water\ Supply}$	$NatureDep^{Nursery\ Population\ \&\ Habitat\ Maintenance}$	$NatureDep^{Noise\ Attenuation}$	$NatureDep^{Mediation\ Sensory\ Impact}$	$NatureDep^{Local\ Climate\ Regulation}$	$NatureDep^{Pollination}$	$NatureDep^{Storm\ Mitigation}$	$NatureDep^{Water\ Flow\ Regulation}$	$NatureDep^{Rainfall\ Pattern\ Regulation}$	$NatureDep^{Overall}$	$NatureDep^{High}$
Automobiles & Components	0.03	0.02	2.76	3.31	3.51	0.01	2.36	0.16	1.76	3.86	0.02	2.01	3.42	0.01	1.81	1.64	3.00	0.00	3.87	3.87	1.91	2.88	2.43
Banks	0.01	0.00	0.01	2.03	0.01	0.00	0.01	0.01	0.03	2.02	0.00	2.00	2.01	0.00	0.04	0.04	3.00	0.00	2.04	2.02	0.05	2.16	0.00
Capital Goods	0.13	0.05	1.95	3.38	2.96	0.02	1.87	0.35	1.55	3.70	0.05	2.27	3.62	0.01	1.61	1.51	2.98	0.01	3.76	3.73	2.68	2.89	2.29
Commercial & Professional Services	0.10	0.16	1.13	2.64	1.23	0.05	0.83	0.64	0.88	2.74	0.13	1.97	2.89	0.01	1.13	0.97	2.69	0.02	3.01	2.87	1.71	2.43	0.63
Consumer Discretionary Distribution & Retail	0.12	0.08	0.56	3.16	0.88	0.04	0.43	1.16	0.87	2.95	0.06	2.10	2.86	0.02	0.69	0.53	2.97	0.01	3.09	3.07	1.69	2.59	0.75
Consumer Durables & Apparel	0.18	0.28	2.65	3.33	3.21	0.25	2.23	0.45	1.88	3.71	0.22	2.25	3.70	0.10	1.71	1.51	3.04	0.00	3.81	3.78	2.32	2.90	2.81
Consumer Services	0.42	0.19	1.17	2.80	2.92	0.06	0.19	1.62	1.59	2.51	0.07	2.65	2.82	0.06	1.63	1.21	2.97	0.06	2.96	2.78	2.34	2.60	0.95
Consumer Staples Distribution & Retail	0.07	0.02	0.63	3.30	1.09	0.00	0.44	1.71	1.12	3.41	0.09	2.10	3.43	0.00	0.23	0.21	2.90	0.00	3.44	3.76	1.71	2.82	1.35
Energy	0.09	0.07	1.22	3.48	2.18	0.02	1.25	0.78	1.56	3.47	0.05	2.31	3.29	0.01	1.12	0.67	2.99	0.00	3.44	3.56	1.96	2.82	1.83
Equity Real Estate Investment Trusts (REITs)	0.06	0.03	0.14	3.90	0.31	0.02	0.13	0.12	1.92	2.14	0.02	2.07	2.13	0.01	1.91	1.88	3.00	0.00	3.04	2.15	0.35	2.41	0.83
Financial Services	0.06	0.04	0.29	2.41	0.43	0.01	0.21	0.24	0.46	2.28	0.05	2.04	2.27	0.00	0.50	0.45	2.96	0.01	2.43	2.31	0.51	2.26	0.26
Food, Beverage & Tobacco	0.04	0.03	3.25	3.06	4.67	0.01	2.42	1.63	1.62	3.81	0.50	2.03	4.60	0.00	0.25	0.52	2.55	0.01	3.82	4.61	0.69	3.24	3.98
Health Care Equipment & Services	0.04	0.09	2.28	2.93	3.58	0.01	1.18	1.01	1.43	3.58	0.41	2.01	3.55	0.00	1.34	1.03	2.98	0.06	3.64	3.80	1.16	2.84	2.55
Household & Personal Products	0.02	0.11	3.05	3.48	3.38	0.04	2.36	0.68	1.70	3.75	0.63	2.03	3.97	0.02	1.30	1.11	2.93	0.05	3.79	4.00	1.06	3.00	3.25
Insurance	0.01	0.01	0.02	2.04	0.04	0.00	0.01	0.03	0.06	2.02	0.01	2.01	2.02	0.00	0.06	0.06	2.99	0.00	2.04	2.02	0.04	2.16	0.02
Materials	0.03	0.07	2.81	3.37	3.31	0.04	2.02	0.36	1.91	3.79	0.18	2.04	3.92	0.02	1.54	1.34	2.98	0.01	3.81	4.01	2.48	2.98	2.84
Media & Entertainment	0.24	0.21	0.50	2.45	0.52	0.07	0.18	0.97	0.53	2.37	0.06	2.11	2.36	0.07	1.18	1.03	2.68	0.04	2.80	2.41	1.29	2.25	0.31
Pharmaceuticals, Biotechnology & Life Sciences	0.03	0.40	2.66	3.46	4.74	0.00	2.37	0.55	1.77	3.58	3.40	2.12	4.30	0.00	0.59	0.54	2.98	0.39	3.73	4.33	0.41	3.24	3.82
Real Estate Management & Development	0.57	0.03	0.80	4.11	1.92	0.02	1.19	0.20	1.83	2.96	0.02	2.74	2.90	0.01	1.89	1.86	2.99	0.01	3.46	2.92	2.49	2.70	1.47
Semiconductors & Semiconductor Equipment	0.01	0.03	2.69	3.03	3.57	0.00	2.53	0.12	1.79	3.85	0.02	2.04	3.83	0.00	1.84	1.81	3.00	0.00	3.87	3.86	2.01	2.89	3.03
Software & Services	0.02	0.06	0.29	2.21	0.37	0.00	0.22	1.48	0.36	2.25	0.08	1.97	2.25	0.00	0.44	0.39	2.97	0.00	2.37	2.29	1.71	2.17	0.15
Technology Hardware & Equipment	0.01	0.03	2.33	2.95	3.00	0.01	2.06	0.40	1.51	3.62	0.03	1.99	3.50	0.00	1.54	1.52	2.99	0.00	3.65	3.64	2.08	2.78	2.21
Telecommunication Services	0.07	0.06	0.36	2.72	0.69	0.01	0.43	0.85	0.73	2.59	0.03	2.09	2.49	0.01	0.74	0.71	2.97	0.00	2.78	2.60	1.76	2.35	0.59
Transportation	0.67	0.09	0.15	3.05	0.99	0.01	1.00	1.12	1.55	3.14	0.06	2.90	2.49	0.00	1.29	0.33	2.96	0.00	3.47	2.89	3.04	2.62	0.80
Utilities	0.02	0.36	2.28	3.82	2.47	0.00	0.59	0.34	1.52	3.67	0.03	2.92	3.51	0.00	1.53	0.38	3.06	0.00	3.05	3.71	1.98	2.86	1.85

Table 3. NatureDep scores and nature dependence metrics by S&P and IDL.

Note: This table presents Pearson correlations for our firm-level measures of nature dependence with two alternative measures of nature dependence by S&P and IDL. The sample period depends on the intersections between the NatureDep scores and the other constructs. The S&P score is available from 2020 to 2021 (but mostly 2021), the IDL score from 2018 to 2022. * represents a significance level of 0.01. Appendix Table A1 provides variable definitions.

	$NatureDep^{Overall}$	$NatureDep^{High}$
S&P DC score	0.468*	0.324*
IDL BD score	0.574*	0.442*

Table 4. Determinant analysis of NatureDep scores.

Note: Panel A reports the results of a variance decomposition of $NatureDep^{Overall}$ and $NatureDep^{High}$, and Panel B the results of regressions relating $NatureDep^{Overall}$ (Columns 1 to 4) and $NatureDep^{High}$ (Columns 5 to 8) to firm-level determinants. In Panel B, control variables are measured in the previous year and standard errors clustered at the firm level. The sample period is from 2010 to 2023. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix Table A1 provides variable definitions.

Panel A: Variance decomposition

	(1)	(2)	(3)	(4)	(5)	(6)
Fixed effects	Industry	Country	Year	Year, Country, Industry	Year × country, Year × industry	Firm, Year × country, Year × industry
R^2 for						
$NatureDep^{Overall}$	0.457	0.059	0.001	0.476	0.478	0.917
$NatureDep^{High}$	0.251	0.060	0.002	0.287	0.290	0.880
Obs.	191,137	219,005	219,248	191,020	190,859	189,543

Panel B: Determinant regressions

Dependent variable:	$NatureDep^{Overall}$				$NatureDep^{High}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(Total assets) (lag)	0.009***	–0.015**	–0.042***	0.005**	0.046***	–0.056	–0.153***	0.035***
	(0.001)	(0.006)	(0.004)	(0.002)	(0.008)	(0.035)	(0.021)	(0.013)
Capex/Total assets (lag)	–0.020	–0.127	–0.091	–0.080	0.879***	0.579	1.118***	1.163***
	(0.036)	(0.161)	(0.070)	(0.069)	(0.197)	(0.991)	(0.387)	(0.386)
PPE/Total assets (lag)	0.197***	0.192***	0.130***	0.093***	0.929***	1.049***	0.657***	0.444***
	(0.013)	(0.044)	(0.022)	(0.022)	(0.072)	(0.237)	(0.117)	(0.117)
Debt/Total assets (lag)	0.017	0.056	0.005	–0.007	–0.074	0.014	–0.184*	–0.231**
	(0.012)	(0.042)	(0.020)	(0.020)	(0.069)	(0.239)	(0.110)	(0.109)
Market/Book ratio (lag)	–0.002***	–0.005***	–0.003***	–0.001	–0.000	–0.008	0.002	0.008
	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)	(0.009)	(0.005)	(0.005)
ROA (lag)	0.044**	0.172**	-0.022	0.078**	0.173*	0.287	–0.199	0.207
	(0.019)	(0.075)	(0.036)	(0.035)	(0.101)	(0.446)	(0.187)	(0.184)
Ln(# segments) (lag)	–0.033***	–0.052***	–0.036***	–0.033***	–1.173***	–1.099***	–1.078***	–1.068***
	(0.004)	(0.012)	(0.006)	(0.006)	(0.025)	(0.073)	(0.038)	(0.037)
Ln(CBF) (lag)		0.012***				0.033**		
		(0.003)				(0.017)		
Ln(Scope 123 emissions) (lag)			0.051***				0.205***	
			(0.003)				(0.017)	
Ln(Scope 123 intensity) (lag)				0.076***				0.358***
				(0.005)				(0.026)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	170,082	8,748	61,736	61,736	170,082	8,748	61,736	61,736
R^2	0.479	0.608	0.536	0.538	0.352	0.447	0.375	0.380

Table 5. Nature-related actions and NatureDep scores.

Note: Panel A reports summary statistics of responses to biodiversity-related questions in the CDP questionnaire for 2023. Panel B relates these responses to NatureDep scores as of 2022 using Pearson correlations. We identify the following questions as related to biodiversity and create dummies coding for positive answers to these questions: (i) (C15.1) "Is there board-level oversight and/or executive management-level responsibility for biodiversity-related matters within your organization?;" (ii) (C15.2) "Has your organization made a public commitment and/or endorsed any initiatives related to biodiversity?;" (iii) (C15.3) "Does your organization assess the impacts and dependencies of its value chain on biodiversity?;" (iv) (C15.4) "Does your organization have activities located in or near to biodiversity-sensitive areas in the reporting year?;" (v) (C15.5) "What actions has your organization taken in the reporting year to progress your biodiversity-related commitments?;" (vi) (C15.6) "Does your organization use biodiversity indicators to monitor performance across its activities?;" and (vii) (C15.7) "Have you published information about your organization's response to biodiversity-related issues for this reporting year in places other than in your CDP response?." * represents a significance level of 0.01. Appendix Table A1 provides variable definitions.

Panel A: Summary statistics

Variable	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
CDP Oversight (C15.1)	2,317	0.59	0.49	0.00	0.00	1.00	1.00	1.00
CDP Commitment (C15.2)	2,309	0.54	0.50	0.00	0.00	1.00	1.00	1.00
CDP Value chain (C15.3)	2,245	0.22	0.41	0.00	0.00	0.00	0.00	1.00
CDP Location (C15.4)	2,263	0.21	0.41	0.00	0.00	0.00	0.00	1.00
CDP Actions (C15.5)	2,273	0.53	0.50	0.00	0.00	1.00	1.00	1.00
CDP Indicators (C15.6)	2,307	0.27	0.45	0.00	0.00	0.00	1.00	1.00
CDP Disclosure (C15.7)	1,920	0.69	0.46	0.00	0.00	1.00	1.00	1.00
$NatureDep^{Overall}$	2,466	2.73	0.42	1.79	2.40	2.80	3.01	4.00
$NatureDep^{High}$	2,466	1.75	2.14	0.00	0.00	1.00	3.00	8.00

Panel B: Correlations between CDP questions and NatureDep scores

	$NatureDep^{Overall}$	$NatureDep^{High}$
CDP Oversight (C15.1)	0.124*	0.068*
CDP Commitment (C15.2)	0.096*	0.048
CDP Value chain (C15.3)	0.085*	0.043
CDP Location (C15.4)	0.163*	0.090*
CDP Actions (C15.5)	0.119*	0.070*
CDP Indicators (C15.6)	0.139*	0.069*
CDP Disclosure (C15.7)	0.101*	0.067*

Table 6. Earnings call disclosure and NatureDep scores**.**

Note: Panel A reports summary statistics of textual measures of biodiversity mentions in earnings calls. Panel B relates these measures to NatureDep scores using Pearson correlations. We link earnings calls in year *t+1* (the four quarters of the year) to nature dependence in year *t*. In Panel C, we report the Pearson correlations by year. The sample period is from 2018 to 2023 (NatureDep scores from 2017 to 2022). * represents a significance level of 0.01. Appendix Table A1 provides variable definitions.

Panel A: Summary statistics

Variable	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
ConfCall (%)	65,721	0.00	0.01	0.00	0.00	0.00	0.00	0.61
ConfCall (count)	65,721	0.11	1.04	0.00	0.00	0.00	0.00	51.00
$NatureDep^{Overall}$	65,721	2.68	0.44	1.67	2.25	2.71	3.00	4.00
$NatureDep^{High}$	65,721	1.73	2.18	0.00	0.00	0.00	4.00	8.00

Panel B: Correlations between earnings call disclosures and NatureDep scores

	$NatureDep^{Overall}$	$NatureDep^{High}$
ConfCall (%)	0.036*	0.010
ConfCall (count)	0.035*	0.011*

Panel C: Correlations between earnings call disclosures and NatureDep scores over time

	$NatureDep^{Overall}$		$NatureDep^{High}$	
Year	*ConfCall (%)*	*ConfCall (count)*	*ConfCall (%)*	*ConfCall (count)*
2018	0.031*	0.026*	–0.001	–0.001
2019	0.030*	0.033*	0.01	0.012
2020	0.045*	0.048*	0.021	0.026*
2021	0.046*	0.041*	0.023	0.017
2022	0.041*	0.049*	0.012	0.018
2023	0.056*	0.063*	0.011	0.014

Table 7. BlackRock biodiversity engagements and NatureDep scores.

Note: This table presents regressions relating NatureDep scores to biodiversity engagements by BlackRock. The sample period is the year 2023 (NatureDep scores for 2022). *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. We multiply the dependent variable by 100. Appendix Table A1 provides variable definitions.

Dependent variable:	*BiodivEng*	
	(1)	(2)
NatureDep^{Overall} (lag)	1.038***	
	(0.376)	
NatureDep^{High} (lag)		0.106*
		(0.063)
BlackRock stake (lag)	0.020	0.019
	(0.042)	(0.042)
BlackRock portfolio share (lag)	1.189***	1.188***
	(0.154)	(0.154)
PPE/Total assets (lag)	0.639	0.748
	(0.738)	(0.737)
Ln(Total assets) (lag)	0.147	0.156*
	(0.092)	(0.092)
Cash/Total assets (lag)	1.302	1.269
	(0.978)	(0.979)
Debt/Total assets (lag)	1.918***	1.918***
	(0.685)	(0.686)
Market/Book ratio (lag)	–0.126***	–0.131***
	(0.045)	(0.045)
ROA (lag)	0.617	0.701
	(1.087)	(1.087)
Stock return 1y (lag)	–0.070	–0.068
	(0.249)	(0.249)
Country fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Obs.	6,396	6,396
R^2	0.043	0.042

Table 8. Downside risk and NatureDep scores.

Note: Panel A reports regressions relating NatureDep scores to measures of downside risk (*VaR* or *LPM*). Panel B reports regressions relating S&P's and IDL's nature dependence scores to measures of downside risk. Panel C explores cross-sectional heterogeneity in the effects of nature dependence using corporate diversification and asset tangibility. Panel D provides robustness and placebo tests. The sample period is from 2011 to 2024, except if we control for *Ln(CBF)*, then it is from 2019 to 2023 (NatureDep scores from 2018 to 2022). Standard errors are clustered at the firm and year-month level. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix Table A1 provides variable definitions.

Panel A: Downside risk and NatureDep scores: Main estimates

Dependent variable:	*VaR*	*VaR*	*LPM*	*LPM*	*VaR*	*VaR*	*LPM*	*LPM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NatureDep^{Overall} (lag)	–0.006		–0.002		–0.018		–0.010	
	(0.020)		(0.006)		(0.055)		(0.017)	
NatureDep^{High} (lag)		0.012***		0.004***		0.020**		0.005**
		(0.003)		(0.001)		(0.008)		(0.002)
Ln(CBF) (lag)					-0.009	-0.009	–0.002	–0.002
					(0.009)	(0.009)	(0.003)	(0.003)
Ln(Total assets) (lag)	–0.064***	–0.064***	–0.025***	–0.025***	–0.066**	–0.062**	–0.021**	–0.020**
	(0.014)	(0.014)	(0.004)	(0.004)	(0.028)	(0.028)	(0.009)	(0.009)
Ln(Market cap) (lag)	–0.234***	–0.235***	–0.068***	–0.068***	–0.128***	–0.129***	–0.036***	–0.036***
	(0.015)	(0.015)	(0.005)	(0.005)	(0.031)	(0.031)	(0.010)	(0.010)
Capex/Total assets (lag)	1.696***	1.680***	0.543***	0.537***	2.637***	2.625***	0.780***	0.778***
	(0.154)	(0.154)	(0.049)	(0.049)	(0.492)	(0.489)	(0.152)	(0.151)
PPE/Total assets (lag)	–0.287***	–0.300***	–0.100***	–0.105***	–0.174	–0.195	–0.046	–0.053
	(0.047)	(0.047)	(0.015)	(0.015)	(0.128)	(0.127)	(0.039)	(0.038)
Debt/Total assets (lag)	0.164***	0.165***	0.068***	0.068***	0.024	0.028	0.008	0.009
	(0.054)	(0.054)	(0.017)	(0.017)	(0.124)	(0.124)	(0.038)	(0.038)
Market/Book ratio (lag)	0.038***	0.038***	0.011***	0.011***	0.023***	0.023***	0.007***	0.007***
	(0.003)	(0.003)	(0.001)	(0.001)	(0.006)	(0.006)	(0.002)	(0.002)
ROA (lag)	–3.840***	–3.843***	–1.109***	–1.110***	–1.933***	–1.951***	–0.576***	–0.582***
	(0.106)	(0.106)	(0.033)	(0.033)	(0.319)	(0.320)	(0.097)	(0.097)
Momentum 12M	–0.054***	–0.054***	–0.004***	–0.004***	–0.015	–0.015	–0.001	–0.001
	(0.004)	(0.004)	(0.001)	(0.001)	(0.013)	(0.013)	(0.004)	(0.004)
Standard deviation 12M	0.070***	0.070***	0.015***	0.015***	0.124***	0.124***	0.037***	0.037***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.009)	(0.009)	(0.003)	(0.003)
Industry × country × year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,851,567	1,851,567	1,851,567	1,851,567	90,526	90,526	90,526	90,526
R^2	0.427	0.427	0.377	0.377	0.551	0.551	0.545	0.545

Table 8 (continued)

Panel B: Downside risk and S&P and IDL scores

Dependent variable:	*VaR*	*VaR*	*LPM*	*LPM*
	(1)	(2)	(3)	(4)
S&P DC score (lag)	–0.080		–0.038	
	(0.093)		(0.029)	
IDL BD score (lag)		–0.003		–0.001
		(0.003)		(0.001)
Control variables as in Table 8, Panel A	Yes	Yes	Yes	Yes
Industry × country × year-month fixed effects	Yes	Yes	Yes	Yes
Obs.	103,402	82,140	103,402	82,140
R^2	0.406	0.559	0.384	0.552

Panel C: Downside risk and NatureDep scores: Cross-sectional heterogeneity

Dependent variable:	*VaR*	*LPM*	*VaR*	*LPM*
	(1)	(2)	(3)	(4)
$NatureDep^{High}$ *(lag)*	0.008**	0.003***	0.002	0.001
	(0.004)	(0.001)	(0.004)	(0.001)
High diversification (lag)	–0.061***	–0.017***		
	(0.016)	(0.005)		
$NatureDep^{High}$ *(lag)* × *High diversification (lag)*	0.004	0.001		
	(0.006)	(0.002)		
High tangibility (lag)			–0.159***	–0.049***
			(0.020)	(0.006)
$NatureDep^{High}$*(lag)* × *High tangibility (lag)*			0.020***	0.006***
			(0.005)	(0.002)
Control variables as in Table 8, Panel A	Yes	Yes	Yes	Yes
Industry × country × year-month fixed effects	Yes	Yes	Yes	Yes
Obs.	1,851,567	1,851,567	1,851,567	1,851,567
R^2	0.427	0.377	0.427	0.377

Panel D: Downside risk and NatureDep scores: Robustness and placebo tests

Dependent variable:	*VaR*	*LPM*	*VaR*	*LPM*	*VaR*	*LPM*
	(1)	(2)	(3)	(4)	(5)	(6)
$NatureDep^{High}$ *(lag)*	0.008***	0.003***	0.018***	0.006***		
	(0.003)	(0.001)	(0.004)	(0.001)		
HHI Revenue shares (lag)	0.148***	0.044***				
	(0.026)	(0.008)				
Ln(Scope 123 emissions) (lag)			0.007	0.003	0.010	0.004
			(0.009)	(0.003)	(0.009)	(0.003)
$PlaceboNatureDep^{High}$ *(lag)*					–0.006	–0.000
					(0.017)	(0.005)
Control variables as in Table 8, Panel A	Yes	Yes	Yes	Yes	Yes	Yes
Industry × country × year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,851,533	1,851,533	650,347	650,347	650,347	650,347
R^2	0.427	0.377	0.468	0.450	0.468	0.450

Table 9. NatureDep scores and nature-related incidents.

Note: Panels A and B report regressions relating NatureDep scores to nature-related incidents based on data from RepRisk. In both panels, we also report placebo tests from regressions relating NatureDep scores to governance-related incidents. The regressions include the following firm characteristics (not reported): *Ln(Total assets)*, *Capex/Total assets*, *PPE/Total assets*, *Debt/Total assets*, *Market/Book ratio*, and *ROA*. We multiply the coefficient and standard error of the NatureDep variables by 100. Panel C reports regressions relating NatureDep scores to measures of downside risk (*VaR* or *LPM*), whereby we split the sample using firm-years with and without nature-related incidents. The sample period is from 2011 to 2024. Standard errors are clustered at the firm and year level. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix Table A1 provides variable definitions.

Panel A: ***NatureDep^{Overall}***

Incident issue category	*NatureDep^{Overall}(lag)*	Obs.	Control variables	Country × year, industry × year fixed effects	R^2
Nature-related incident$^{Impacts\ on\ Ecosystems\ and\ Biodiversity}$ (%)	0.990**	84,340	Yes	Yes	0.134
Nature-related incident$^{Animal\ Mistreatment}$ (%)	0.007	84,340	Yes	Yes	0.038
Nature-related incident$^{Climate\ Change,\ GHG\ Emissions,\ and\ Global\ Poll.}$ (%)	0.223	84,340	Yes	Yes	0.115
Nature-related incident$^{Local\ Pollution}$ (%)	0.669*	84,340	Yes	Yes	0.116
Nature-related incident$^{Overuse\ and\ Wasting\ of\ Resources}$ (%)	0.185	84,340	Yes	Yes	0.061
Nature-related incident$^{Waste\ Issues}$ (%)	0.730***	84,340	Yes	Yes	0.067
Nature-related incident$^{Impacts\ on\ Communities}$ (%)	0.915**	84,340	Yes	Yes	0.143
Governance-related incident$^{All\ Incidents}$ (%)	-0.109	84,340	Yes	Yes	0.166

Panel B. ***NatureDep^{High}***

Incident issue category	*NatureDep^{High}(lag)*	Obs.	Control variables	Country × year, industry × year fixed effects	R^2
Nature-related incident$^{Impacts\ on\ Ecosystems\ and\ Biodiversity}$ (%)	0.133**	84,340	Yes	Yes	0.134
Nature-related incident$^{Animal\ Mistreatment}$ (%)	0.000	84,340	Yes	Yes	0.038
Nature-related incident$^{Climate\ Change,\ GHG\ Emissions,\ and\ Global\ Poll.}$ (%)	0.022	84,340	Yes	Yes	0.115
Nature-related incident$^{Local\ Pollution}$ (%)	0.087	84,340	Yes	Yes	0.116
Nature-related incident$^{Overuse\ and\ Wasting\ of\ Resources}$ (%)	0.034	84,340	Yes	Yes	0.061
Nature-related incident$^{Waste\ Issues}$ (%)	0.093**	84,340	Yes	Yes	0.067
Nature-related incident$^{Impacts\ on\ Communities}$ (%)	0.085	84,340	Yes	Yes	0.143
Governance-related incident$^{All\ Incidents}$ (%)	0.017	84,340	Yes	Yes	0.166

Table 9 (continued)

Panel C: *NatureDep*^{High} and downside risk: Role of nature incidents

	Incidents related to Ecosystem and Biodiversity Impact		Incidents related to Ecosystem and Biodiversity Impact	
	Yes	No	Yes	No
Dependent variable:	*VaR*	*VaR*	*LPM*	*LPM*
	(1)	(2)	(3)	(4)
NatureDep^{High}*(lag)*	0.049***	0.009**	0.014***	0.004***
	(0.016)	(0.004)	(0.005)	(0.001)
Control variables as in Table 8, Panel A	Yes	Yes	Yes	Yes
Industry × country × year-month fixed effects	Yes	Yes	Yes	Yes
Obs.	24,101	854,172	24,101	854,172
R^2	0.649	0.453	0.640	0.431

Supplementary Appendix

for

Firm-level nature dependence

Alexandre Garel, Arthur Romec, Zacharias Sautner, Alexander Wagner

Supplementary Appendix A. Ecosystem services in the updated ENCORE database.

This appendix reports the list of ecosystem services used in the updated ENCORE database. These 25 ecosystem services correspond to the SEEA-EA level 1. Level 2 ecosystem services are also included because some of the Level 1 ecosystem services are defined based on which Level 2 ecosystem services are included within them. The text is reproduced from ENCORE.

Level 1 ecosystem services	**Level 2 ecosystem services**	**Definition**
Provisioning services		
Biomass Provisioning	Crop provisioning services	Crop provisioning services are the ecosystem contributions to the growth of cultivated plants that are harvested by economic units for various uses including food and fibre production, fodder and energy. This is a final ecosystem service.
	Grazed biomass provisioning services	Grazed biomass provisioning services are the ecosystem contributions to the growth of grazed biomass that is an input to the growth of cultivated livestock. This service excludes the ecosystem contributions to the growth of crops used to produce fodder for livestock (e.g., hay, soybean meal). These contributions are included under crop provisioning services. This is a final ecosystem service but may be intermediate to livestock provisioning services.
	Livestock provisioning services	Livestock provisioning services are the ecosystem contributions to the growth of cultivated livestock and livestock products (e.g., meat, milk, eggs, wool, leather), that are used by economic units for various uses, primarily food production. This is a final ecosystem service. No distinct livestock provisioning services to be recorded if grazed biomass provisioning services are recorded as a final ecosystem service.
	Aquaculture provisioning services	Aquaculture provisioning services are the ecosystem contributions to the growth of animals and plants (e.g. fish, shellfish, seaweed) in aquaculture facilities that are harvested by economic units for various uses. This is a final ecosystem service
	Wood provisioning services	Wood provisioning services are the ecosystem contributions to the growth of trees and other woody biomass in both cultivated (plantation) and uncultivated production contexts that are harvested by economic units for various uses including timber production and energy. This service excludes contributions to non-wood forest products. This is a final ecosystem service.
	Wild fish and other natural aquatic products provisioning services	Wild fish and other natural aquatic biomass provisioning services are the ecosystem contributions to the growth of fish and other aquatic biomass that are captured in uncultivated production contexts by economic units for various uses, primarily food production. This is a final ecosystem service.
	Wild animals, plants and other biomass provisioning services	Wild animals, plants and other biomass provisioning services are the ecosystem contributions to the growth of wild animals, plants and other biomass that are captured and harvested in uncultivated production contexts by economic units for various uses. The scope includes non-wood forest products (NWFP) and services related to hunting, trapping and bio-prospecting activities; but excludes wild fish and other natural aquatic biomass (included in previous class). This is a final ecosystem service.
Genetic Material		Genetic material services are the ecosystem contributions from all biota (including seed, spore or gamete production) that are used by economic units, for example (i) to develop new animal and plant breeds; (ii) in gene synthesis; or (iii) in product development directly using genetic material. This is most commonly recorded as an intermediate service to biomass provisioning.
Water Supply		Water supply services reflect the combined ecosystem contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses including household consumption. This is a final ecosystem service.
Other Provisioning Services - Animal-Based Energy		Physical labour is provided by domesticated or commercial species, including oxen, horses, donkeys, goats and elephants. These can be grouped as draught animals, pack animals and mounts.
Regulating and maintenance services		
Global Climate Regulation		Global climate regulation services are the ecosystem contributions to the regulation of the chemical composition of the atmosphere and oceans that affect global climate through the accumulation and retention of carbon and other GHG (e.g., methane) in ecosystems and the ability of ecosystems to remove (sequester) carbon from the atmosphere. This is a final ecosystem service.
Rainfall Pattern Regulation (at		Rainfall pattern regulation services are the ecosystem contributions of vegetation, in particular forests, in maintaining rainfall patterns through evapotranspiration at the sub-continental scale. Forests and other vegetation recycle moisture back to the atmosphere where it is available for the generation of

sub-continental scale)		rainfall. Rainfall in interior parts of continents fully depends upon this recycling. This may be a final or intermediate service.
Local (Micro and Meso) Climate Regulation		Local climate regulation services are the ecosystem contributions to the regulation of ambient atmospheric conditions (including micro and mesoscale climates) through the presence of vegetation that improves the living conditions for people and supports economic production. Examples include the evaporative cooling provided by urban trees ('green space'), the role of urban water bodies ('blue space') and the contribution of trees in providing shade for humans and livestock. This may be a final or intermediate service.
Air Filtration		Air filtration services are the ecosystem contributions to the filtering of air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components, particularly plants, that mitigates the harmful effects of the pollutants. This is most commonly a final ecosystem service.
Soil Quality Regulation		Soil quality regulation services are the ecosystem contributions to the decomposition of organic and inorganic materials and to the fertility and characteristics of soils, e.g., for input to biomass production. This is most commonly recorded as an intermediate service.
Soil & Sediment Retention	Soil erosion control services	Soil erosion control services are the ecosystem contributions, particularly the stabilising effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). This may be recorded as a final or intermediate service.
	Landslide mitigation	Landslide mitigation services are the ecosystem contributions, particularly the stabilising effects of vegetation, that mitigates or prevents potential damage to human health and safety and damaging effects to buildings and infrastructure that arise from the mass movement (wasting) of soil, rock and snow. This is a final ecosystem service.
Solid Waste Remediation		Solid waste remediation services are the ecosystem contributions to the transformation of organic or inorganic substances, through the action of micro-organisms, algae, plants and animals that mitigates their harmful effects. This may be recorded as a final or intermediate service.
Water Purification (Water Quality Amelioration)		Water purification services are the ecosystem contributions to the restoration and maintenance of the chemical condition of surface water and groundwater bodies through the breakdown or removal of nutrients and other pollutants by ecosystem components that mitigate the harmful effects of the pollutants on human use or health. This may be recorded as a final or intermediate ecosystem service.
Water Flow Regulation	Baseline flow maintenance services	Water regulation services are the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and gradually release water during dry seasons or periods through evapotranspiration and hence secure a regular flow of water. This may be recorded as a final or intermediate ecosystem service.
	Peak flow mitigation services	Water regulation services are the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and hence mitigate the effects of flood and other extreme water-related events. Peak flow mitigation services will be supplied together with river flood mitigation services in providing the benefit of flood protection. This is a final ecosystem service.
Flood Mitigation	Coastal protection services	Coastal protection services are the ecosystem contributions of linear elements in the seascape, for instance coral reefs, sand banks, dunes or mangrove ecosystems along the shore, in protecting the shore and thus mitigating the impacts of tidal surges or storms on local communities. This is a final ecosystem service.
	River flood mitigation services	River flood mitigation services are the ecosystem contributions of riparian vegetation which provides structure and a physical barrier to high water levels and thus mitigates the impacts of floods on local communities. River flood mitigation services will be supplied together with peak flow mitigation services in providing the benefit of flood protection. This is a final ecosystem service.
Storm Mitigation		Storm mitigation services are the ecosystem contributions of vegetation including linear elements, in mitigating the impacts of wind, sand and other storms (other than water-related events) on local communities. This is a final ecosystem service.
Noise Attenuation		Noise attenuation services are the ecosystem contributions to the reduction in the impact of noise on people that mitigates its harmful or stressful effects. This is most commonly a final ecosystem service.
Pollination		Pollination services are the ecosystem contributions by wild pollinators to the fertilization of crops that maintains or increases the abundance and/or diversity of other species that economic units use or enjoy. This may be recorded as a final or intermediate service.
Biological Control	Pest control services	Biological control services are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of pests on biomass production processes or other economic and human activity. This may be recorded as a final or intermediate service.
	Disease control services	Disease control services are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of species on human health. This is most commonly a final ecosystem service.

Nursery Population and Habitat Maintenance		Nursery population and habitat maintenance services are the ecosystem contributions necessary for sustaining populations of species that economic units ultimately use or enjoy either through the maintenance of habitats (e.g., for nurseries or migration) or the protection of natural gene pools. This service is an intermediate service and may input to a number of different final ecosystem services including biomass provision and recreation-related services.
Dilution (by Atmosphere and Ecosystems) - Other Regulating and Maintenance		Water, both fresh and saline, and the atmosphere can dilute the gases, fluids and solid waste produced by human activity.
Mediation of Sensory Impacts (Other than Noise) - Other Regulating and Maintenance		Vegetation is the main (natural) barrier used to reduce light pollution and other sensory impacts, limiting the impact it can have on human health and the environment.
Cultural services (not used in the main analysis)		
Recreation-related Services		Recreation-related services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. This includes services to both locals and non-locals (i.e. visitors, including tourists). Recreation-related services may also be supplied to those undertaking recreational fishing and hunting. This is a final ecosystem service.
Visual Amenity Services		Visual amenity services are the ecosystem contributions to local living conditions, in particular through the biophysical characteristics and qualities of ecosystems that provide sensory benefits, especially visual. This service combines with other ecosystem services, including recreation-related services and noise attenuation services to underpin amenity values. This is a final ecosystem service.
Education, Scientific, and Research Services		Education, scientific and research services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use the environment through intellectual interactions with the environment. This is a final ecosystem service.
Spiritual, Artistic, and Symbolic services		Spiritual artistic and symbolic services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that are recognized by people for their cultural, historical, aesthetic, sacred or religious significance. These services may underpin people's cultural identity and may inspire people to express themselves through various artistic media. This is a final ecosystem service.

Supplementary Appendix B. Illustration of the computation of the NatureDep scores.

This appendix illustrates the computation of the NatureDep scores for ABC Mining, a fictitious mining company with two main economic activities (we provide the revenue distribution per activity). We first map the Refinitiv NAICS activities to their corresponding ISIC in the ENCORE database.

Segment Industry Name	Segment Revenue (%)	Segment Activities NAICS code	Corresponding ENCORE ISIC group/class code	Corresponding ENCORE ISIC group/class name
Other Warehousing and Storage	50%	493190	H_52_521	Warehousing and storage
Copper, Nickel, Lead, and Zinc Mining, Underground Coal Mining	50%	212230	B_7_72	Mining of non-ferrous metal ores

Based on ISIC codes, we map these activities to ENCORE's *Dependency Materiality Rating* and generate dependence scores for the different ecosystem services at the firm level, and an aggregate nature dependence score:

ENCORE Ecosystem Services VL=*Very Low*, L=*Low*, M=*Medium*, H=*High*, VH=*Very high*	ISIC: H_52_521 (50%)	ISIC: B_7_72 (50%)	ABC Mining Ecosystem *Dependence scores*: 0.5× H_52_521 + 0.5 × B_7_72
Other Provisioning Services			0
Biomass Provisioning		VL (2)	1
Solid Waste Remediation		L (3)	1.5
Soil & Sediment Retention	M (4)	M (4)	4
Water Purification		VH (6)	3
Soil Quality Regulation			0
Dilution		M (4)	2
Biological Control	VL (2)		1
Air Filtration	VL (2)	VL (2)	2
Flood Control	VL (2)	H (5)	3.5
Genetic Material			0
Global Climate Regulation	VL (2)	H (5)	3.5
Water Supply	VL (2)	H (5)	3.5
Nursery Population & Habitat Maintenance			0
Noise Attenuation		VL (2)	1
Mediation of Sensory Impact		L (3)	1.5
Local Climate Regulation	L (3)	L (3)	3
Pollination			0
Storm Mitigation	L (3)	M (4)	3.5
Water Flow Regulation	VL (2)	H (5)	3.5
Rainfall Pattern Regulation	VL (2)	VH (6)	4

The overall nature dependence score of ABC Mining is computed as the mean of the non-zero ecosystem services dependence scores. We remove zeros from the computation of the mean because they stand for an ecosystem service being irrelevant to an activity:

$$NatureDep_{ABC\ Mining}^{Overall} = \frac{1 + 1.5 + 4 + 3 + 2 + 1 + 2 + 3.5 + 3.5 + 3.5 + 1 + 1.5 + 3 + 3.5 + 3.5 + 4}{16}$$

$$= 2.59$$

Alternatively, the computation of our second aggregate measure is as follows:

$$NatureDep_{ABC\ Mining}^{High} = 2$$

Supplementary Appendix C. Computation of the NatureDep scores for Danone.

This appendix illustrates the computation of the NatureDep scores for Danone in the year 2023. The computation consists of five steps.

Step 1: Retrieving Refinitiv data on business activities

We retrieve information about Danone's economic activities from Refinitiv (RIC: *DANO.PA*), which provides revenue data by business segment together with the respective NAICS codes. Danone operates three business segments:

Segment name	Essential Dairy & Plant-based	Water	Specialized Nutrition
NAICS code	311514	312112	311511
Segment revenue (% of total revenue)	51.9	17.4	30.8

"Essential Dairy & Plant-based" produces dairy products and plant-based food, "Water" is active in water bottling, (e.g., Evian or Volvic), and "Specialized Nutrition" produces, for example, breast milk substitutes.

Step 2: Matching Refinitiv business segment data to ENCORE materiality ratings

We match Refinitiv business segment information to ENCORE materiality ratings by ecosystem services. To do so, we match NAICS codes to ISIC codes included in the ENCORE data. One NAICS code can match multiple ISIC codes. We then turn the ENCORE materiality ratings into numbers using the correspondence table in Section 2.1.2. (See Step 4 for cases where one segment has multiple NAICS codes.)

Segment name	Essential Dairy & Plant-based	Essential Dairy & Plant-based	Water	Specialized Nutrition	Specialized Nutrition
NAICS code	311514	311514	312112	456191	311511
Segment revenue (% of total revenue)	51.9	51.9	17.4	30.8	30.8
ENCORE ISIC code	C_10_105	C_10_107	C_11_110_1104	C_10_105	C_10_107
Other Provisioning Services	0	0	0	0	0
Biomass Provisioning	0	0	0	0	0
Solid Waste Remediation	4	4	4	4	4
Soil & Sediment Retention	3	3	3	3	3
Water Purification	6	6	6	6	5
Soil Quality Regulation	0	0	0	0	0
Dilution	3	3	3	3	3
Biological Control	2	2	2	2	2
Air Filtration	2	2	2	2	2
Flood Control	4	4	4	4	4
Genetic Material	0	0	0	0	0
Global Climate Regulation	2	2	2	2	2
Water Supply	5	5	5	5	5
Nursery Population & Habitat Maintenance	0	0	0	0	0
Noise Attenuation	0	0	0	0	0
Mediation of Sensory Impact	2	0	2	0	0
Local Climate Regulation	3	3	3	3	3
Pollination	0	0	0	0	0
Storm Mitigation	4	4	4	4	4
Water Flow Regulation	5	5	5	5	5
Rainfall Pattern Regulation	0	0	0	0	4
Recreation-Related Services	0	0	0	0	0
Visual Amenity Services	0	0	0	0	0
Education, Science, and Research Services	0	0	0	0	0
Spiritual, Artistic, and Symbolic Services	0	0	0	0	0

Supplementary Appendix C (continued)

Step 3: Averaging ENCORE materiality ratings by NAICS code

We average the information at the unique NAICS level for a given segment because one NAICS can map into several ENCORE ISIC codes (e.g., for "Essential Dairy & Plant-based").

Segment name	Essential Dairy & Plant-based	Water	Specialized Nutrition
NAICS code	311514	312112	311511
Segment revenue (%)	51.86	17.35	30.79
Other Provisioning Services	0	0	0
Biomass Provisioning	0	0	0
Solid Waste Remediation	4	4	4
Soil & Sediment Retention	3	3	3
Water Purification	6	5	6
Soil Quality Regulation	0	0	0
Dilution	3	3	3
Biological Control	2	2	2
Air Filtration	2	2	2
Flood Control	4	4	4
Genetic Material	0	0	0
Global Climate Regulation	2	2	2
Water Supply	5	5	5
Nursery Population & Habitat Maintenance	0	0	0
Noise Attenuation	0	0	0
Mediation of Sensory Impact	1	0	1
Local Climate Regulation	3	3	3
Pollination	0	0	0
Storm Mitigation	4	4	4
Water Flow Regulation	5	5	5
Rainfall Pattern Regulation	0	4	0
Recreation-Related Services	0	0	0
Visual Amenity Services	0	0	0
Education, Science, and Research Services	0	0	0
Spiritual, Artistic, and Symbolic Services	0	0	0

Step 4: Averaging NAICS level data at the business segment level

In cases where one business segment has multiple NAICS codes with the same revenue imputed to all of them, we average information at the business segment level (this step is not relevant in the Danone example as every segment has one NAICS code only).

Supplementary Appendix C (continued)

Step 5: Revenue-weighting of ENCORE materiality ratings

We weight the segment-level information on nature dependence by revenue and generate firm-level nature dependence scores for each ecosystem service.

Ecosystem service	NatureDep scores in 2023
Other Provisioning Services	0.00
Biomass Provisioning	0.00
Solid Waste Remediation	4.00
Soil & Sediment Retention	3.00
Water Purification	5.83
Soil Quality Regulation	0.00
Dilution	3.00
Biological Control	2.00
Air Filtration	2.00
Flood Control	4.00
Genetic Material	0.00
Global Climate Regulation	2.00
Water Supply	5.00
Nursery Population & Habitat Maintenance	0.00
Noise Attenuation	0.00
Mediation of Sensory Impact	0.83
Local Climate Regulation	3.00
Pollination	0.00
Storm Mitigation	4.00
Water Flow Regulation	5.00
Rainfall Pattern Regulation	0.69
Recreation-Related Services	0.00
Visual Amenity Services	0.00
Education, Science, and Research Services	0.00
Spiritual, Artistic, and Symbolic Services	0.00

Step 6: Aggregation at the firm level

We aggregate dependencies on ecosystem services to an overall firm-level nature dependence, either using the average one (excluding dependencies lower than 1 and cultural ecosystem services) or the number of dependencies on ecosystem services greater than or equal to 4 (excluding cultural services).

Overall NatureDep scores for 2023	Value
$NatureDep^{Overall}$	3.57
$NatureDep^{High}$	6

Supplementary Appendix D. Construction of nature dependence metrics by IDL and S&P.

This appendix illustrates how the nature dependence metrics by IDL and S&P are constructed. We use the IDL score described in IDL (2023) and the S&P score provided at the end of 2024.

1. IDL's Biodiversity Dependence Score (*IDL BD score*)

The starting point for the computation of the *IDL BD score* is also the *Dependency Materiality Rating* from ENCORE. IDL considers the 21 ecosystem services covered by the old version of the ENCORE database as well as four cultural ecosystem services for which they internally compute dependence scores based on sector research and expert interviews. On top of considering a different set of ecosystem services, the starting point for the construction of IDL measure also differs from ours because the materiality ratings of the previous iteration of the ENCORE database consider only direct potential dependencies whereas the updated version also considers some indirect dependencies due to downstream and upstream value chain links. At the firm level, for each ecosystem service, IDL computes a dependence score by taking the weighted average of the dependence scores for the different sectors in which the firm operates. This step also creates another source of divergence with our metric. As mentioned, the updated version of the ENCORE database offers more granularity for economic sectors. Overall, although the construction of the IDL's Biodiversity Score follows similar steps to ours, the major improvements to the ENCORE database, in particular related to the ecosystem services and to the computation of the materiality ratings, imply important differences to our measures.

2. S&P's Dependency Composite Score (*S&P DC score*)

S&P's Dependency Composite score (*S&P DC score*) is provided through S&P Global Sustainable1 and intends to capture the risks associated with business dependencies on nature by combining: (i) a reliance score: the level of reliance on (or exposure to) ecosystem services and (ii) a resilience score: the risk that ecosystems stop providing a continued flow of those services (or likelihood of ecosystem failure) (see S&P Global 2024). The score is calculated for a small fraction of firms using asset locations (e.g., for less than 25 percent of S&P 500 firms).[1] For all other firms, sector-level data of a firm's business activities is used. The reliance score is primarily based on the dependence materiality ratings from the previous version of the ENCORE database. Therefore, as in the case of IDL measure, it does not incorporate the improvements from the updated version. Further, for all firms for which asset-level data is not used, the reliance score is exclusively based on the ENCORE ratings. In some instances, S&P incorporates firm-specific information instead of the ENCORE activity-based score, notably for the ground and surface water ecosystem services for which the materiality scores use Trucost Environmental dataset, which provides information on firms' water withdrawal volumes.

For some regulatory and maintenance ecosystem services, S&P computes the reliance score by adjusting the materiality score using a relevance score. This relevance score captures that the potential for benefits from some ecosystem services are not evenly distributed spatially. For example, the benefits attached to flood protection services will be higher in areas of high flood risk. For ecosystem services for which the relevance score is not applicable, the reliance score is equal to the materiality scores mainly based on the ENCORE database.

[1] At the intersection of our and S&P's sample, location-level data is available for less than 20 percent of firms.

Supplementary Appendix D (continued)

The second component of S&P dependence score is a resilience score which intends to capture the capacity of ecosystems to continue to provide the necessary ecosystem services. While measuring ecosystem capacity is difficult and subject to high uncertainty, S&P uses as a proxy the integrity of the ecosystems providing the services, the underlying assumption being that an ecosystem in good condition is likely to provide the associated services. For the ecosystem for which a resilience score is applicable, S&P generally assesses the resilience risk using the Ecosystem Integrity Index average value locally. Specifically, S&P assesses for firms without asset-level data in which country "sector likely operates" (S&P Global 2024) and then applies the Ecosystem Integrity Index of Hill et al. (2022) to assess the ecosystem state (the index is available at 1km² resolutions and S&P applies average values across a country's spatial area). This approach is not unproblematic as ecosystems can vary substantially within countries and as the country locations of a firm's activities are only inferred (it is unclear based on S&P's methodology document how this is done).

The final dependence score to ecosystem service *i* is given by the following formula:

$$Dependence\ Score_i = \sqrt[n]{Reliance\ score_i \times Resilience\ score_i}$$

where *n* is the number of relevant score components for ecosystem service *i* (i.e., 2 if the resilience score is applicable and 1 if it is not applicable). When a resilience score is not applicable for a given ecosystem service, the dependence score is equal to the reliance score.

Finally, as business risks are not linear and may stem from a few high dependencies to a few ecosystem services, S&P does not use a linear aggregating function and rather constructs an aggregate dependency score as follows:

$$Aggregate\ Dependency\ Score = Min\left[\frac{\log(12\ \times \sum_{i=1}^{21} SigScore_i)}{2.3}, 1\right]$$

Where $SigScore_i$ is the sigmoid transform of the dependency score for ecosystem service *i* ($SigScore_i = 1/\ [1+ \exp\ (-(Score_i-0.5)*15)]$).

A strength of the S&P measure is that it incorporates to some extent the state of the ecosystem and the likelihood that it becomes disrupted and stops providing services. However, similar to IDL, it is based on the old version of the ENCORE database. Different from IDL's and our measures, the S&P measure does not have a time series and is computed at one point in time.

Supplementary Appendix E. Comparison of nature dependence metrics.

This appendix compares different nature dependence scores.

Metrics	Reliance on ENCORE's materiality ratings	Dependency scores available per ecosystem	Ecosystem services considered	Asset-level data and consideration of the state of ecosystem(s)	Dependencies considered	Time coverage	Geographic coverage	#Unique firms	#Firm-year obs.
NatureDep scores	ENCORE 2024	Yes	21 ecosystem services (Level 1 of the SEEA-EA excluding cultural services)	No	Direct and Indirect due to upstream and downstream value chain links	2010-2023	International (ID is GVKEY, ISIN, or RIC)	31,772	248,394
S&P DC score	ENCORE 2018-2023	Yes	21 ecosystem services (Level 1 of the SEEA-EA excluding cultural services)	Partially	Direct	Calendar year 2021 mostly, some data points for 2020.	International (ID is ISIN)	18,823	19,821
IDL BD score	ENCORE 2018-2023	Yes	21 ecosystem services (Common International Classification of Ecosystem Services)	No	Direct	2018-2022	International (ID is ISIN)	4,413	17,176

Supplementary Appendix F. Additional Tables and Figures

Table F.1. Rotated factor loadings of dependence scores at the ecosystem-service level.

Note: This table reports latent dimensions of firms' nature dependence grouped by the dominant factor. We conduct an exploratory factor analysis of the 21 ecosystem service dependence scores at the firm-year level. We estimate the factor model using principal factor extraction on the correlation matrix of the 21 services. The number of factors is selected based on the eigenvalue > 1 criterion, scree plot inspection, and interpretability. To facilitate interpretability, we apply an orthogonal varimax rotation, which redistributes variance across factors and simplifies the loadings such that each service tends to load strongly on one factor and weakly on others.

Ecosystem Service	Factor 1: Hydrological	Factor 2: Terrestrial & Biodiversity	Factor 3: Noise & Sensory	Factor 4: Climate & Rainfall	Uniqueness
Factor 1: Hydrological Dependence					
Water Flow Regulation	**0.98**	0.02	–0.05	0.06	0.03
Water Supply	**0.94**	0.00	–0.05	–0.01	0.12
Flood Control	**0.89**	–0.05	0.11	0.24	0.13
Water Purification	**0.86**	0.05	0.21	–0.04	0.22
Storm Mitigation	**0.86**	0.01	0.31	0.21	0.13
Solid Waste Remediation	**0.82**	0.13	0.25	–0.26	0.17
Dilution	**0.79**	0.00	0.28	0.01	0.30
Air Filtration	**0.63**	0.15	0.38	0.24	0.38
Factor 2: Terrestrial & Biodiversity Dependence					
Biomass Provisioning	0.00	**0.86**	0.06	–0.07	0.26
Nursery Population & Habitat Maint.	0.03	**0.82**	0.03	0.16	0.30
Soil Quality Regulation	0.07	**0.81**	0.02	0.13	0.33
Pollination	0.02	**0.45**	0.03	–0.19	0.76
Genetic Material	0.30	**0.31**	–0.19	–0.27	0.70
Factor 3: Noise & Sensory Regulation					
Noise Attenuation	0.22	0.08	**0.86**	0.16	0.17
Mediation of Sensory Impact	0.26	0.04	**0.86**	0.02	0.20
Factor 4: Climate & Rainfall Regulation					
Global Climate Regulation	0.06	0.16	0.04	**0.73**	0.43
Rainfall Regulation	0.23	0.03	0.17	**0.67**	0.47
Soil & Sediment Retention	0.44	–0.04	0.27	**0.50**	0.48
Not Well Captured (High Uniqueness)					
Local Climate Regulation	–0.09	0.13	0.11	0.17	**0.93**
Biological Control	–0.08	0.23	–0.51	0.07	**0.67**
Other Provisioning Services	–0.07	0.24	0.08	0.51	**0.67**

Table F.2. Dependence scores from IDL and S&P: Summary statistics.

Note: This table reports in Panel A summary statistics at the firm-year level for the *IDL BD score* (2018-2022) and in Panel B descriptive statistics for *S&P DC score* (for 2020-2022). Appendix Table A1 provides variable definitions.

Panel A: IDL BD score

Variable	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
IDL BD score	17,176	10.12	7.71	0.00	2.35	9.23	15.83	53.08
IDL Cultural Dependency score	17,176	2.72	7.06	0.00	0.00	0.00	0.96	48.00
IDL Provisioning Dependency score	17,176	17.02	15.68	-0.58	0.00	20.12	28.00	64.00
IDL Regulating Dependency score	17,176	10.28	8.52	0.00	3.75	8.02	15.09	66.25
IDL Cultural Aesthetic	11,847	2.09	10.31	0.00	0.00	0.00	0.00	80.00
IDL Cultural Information	11,845	3.24	12.00	0.00	0.00	0.00	0.00	80.00
IDL Cultural Inspiration	11,845	3.70	11.57	0.00	0.00	0.00	0.00	80.00
IDL Cultural Recreation	11,845	2.23	10.60	0.00	0.00	0.00	0.00	80.00
IDL Cultural Spirituality	11,845	0.11	1.43	0.00	0.00	0.00	0.00	26.67
IDL Provisioning Animal Energy	11,845	0.03	0.56	0.00	0.00	0.00	0.00	18.64
IDL Provisioning Fiber & Mat	11,845	2.08	10.04	0.00	0.00	0.00	0.00	100.00
IDL Provisioning Genetic Material	11,845	3.63	13.12	0.00	0.00	0.00	0.00	60.00
IDL Provisioning Ground Water	11,845	37.63	33.59	-1.23	0.00	48.60	60.00	100.00
IDL Provisioning Surface Water	11,845	39.54	35.37	-1.64	0.00	49.23	70.34	100.00
IDL Regulating Bioremediation	11,845	11.70	13.48	-4.53	0.00	5.27	20.00	60.00
IDL Regulating Buffering and Attenuation	11,845	0.27	2.74	0.00	0.00	0.00	0.00	43.58
IDL Regulating Climate	11,845	15.08	23.27	0.00	0.00	0.00	20.45	100.00
IDL Regulating Dilution	11,845	9.78	15.90	0.00	0.00	0.00	19.70	54.53
IDL Regulating Disease	11,845	0.22	3.00	0.00	0.00	0.00	0.00	74.55
IDL Regulating Filtration	11,847	8.98	12.55	-0.41	0.00	0.01	19.41	60.00
IDL Regulating Flood and Storm Protection	11,847	21.94	27.40	-0.41	0.00	0.63	52.58	100.00
IDL Regulating Maintain Nursery Habitat	11,847	0.02	0.81	0.00	0.00	0.00	0.00	43.58
IDL Regulating Mass Stabilization	11,847	35.89	15.83	0.00	31.56	40.00	40.00	93.19
IDL Regulating Mediation Sensory Impact	11,847	11.58	19.39	-0.82	0.00	0.00	19.01	60.00
IDL Regulating Pest Control	11,847	0.96	4.46	0.00	0.00	0.00	0.00	74.55
IDL Regulating Pollination	11,847	0.15	2.35	0.00	0.00	0.00	0.00	74.55
IDL Regulating Soil Quality	11,847	3.01	10.21	0.00	0.00	0.00	0.00	80.00
IDL Regulating Ventilation	11,847	3.48	6.77	0.00	0.00	0.00	1.80	43.58
IDL Regulating Water Flow Maintenance	11,847	21.22	26.30	0.00	0.00	0.00	50.28	100.00
IDL Regulating Water Quality	11,845	12.76	18.79	0.00	0.00	0.00	28.50	80.00

Panel B: S&P DC score

Variable	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
S&P DC score	19,821	0.55	0.22	0.01	0.44	0.62	0.71	1.00
S&P Provisioning Animal Energy	19,821	0.00	0.04	0.00	0.00	0.00	0.00	1.00
S&P Provisioning Fiber & Mat	19,821	0.02	0.11	0.00	0.00	0.00	0.00	1.00
S&P Provisioning Genetic Material	19,821	0.03	0.11	0.00	0.00	0.00	0.00	0.60
S&P Provisioning Ground Water	19,821	0.24	0.19	0.00	0.10	0.19	0.32	1.00
S&P Provisioning Surface Water	19,821	0.24	0.19	0.00	0.10	0.19	0.32	1.00
S&P Regulating Bioremediation	19,821	0.30	0.21	0.00	0.03	0.40	0.42	0.77
S&P Regulating Buffering and Attenuation	19,821	0.00	0.04	0.00	0.00	0.00	0.00	0.81
S&P Regulating Climate	19,821	0.19	0.26	0.00	0.00	0.00	0.40	0.98
S&P Regulating Dilution	19,821	0.14	0.22	0.00	0.00	0.00	0.27	0.70
S&P Regulating Disease	19,821	0.00	0.05	0.00	0.00	0.00	0.00	1.00
S&P Regulating Filtration	19,821	0.20	0.21	0.00	0.00	0.10	0.40	0.77
S&P Regulating Flood and Storm Protection	19,821	0.30	0.29	0.00	0.00	0.27	0.56	0.97
S&P Regulating Maintain Nursery Habitat	19,821	0.00	0.01	0.00	0.00	0.00	0.00	0.66
S&P Regulating Mass Stabilization	19,821	0.43	0.21	0.00	0.31	0.55	0.57	0.87
S&P Regulating Mediation Sensory Impact	19,821	0.18	0.26	0.00	0.00	0.00	0.46	0.77
S&P Regulating Pest Control	19,821	0.02	0.08	0.00	0.00	0.00	0.00	0.90
S&P Regulating Pollination	19,821	0.00	0.03	0.00	0.00	0.00	0.00	0.87
S&P Regulating Soil Quality	19,821	0.03	0.12	0.00	0.00	0.00	0.00	0.88
S&P Regulating Ventilation	19,821	0.03	0.07	0.00	0.00	0.00	0.00	0.60
S&P Regulating Water Flow Maintenance	19,821	0.15	0.21	0.00	0.00	0.00	0.34	0.90
S&P Regulating Water Quality	19,821	0.11	0.17	0.00	0.00	0.00	0.25	0.85

Table F.3. Evaluating measurement error in NatureDep scores.

Note: This table shows AR(1) regressions of NatureDep scores at the firm-year level. *Implied share measurement error* is calculated as $1 - (\frac{\beta}{\beta^{IV}})$, where β is the estimated coefficient in $NatureDep_{i,t} = \alpha + \beta\ NatureDep_{i,t-1} + \epsilon$ and β^{IV} is the coefficient on the instrumented $NatureDep_{i,t-1}$ variable in the same specification. Bootstrapped standard errors for *Implied Share Measurement Error* are in parentheses. Standard errors are clustered at the firm level for the bootstrapping. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix Table A1 provides variable definitions.

Panel A: *NatureDep^{Overall}*

Dependent variable:	*NatureDep^{Overall} (t)*		
	(1)	(2)	(3)
NatureDep^{Overall} (t–1)	0.985***	1.000***	0.997***
	(0.002)	(0.004)	(0.005)
Model	OLS	IV	IV
Instrument		*IDL BD score (t–1)*	*IDL BD score (t–2)*
Obs.	6,638	6,638	4,272
Implied share measurement error		0.015	0.012
		(0.003)	(0.004)

Panel B: *NatureDep^{High}*

Dependent variable:	*NatureDep^{High}(t)*		
	(1)	(2)	(3)
NatureDep^{High} (t–1)	0.966***	1.001***	1.002***
	(0.003)	(0.007)	(0.009)
Model	OLS	IV	IV
Instrument		*IDL BD score (t–1)*	*IDL BD score (t–2)*
Obs.	6,638	6,638	4,272
Implied share measurement error		0.035	0.036
		(0.006)	(0.008)

Table F.4. Determinant regressions: Summary statistics.

Note: This table reports summary statistics for the variables in Table 4, Panel B. Appendix Table A1 provides variable definitions.

Variables	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
NatureDep^{Overall}	219,248	2.75	0.44	1.57	2.40	2.80	3.04	4.00
NatureDep^{High}	219,248	1.93	2.24	0.00	0.00	1.00	4.00	13.00
Ln(Total assets) (lag)	219,248	20.07	2.02	15.70	18.67	19.89	21.33	25.50
Capex/Total assets (lag)	216,557	0.04	0.05	0.00	0.01	0.03	0.06	0.25
PPE/Total assets (lag)	216,360	0.26	0.22	0.00	0.07	0.21	0.40	0.86
Debt/Total assets (lag)	208,586	0.24	0.18	0.00	0.09	0.22	0.36	0.75
Market/Book ratio (lag)	207,722	2.41	3.20	0.08	0.79	1.42	2.69	22.18
ROA (lag)	219,083	0.02	0.10	–0.47	0.01	0.03	0.07	0.25
# Segments (lag)	219,248	2.36	1.23	1.00	1.00	2.00	3.00	18.00
Ln(CBF) (lag)	9,127	4.70	2.88	–3.75	3.19	5.18	6.71	9.90
Ln(Scope 123 emissions) (lag)	69,429	12.52	2.21	7.25	10.99	12.48	13.99	17.76
Ln(Scope 123 intensity) (lag)	69,429	5.42	1.21	3.24	4.61	5.38	6.12	8.88

Table F.5. List of BlackRock's engagement targets.

Note: This table lists biodiversity engagement targets of BlackRock since 2023 and their NatureDep scores for 2022.

Firm	$NatureDep^{Overall}$	$NatureDep^{High}$	GICS industry	Incorporation
AmorePacific Corp	3.23	7.00	Household & Personal Products	South Korea
Assurant Inc	2.14	0.00	Insurance	United States
Astra International Tbk PT	2.34	0.00	Capital Goods	Indonesia
BHP Group Ltd	2.89	2.00	Materials	Australia
Barclays PLC	2.14	0.00	Banks	United Kingdom
Bloomin' Brands Inc	3.18	3.00	Consumer Services	United States
Brickworks Ltd	2.97	0.00	Materials	Australia
Burberry Group PLC	2.33	0.00	Consumer Durables & Apparel	United Kingdom
CTBC Financial Holding Co Ltd	2.15	0.00	Banks	Taiwan
China Mengniu Dairy Co Ltd	3.39	6.00	Food, Beverage & Tobacco	Cayman Islands
Companhia Siderurgica Nacional SA	3.10	2.00	Materials	Brazil
Concha y Toro Winery Inc	4.00	7.00	Food, Beverage & Tobacco	Chile
Darling Ingredients Inc	3.42	5.00	Food, Beverage & Tobacco	United States
Deere & Co	2.85	0.00	Capital Goods	United States
Ecopetrol SA	3.01	3.00	Energy	Colombia
First Pacific Co Ltd	3.32	4.00	Food, Beverage & Tobacco	Bermuda
Fuji Oil Co Ltd	3.56	6.00	Food, Beverage & Tobacco	Japan
General Mills Inc	3.52	6.00	Food, Beverage & Tobacco	United States
Genesis Energy Ltd	3.05	3.00	Utilities	New Zealand
Grupo Carso SAB de CV	3.02	2.00	Capital Goods	Mexico
Guangdong Investment Ltd	2.81	1.00	Utilities	Hong Kong
Heineken NV	4.00	7.00	Food, Beverage & Tobacco	Netherlands
Hershey Co	3.52	6.00	Food, Beverage & Tobacco	United States
Holmen AB	2.69	0.00	Materials	Sweden
Hong Kong and China Gas Co Ltd	2.63	1.00	Utilities	Hong Kong
JPMorgan Chase & Co	2.14	0.00	Banks	United States
Jiangxi Copper Co Ltd	3.42	5.00	Materials	China
Levi Strauss & Co	2.38	0.00	Consumer Durables & Apparel	United States
Lululemon Athletica Inc	3.14	6.00	Consumer Durables & Apparel	United States
Marks and Spencer Group PLC	2.95	0.00	Consumer Staples Distribution & Retail	United Kingdom
McDonald's Corp	3.09	1.00	Consumer Services	United States
Meiji Holdings Co Ltd	3.54	5.00	Food, Beverage & Tobacco	Japan
Molson Coors Beverage Co	2.56	2.00	Food, Beverage & Tobacco	United States
Mondelez International Inc	3.57	6.00	Food, Beverage & Tobacco	United States
Nippon Paper Industries Co Ltd	3.02	0.00	Materials	Japan
Papa John's International Inc	3.06	3.00	Consumer Services	United States
PepsiCo Inc	3.31	6.00	Food, Beverage & Tobacco	United States
Procter & Gamble Co	2.86	4.00	Household & Personal Products	United States
Royal Bank of Canada	2.14	0.00	Banks	Canada
SIG Group AG	2.93	3.00	Materials	Switzerland
Sappi Ltd	3.04	3.00	Materials	South Africa
Shiseido Co Ltd	2.71	0.00	Household & Personal Products	Japan
South32 Ltd	3.50	3.00	Materials	Australia
Spirax Group PLC	2.96	5.00	Capital Goods	United Kingdom
Starbucks Corp	3.23	3.00	Consumer Services	United States
Stora Enso Oyj	2.96	1.00	Materials	Finland
Symrise AG	3.13	4.00	Materials	Germany
Tokushu Tokai Paper Co Ltd	2.96	0.00	Materials	Japan
Vestas Wind Systems A/S	3.10	5.00	Capital Goods	Denmark
Vulcan Materials Co	2.85	2.00	Materials	United States
WEC Energy Group Inc	2.65	0.00	Utilities	United States
Yum! Brands Inc	3.27	4.00	Consumer Services	United States

Table F.6. Summary statistics for BlackRock biodiversity engagements.

Note: This table reports summary statistics for the variables in Table 7. Appendix Table A1 provides variable definitions.

Variable	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
BiodivEng	6,522	0.80	8.89	0.00	0.00	0.00	0.00	100.00
NatureDep^{Overall} (lag)	6,522	2.72	0.44	1.67	2.33	2.78	3.02	4.00
NatureDep^{High} (lag)	6,522	1.73	2.14	0.00	0.00	0.00	4.00	8.00
BlackRock stake (lag)	6,522	2.89	4.01	0.00	0.25	1.10	3.82	16.46
BlackRock portfolio share (lag)	6,522	0.30	0.95	0.00	0.00	0.01	0.13	6.66
PPE/Total assets (lag)	6,522	0.25	0.21	0.00	0.09	0.21	0.37	0.92
Ln(Total assets) (lag)	6,522	7.91	1.79	1.41	6.66	7.83	9.13	11.40
Cash/Total assets (lag)	6,522	0.15	0.14	0.00	0.05	0.11	0.21	0.94
Debt/Total assets (lag)	6,522	0.26	0.20	0.00	0.10	0.24	0.37	2.07
Market/Book ratio (lag)	6,522	1.58	3.15	0.10	0.60	0.92	1.54	42.28
ROA (lag)	6,522	0.07	0.11	–1.79	0.03	0.06	0.11	0.51
Stock return 1y (lag)	6,522	–0.07	0.52	–0.83	–0.30	–0.11	0.07	14.54

Table F.7. BlackRock biodiversity engagements: Controlling for S&P's scores.

Note: This table presents regressions relating NatureDep scores to biodiversity engagements by BlackRock after controlling for S&P's score of nature dependence (*S&P DC score*). The sample period is the year 2023 (NatureDep scores for 2022). The sample size is lower than in our baseline estimation because S&P covers fewer firms. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. We multiply the dependent variable by 100. Appendix Table A1 provides variable definitions.

Dependent variable:	*BiodivEng*	
	(1)	(2)
NatureDep^{Overall} (lag)	0.870**	
	(0.406)	
NatureDep^{High} (lag)		0.040
		(0.067)
S&P DC score	–0.571	–0.323
	(0.768)	(0.759)
BlackRock stake (lag)	0.314***	0.314***
	(0.075)	(0.075)
BlackRock portfolio share (lag)	0.213	0.204
	(0.243)	(0.243)
PPE/Total assets (lag)	0.513	0.629
	(0.819)	(0.821)
Ln(Total assets) (lag)	0.083	0.089
	(0.105)	(0.105)
Cash/Total assets (lag)	–0.013	0.005
	(1.090)	(1.093)
Debt/Total assets (lag)	0.137	0.160
	(0.838)	(0.838)
Market/Book ratio (lag)	–0.056	–0.059
	(0.048)	(0.049)
ROA (lag)	–1.102	–0.968
	(1.353)	(1.353)
Stock return 1y (lag)	–0.079	–0.080
	(0.264)	(0.264)
Country fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Obs.	4,463	4,463
R^2	0.038	0.037

Table F.8. Stock returns and NatureDep scores.

Note: This table reports regressions relating NatureDep scores to stock returns (*Stock return*). The sample period is from 2011 to 2024. Standard errors are clustered at the firm and year-month level. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix Table A1 provides variable definitions.

Dependent variable:	*Stock return*	*Stock return*
	(1)	(2)
$NatureDep^{Overall}$ *(lag)*	–0.035	
	(0.040)	
$NatureDep^{High}$ *(lag)*		0.003
		(0.007)
Control variables as in Table 8, Panel A	Yes	Yes
Industry × country × year-month fixed effects	Yes	Yes
Obs.	1,851,567	1,851,567
R^2	0.283	0.283

Table F.9. Downside risk regressions: Summary statistics.

Note: This table reports summary statistics for the variables in Table 8. Appendix Table A1 provides variable definitions.

Variable	Obs.	Mean	S.D.	Min	p25	p50	p75	Max
VaR (%)	1,851,567	4.71	3.30	0.66	2.53	3.82	5.83	20.73
LPM (%)	1,851,567	1.41	1.04	0.00	0.74	1.14	1.76	6.33
Stock return (%)	1,851,567	0.66	13.12	–46.25	–5.78	0.00	6.05	55.15
NatureDep^{Overall} (lag)	1,851,567	2.76	0.43	1.57	2.41	2.82	3.04	4.00
NatureDep^{High} (lag)	1,851,567	1.90	2.21	0.00	0.00	1.00	4.00	13.00
PlaceboNatureDep^{High} (lag)	1,851,567	0.22	0.62	0.00	0.00	0.00	0.00	4.00
High diversification (lag)	1,851,567	0.41	0.49	0.00	0.00	0.00	1.00	1.00
High tangibility (lag)	1,851,567	0.50	0.50	0.00	0.00	0.00	1.00	1.00
HHI Revenue shares (lag)	1,851,567	0.71	0.24	0.08	0.51	0.71	0.99	1.00
Ln(Total assets) (lag)	1,851,567	20.38	1.98	15.97	19.01	20.20	21.63	25.59
Ln(Market cap) (lag)	1,851,567	19.88	1.99	14.69	18.45	19.89	21.20	24.55
Capex/Total assets (lag)	1,851,567	0.04	0.04	0.00	0.01	0.03	0.06	0.24
PPE/Total assets (lag)	1,851,567	0.26	0.21	0.00	0.08	0.22	0.39	0.85
Debt/Total assets (lag)	1,851,567	0.24	0.18	0.00	0.09	0.22	0.36	0.73
Market/Book ratio (lag)	1,851,567	2.34	2.93	0.08	0.80	1.44	2.68	20.89
ROA (lag)	1,851,567	0.02	0.09	–0.46	0.01	0.03	0.06	0.24
Momentum 12M (%)	1,851,567	0.32	4.42	–20.32	–1.71	0.26	2.25	18.40
Standard deviation 12M (%)	1,851,567	12.79	12.49	2.43	6.83	9.79	14.28	111.32

Table F.10. Downside risk regressions: Dependence on individual ecosystem services.

Note: This table reports coefficient estimates from regressions relating high dependencies to specific ecosystem services to measures of downside risk (*VaR* or *LPM*). The sample period is from 2011 to 2024. Control variables as in Table 8, Panel A, are included. Standard errors are clustered at the firm and year-month level. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. We require the dummy to be populated for at least 5 percent of the sample.

	VaR	Obs.	R^2	*LPM*	Obs.	R^2
Solid Waste Remediation	–0.030	1,851,567	0.427	–0.003	1,851,567	0.377
Soil & Sediment Retention	–0.004	1,851,567	0.427	–0.002	1,851,567	0.377
Water Purification	0.067***	1,851,567	0.427	0.021***	1,851,567	0.377
Flood Control	0.076***	1,851,567	0.427	0.027***	1,851,567	0.377
Water Supply	0.025	1,851,567	0.427	0.007	1,851,567	0.377
Storm Mitigation	0.063***	1,851,567	0.427	0.024***	1,851,567	0.377
Water Flow Regulation	0.032**	1,851,567	0.427	0.014***	1,851,567	0.377
Rainfall Pattern Regulation	0.007	1,851,567	0.427	0.007	1,851,567	0.377

Table F.11. Downside risk regressions: Further robustness checks.

Note: This table reports regressions relating $NatureDep^{High}$ to measures of downside risk (*VaR* or *LPM*). Standard errors are clustered at the firm and year-month level, except in Columns 1 and 2 where we two-way cluster standard errors at the country-by-time and industry-by-time level. In Column 3, we use an alternative definition of *LPM*, which focuses on returns below the monthly mean (instead of below zero). In Columns 4 to 7, we evaluate the sensitivity of our results to how we map segment activities and high dependencies. We consider whether results change if we winsorize segment weights at the 1 percent level or cap the counted high dependencies at six. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Appendix Table A1 provides variable definitions.

Dependent variable:	*VaR*	*LPM*	*LPM*	*VaR*	*VaR*	*LPM*	*LPM*
			Mean as Threshold	Winsorize Segment Weights at 1 percent	Cap High Dependence at 6	Winsorize Segment Weights at 1 percent	Cap High Dependence at 6
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$NatureDep^{High}$ *(lag)*	0.012***	0.004***	0.005***	0.012***	0.013***	0.004***	0.005***
	(0.001)	(0.000)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)
Control variables as in Table 8, Panel A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × country × year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,851,567	1,851,567	1,848,045	1,851,567	1,851,567	1,851,567	1,851,567
R^2	0.427	0.377	0.276	0.427	0.427	0.377	0.377

Table F.12. NatureDep scores, ecosystem and regulation shocks: Stock price reactions.

Note: This table presents results relating NatureDep scores ($NatureDep^{High}$) to the market reaction to various nature-related events (indicated in the table). We split firms based on median values of $NatureDep^{High}$ into high- and low groups. CR stands for unadjusted cumulative daily returns. CAR stands for cumulated daily excess return relative to sample firms sharing same GICS industry group and country of stock exchange. The event windows are [-3,3] days. For CR and CAR constructions, we winsorize daily returns at 1 and 99 percent levels.

Event	Low Nature Dep (%)	High Nature Dep (%)	Diff (%)	*p*-value
Kunming Event (13/10/2021, all firms)				
CR [–3,3]	2.217	2.081	0.137	0.327
CAR [–3,3]	0.147	0.080	0.067	0.599
Montreal Event (19/12/2022, all firms)				
CR [–3,3]	–2.241	–2.737	0.496	0.000
CAR [–3,3]	0.107	0.063	0.044	0.695
EU Nature Restoration Law (24/6/2024, EU firms)				
CR [–3,3]	–0.432	–0.601	0.169	0.570
CAR [–3,3]	0.052	–0.031	0.083	0.750
President Trump Removal Endangered Species Act (15/12/2020, US firms)				
CR [–3,3]	1.544	1.058	0.486	0.339
CAR [–3,3]	0.389	–0.200	0.589	0.234
President Biden Restoration Endangered Species Act (28/3/2024, US firms)				
CR [–3,3]	0.484	0.875	–0.391	0.428
CAR [–3,3]	0.077	0.177	–0.099	0.834

Table F.13. RepRisk incidents: Summary statistics

Note: This table reports summary statistics for the dependent variables in Table 9. Appendix Table A1 provides variable definitions.

Variable	Obs.	Mean
Nature-related incident$^{Impacts\ on\ Ecosystems\ and\ Biodiversity}$ (%)	108,344	3.83
Nature-related incident$^{Impacts\ on\ Communities}$ (%)	108,344	4.43
Nature-related incident$^{Local\ Pollution}$ (%)	108,344	3.02
Nature-related incident$^{Climate\ Change,\ GHG\ Emissions,\ and\ Global\ Pollution}$ (%)	108,344	2.05
Nature-related incident$^{Waste\ Issues}$ (%)	108,344	1.40
Nature-related incident$^{Overuse\ and\ Wasting\ of\ Resources}$ (%)	108,344	0.55
Nature-related incident$^{Animal\ Mistreatment}$ (%)	108,344	0.20
Governance-related incidents$^{All\ incidents}$ *(%)*	108,344	6.67

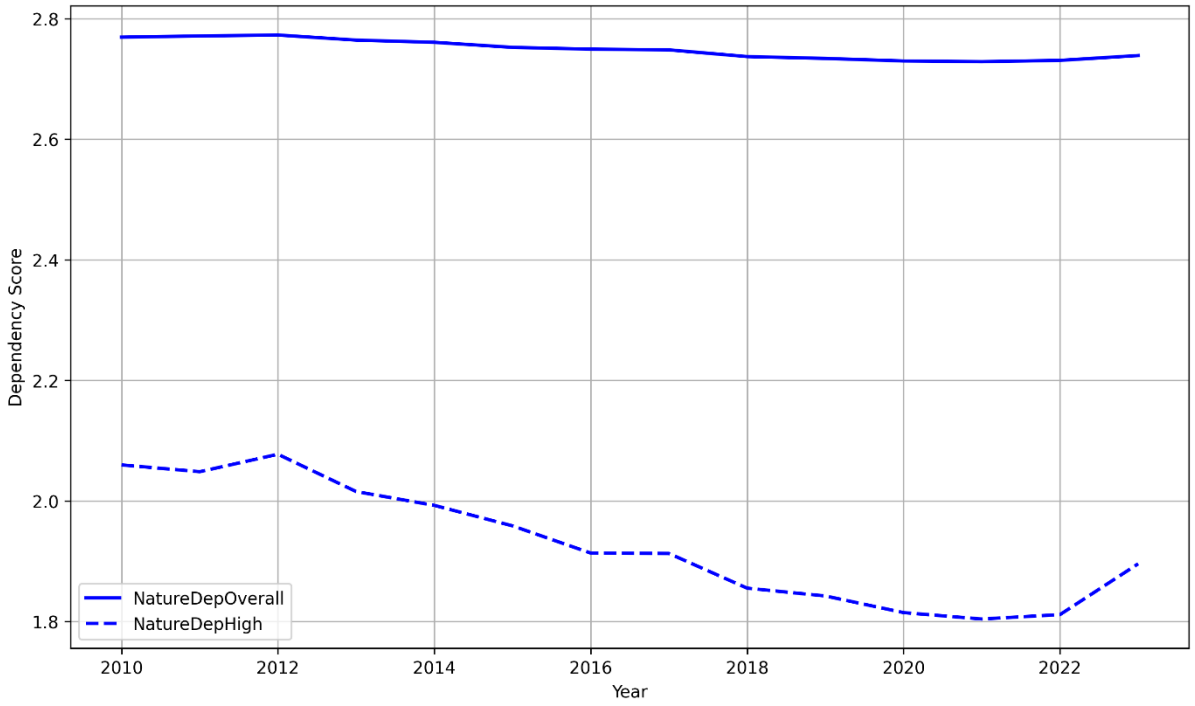


Figure F.1. NatureDep scores over time.

Note: This figure shows the time-series evolution of $NatureDep^{Overall}$ and $NatureDep^{High}$, calculated based on yearly average values across sample firms.

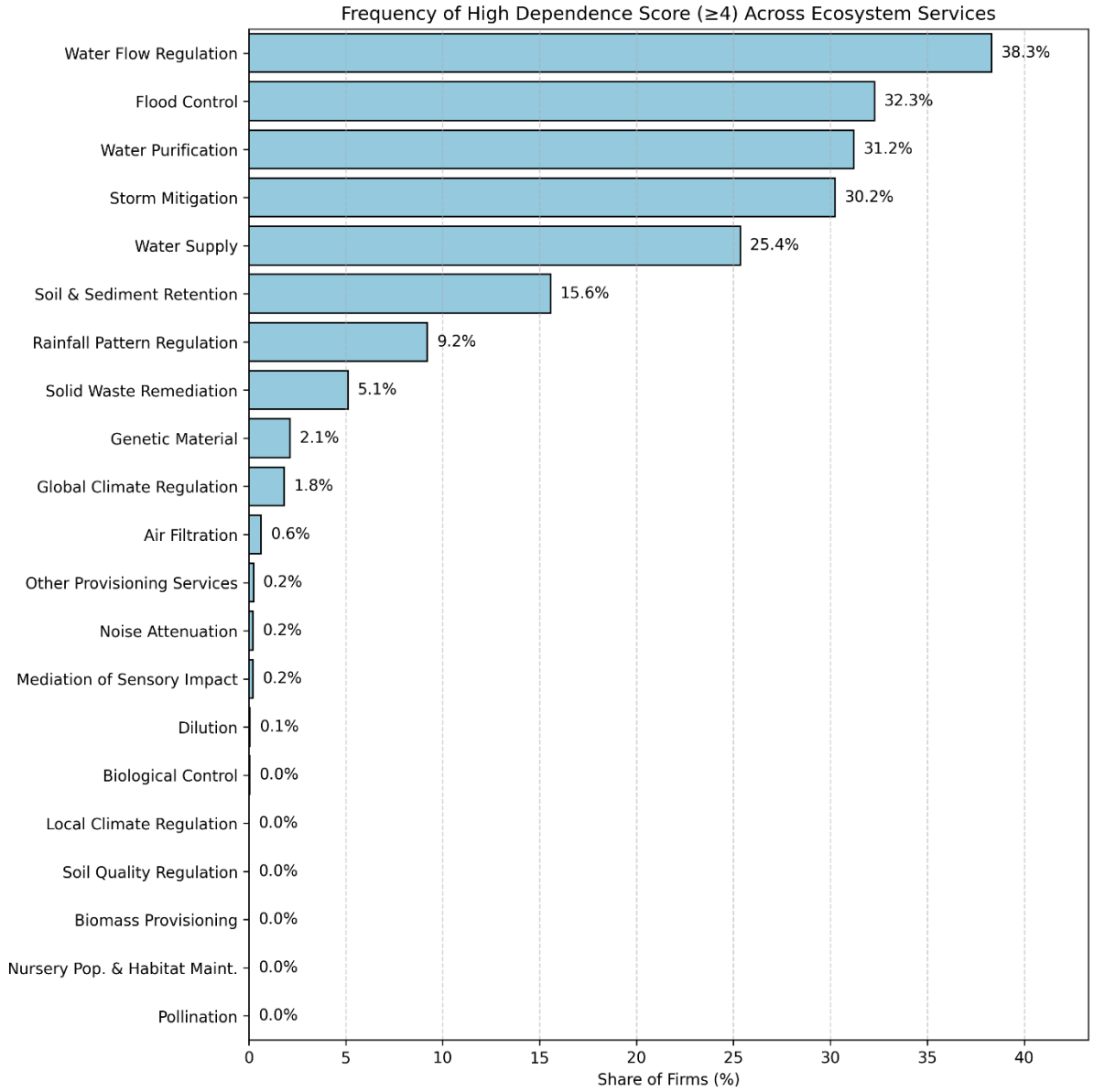


Figure F.2. High dependence scores for different ecosystem services.

Note: This figure shows the percentage of sample firm-year observations with dependence score of four or larger for each ecosystem service. Reported percentages are rounded to the first decimal place.

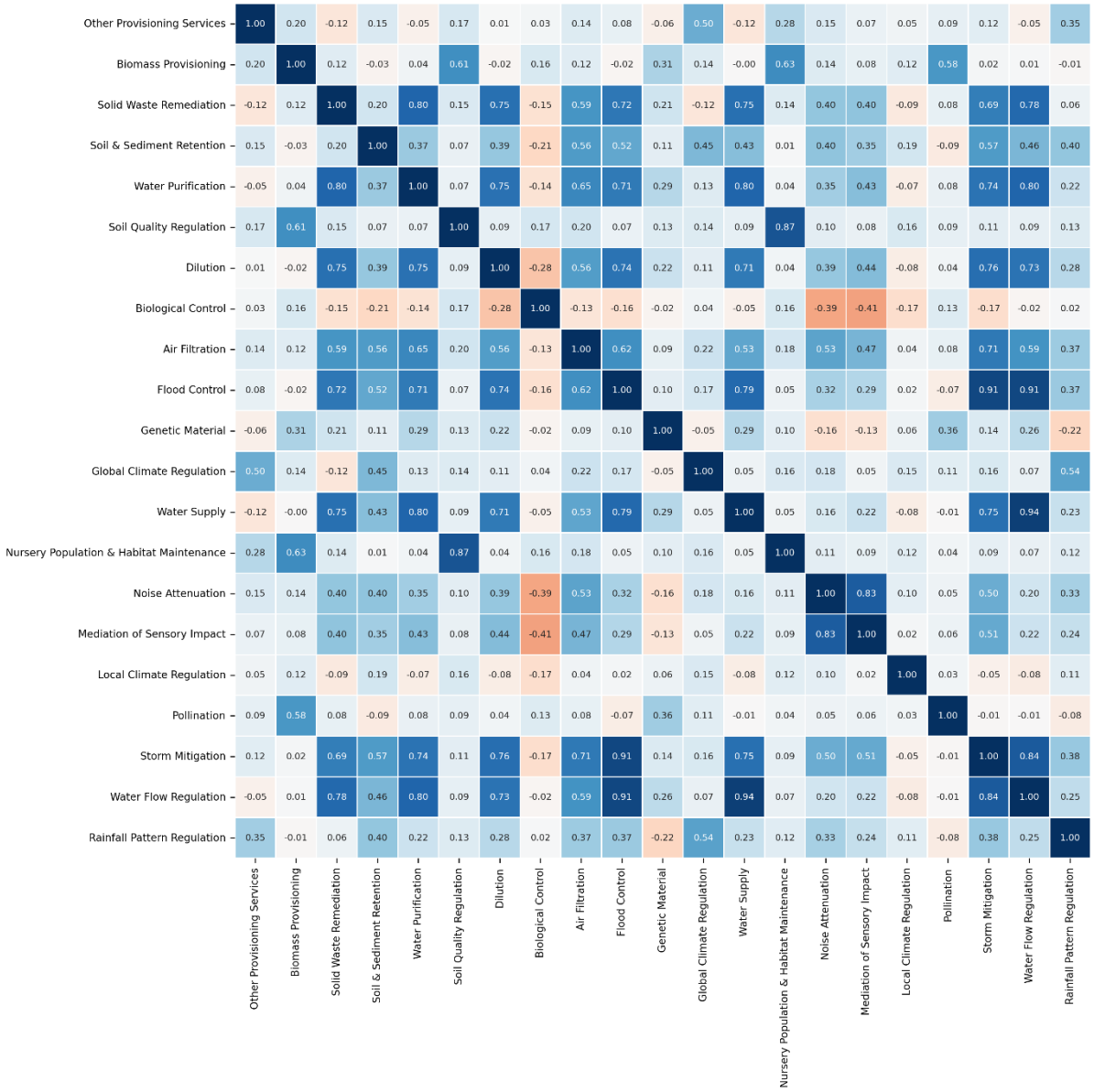


Figure F.3. Pairwise correlations across ecosystem service dependence scores.

Note: This figure shows a heatmap of the pairwise correlations across the dependence scores at the ecosystem-service level (based on the overall measures).

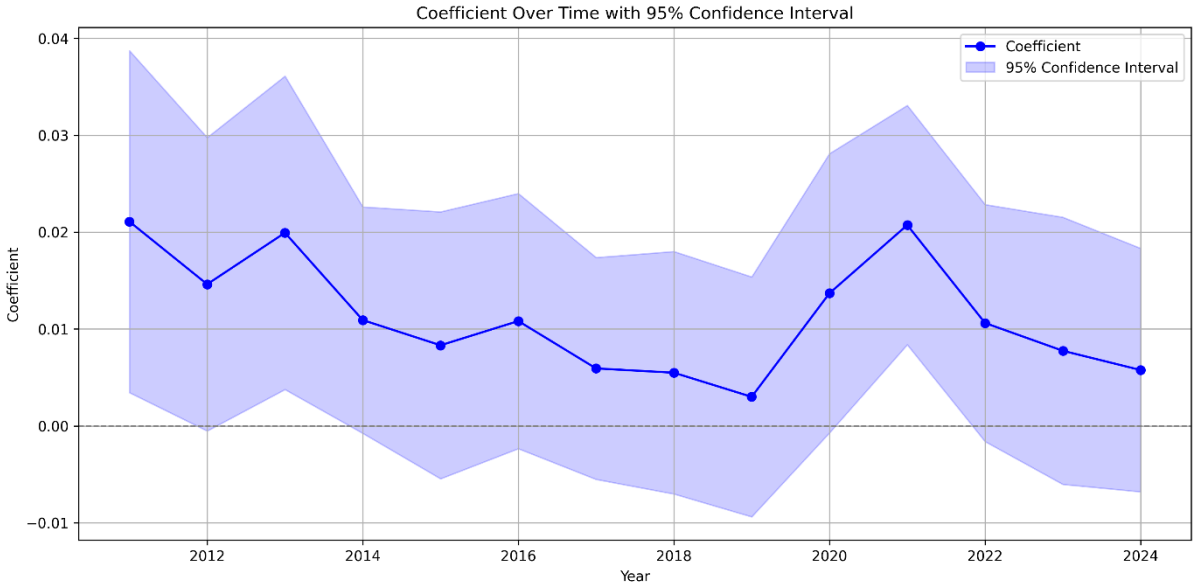


Figure F.4. Downside risk regressions: Year-by-year regression estimates.

Note: This figure shows the coefficient estimates and 95 percent confidence intervals for $NatureDep^{High}$ *(lag)* based on year-by-year regressions using the specification in Table 8, Panel A, Column 2.

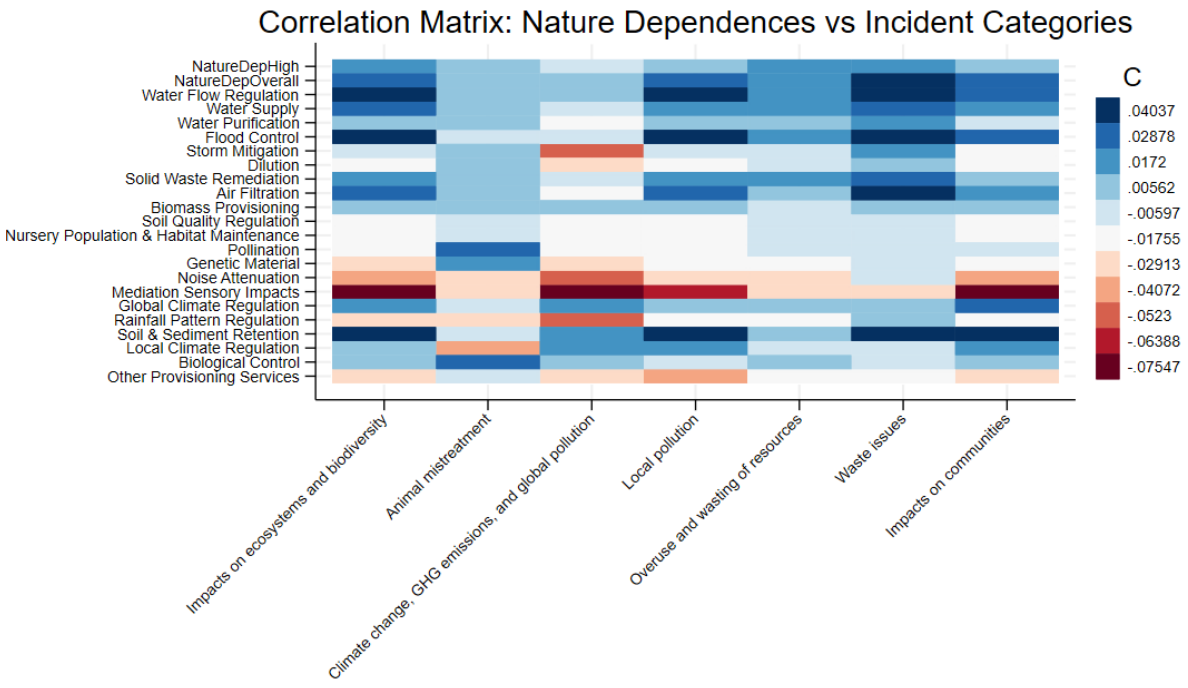


Figure F.5. Correlation matrix: NatureDep scores vs. nature-related incidents.

Note: This figure reports the correlations (C) between our nature dependence scores (*t–1*) and categories of nature-related incidents (*t*).

Supplementary Appendix G. Comparison with biodiversity and physical climate risk metrics.

This appendix compares the NatureDep scores with biodiversity and physical climate risk exposure measures. In Supplementary Appendix Table G.1, Panel A, we compare the NatureDep scores with biodiversity-related measures. We consider *MSCI Biodiversity & Land Use Exposure*, which captures biodiversity impact with a focus on land use. $NatureDep^{Overall}$ exhibits a correlation of 0.42 with the MSCI metric, while the correlation with $NatureDep^{High}$ is only 0.28. We find no meaningful correlations with the 10-K-based biodiversity risk measures from Giglio et al. (2025c), which are dummy variables capturing whether U.S. firms discuss biodiversity in their 10-Ks. The low correlations are consistent with the earlier evidence that the NatureDep scores overlap poorly with text-based measures from earnings calls. Another reason is that Giglio et al. (2025c)'s measures do not seek to *quantify* how firms are exposed to physical risks. Finally, we consider *S&P Biodiversity impact*, a metric that captures risks associated with a business' impact on nature (measured as the degree to which business operations cause a footprint on the state of nature based on land use, ecosystem integrity degradation, and the significance of the locations impacted). The NatureDep scores appear largely orthogonal to this metric (correlations below 1 percent).

In Supplementary Appendix Table G.1, Panel B, we compare the NatureDep scores with measures of *physical* climate risk exposure. Both risk exposures may overlap if disruptions to ecosystems induced by climate change deteriorate some of the services they provide. In addition, some ecosystem services—such as the protection against floods or storms or the access to fresh water—may directly be affected by climate change. Hence, there may be compound shocks to financial systems resulting from any interconnectedness of exposure to nature and climate risks (Financial Stability Board 2024). That said, other aspects cause these two risk exposures to be possibly distinct. First, while the fundamental sources of the risks underlying both measures can overlap (e.g., if disruptions to ecosystems induced by climate change deteriorate some of the services they provide), they can also differ. For example, while many pharmaceutical firms are highly dependent on nature—especially genetic material—their labs, processing plants, and headquarters may be in climate-stable regions. Similarly, exposure to both risks may be distinct because insurance to hedge against physical climate risks exists, while such hedging is less available for nature risks. Second, our measures do not reflect risk *realizations*, while the text-based measures can reflect realized climate risks. Third, the construction of the measures is distinct; while the two climate risk measures tend to be forward-looking in nature (e.g., by reflecting expected changes in the climate as perceived by managers or analysts), the ENCORE data underlying our measures focus more on the status quo, not future projections.

We use proxies from Sautner et al. (2023) and Li et al. (2024), who both apply textual analysis to earnings calls to identify climate risk exposures. The measures differ in terms of methodology and sample. Sautner et al. (2023) develop a keyword discovery algorithm to construct climate change bigrams in earnings calls whereas Li et al. (2024) use a pre-specified training library to identify climate risk words. The Li et al. (2024) measures focus on U.S. firms, and the measures from Sautner et al. (2023) are available for an international sample. The correlations range from -0.02 to 0.04, indicating that while nature dependence and physical climate risk measures have some overlap, the NatureDep metrics are not strongly influenced by a firm's physical climate risk exposure. Hence, although in aggregate nature loss and climate change are closely intertwined, the firm-level link between physical nature and climate risk exposures is modest, at least based on the measures we use. A conclusion is that physical nature risk and nature dependence constitute distinct firm-level exposures, implying that separate risk management strategies are needed.

Table G.1. NatureDep scores and biodiversity and physical climate risk exposure metrics.

Note: Panel A reports Pearson correlations for our firm-level measures of nature dependence with biodiversity measures. The sample period depends on the intersections between the NatureDep scores and the other constructs. The MSCI score from 2013 to 2021, the biodiversity risk count scores from 2010 to 2022, and the second S&P score for 2020 or 2021 (mostly 2021). Panel B reports correlations with measures of physical climate risks. The sample period depends on the intersections between the NatureDep scores and the other constructs. The first five measures are constructed by Sautner et al. (2023) based on discussions of physical climate change topics in earnings calls for a global sample of firms. The sample period is from 2010 to 2022. The next two measures are constructed by Li et al. (2024) for earnings calls of U.S. firms. The sample period from 2010 to 2022.* represents a significance level of 0.01. Appendix table A1 provides variable definitions.

Panel A: Correlations with biodiversity metrics

	$NatureDep^{Overall}$	$NatureDep^{High}$
MSCI Biodiversity & Land Use Exposure	0.422*	0.276*
Biodiversity risk count	0.078*	0.032*
Biodiversity risk count negative	0.033*	0.024*
S&P Biodiversity impact	0.014	–0.006

Panel B: Correlations with physical climate risk metrics

	$NatureDep^{Overall}$	$NatureDep^{High}$
Physical climate exposure	0.036*	0.017*
Physical climate risk	–0.019*	–0.014*
Physical climate positive sent	0.025*	0.009
Physical climate negative sent	0.003	0.003
Physical climate overall sent	0.022*	0.010
Acute physical climate risk	0.004	–0.016
Chronic physical climate risk	0.037*	–0.014

Supplementary Appendix H. Case studies illustrating the financial effects of nature dependence.

This appendix provides examples illustrating how nature dependence can create financially material impacts.

Firm	Date	ENCORE ecosystem services	Trigger: Ecosystem event or restriction	Financial impact	Channel linking dependence to impact
Tesla Gigafactory (Germany)	2020–2024	Surface & Groundwater Regulation	Water stress, local protests, regulatory restrictions on groundwater use	~$5.7 bn extra cost; 3.1 percent share price drop	Denied water permits and protests delayed construction and increased costs
Manitoba Hydro (Canada)	2024	Surface Water for Hydropower Generation	Drought reducing precipitation and reservoir levels	CAD 157 m net loss (vs. CAD 638 m profit prior year)	Reduced reservoir inflows cut hydro generation; expensive imports needed
Engie (France)	2022	Surface Water for Hydropower Generation	Severe drought in France and Southern Europe	~20 percent drop in hydro output; no financial figures disclosed for France	Drought reduced water availability for hydroelectric production
EDP – Energias de Portugal (Portugal)	2022	Surface Water for Hydropower Generation	Severe drought in Iberia	Hydro profit fell from €160 m to a €181 m loss	Hydro output fell 53 percent; costlier fossil generation used instead
Anglo American Platinum (South Africa)	2023	Surface Water Regulation & Supply	Drought and degraded water infrastructure in the Olifants River basin	~7 percent share drop; EBIT down $1.5 bn	Mining operations curtailed due to insufficient water supply
Anglo American Platinum (South Africa)	2023	Surface Water Regulation & Supply	Unplanned water stoppage at Amplats' processing operations in Rustenburg	Production of PGM fell by 9 percent	Mining operations curtailed due to insufficient water supply
Harmony Gold Mining (South Africa)	2022–2023	Surface Water Regulation & Supply	Freshwater shortages at mine site	~US$200k/day revenue loss at impacted site	Disruption of mine activity due to water access issues
Bunge (Argentina)	2023	Climate Regulation (Rainfall), River Water for Transport	Historic drought affecting Paraná River basin	$127 m loss for fertilizer unit; 24 percent drop in Q3 revenue	Crop yield failure and impaired river transport reduced export volumes
Ørsted (US)	2023	Marine Areas for Renewable Energy Siting	Permitting delays and regulatory blockages for seabed access	$4 bn write-down; worst quarterly loss in the firm's history	Restricted access to seabed halted offshore wind projects
Itochu / Dole (Philippines)	2012	Climate Regulation (Storm Protection), Soil Quality Regulation	Severe typhoon and flooding in banana-producing regions	30–40 percent yield loss; ~$150 m net loss for Dole Asia	Destruction of plantations by typhoon reduced production and revenues

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c/o University of Geneva, Bd. Du Pont d'Arve 42, CH-1211 Geneva 4
T +41 22 379 84 71, rps@sfi.ch, www.sfi.ch

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