Biodiversity Risk

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Recent developments in finance research

Recent interest in understanding and managing the complex relationships between the economy and the health of our planet.

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- How does climate change affect economic activity and asset values?
- What role can financial markets play to accelerate the "green transition"
- Active literature reviewed in Giglio, Kelly and Stroebel (2021)

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Biodiversity Loss: Similarly important and understudied theme.

This Paper:

- Attempt at measuring biodiversity risks over time and across firms and industries.
- Study the effects of biodiversity risks on economic activity and asset values.
- Construct and release new data to facilitate research on biodiversity risks (`www.biodiversityrisk.org`)

What is Biodiversity Risk? Physical vs. Transition

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Physical Biodiversity Risks from the loss of biodiversity and ecosystem services

- Deforestation or habitat loss $\rightarrow$ raw material and supply chain of paper product firms
- Species or genetic biodiversity loss $\rightarrow$ R&D of pharma and biotech sectors
- Biodiversity loss $\rightarrow$ disruption of ecosystem, increased vulnerability to climate change

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Transition Biodiversity Risks from responses to reduce biodiversity loss

- Regulation: land-use regulations, sustainable forestry requirements, or species protection laws
- Consumer preference: shifts away from palm oil due to its effect on deforestation
- Reputation: increased cost of causing ecological disasters such as oil spills

Do People Worry About Biodiversity Risk?

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→ A survey of the perceptions of biodiversity risks among finance academics, professionals, public sector regulators, and policy economists (668 responses).

Do People Worry About Biodiversity Risk?

Biodiversity risks for investors and firms are often divided into (i) physical risks coming from actual changes in biodiversity (e.g., reduced pollinators, freshwater scarcity) and (ii) transition risks coming from changes in the regulatory environment to combat biodiversity loss (e.g., the Clean Water Act). Please rate the financial materiality of these risks for corporations in the United States.

	Not at all important	Slightly important	Moderately important	Very important
Physical Biodiversity Risks	○	○	○	○
Transition Biodiversity Risks	○	○	○	○

Do People Worry About Biodiversity Risk?

		Role			Location				Biodiversity Concern			
	Pooled	Academic Institution	Private Sector	Public Sector	North America	Europe	Asia	ROW	Very High	High	Low	No Concern
Physical Risk Importance (%)												
Not at all important	8	9	9	5	9	6	9	6	1	3	9	100
Slightly important	24	26	23	20	26	20	26	14	6	27	91	0
Moderately important	35	37	28	40	34	36	38	26	19	69	0	0
Very important	34	28	40	35	31	38	28	54	73	0	0	0
Transition Risk Importance (%)												
Not at all important	7	7	6	11	8	6	7	9	1	1	9	100
Slightly important	20	22	19	18	22	19	19	11	8	17	91	0
Moderately important	42	46	34	46	40	50	36	40	26	82	0	0
Very important	30	25	41	25	30	25	38	40	66	0	0	0

- Around 70% of respondents perceive physical and transition biodiversity risks to have at least moderate financial materiality for firms in the United States
- Private sector respondents report highest perceived financial materiality of risks.

Do People Worry About Biodiversity Risk?

Over what time horizon, if any, do you expect these biodiversity risks to materialize?

	Already today	1 to 5 years	5 to 30 years	More than 30 years	Never
Physical Biodiversity Risks	○	○	○	○	○
Transition Biodiversity Risks	○	○	○	○	○

Do People Worry About Biodiversity Risk?

	Pooled	Role			Location				Biodiversity Concern			
		Academic Institution	Private Sector	Public Sector	North America	Europe	Asia	ROW	Very High	High	Low	No Concern
Physical Risk Materialization (%)												
Already today	23	18	29	24	24	18	19	29	32	15	12	13
1 to 5 years	10	8	10	14	9	9	5	23	11	9	8	7
5 to 30 years	46	51	43	41	45	52	43	43	45	57	36	7
More than 30 years	17	18	14	19	17	17	22	3	10	17	35	30
Never	5	6	4	1	4	4	10	3	1	2	9	43
Transition Risk Materialization (%)												
Already today	20	16	27	17	23	14	16	23	27	14	15	10
1 to 5 years	26	28	25	24	25	29	22	34	33	23	15	7
5 to 30 years	41	44	34	47	40	44	43	34	33	54	41	13
More than 30 years	8	7	10	7	9	7	9	3	4	7	20	27
Never	5	5	4	6	3	7	10	6	2	2	9	43

- About 20% of respondents believe that physical and transition biodiversity risks are already materializing today
- Transition risks perceived as somewhat more important over the next five years.

Any particular ways in which biodiversity risks are important in professional life?

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Physical Risk:

"I co-run an investment fund in farmland and timberland, which are directly affected by these risks"

Transition Risk:

"Regulatory risk related to biodiversity are a chief driver of long-term uncertainty in the energy markets in which I work"

Through the Economy:

"Biodiversity risks are a serious threat to financial stability and the resilience of financial companies"

Key: Biodiversity is a growing concern among ESG analysts, fund managers, VCs, and management consultants, especially those working with the energy, materials, and construction sectors, as well as among academics and public sector employees.

Measuring Aggregate Biodiversity Risk

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The risk exposure of a slow-moving long-term risk can be explored by obtaining higher-frequency measures of news about future damages arising from the risk

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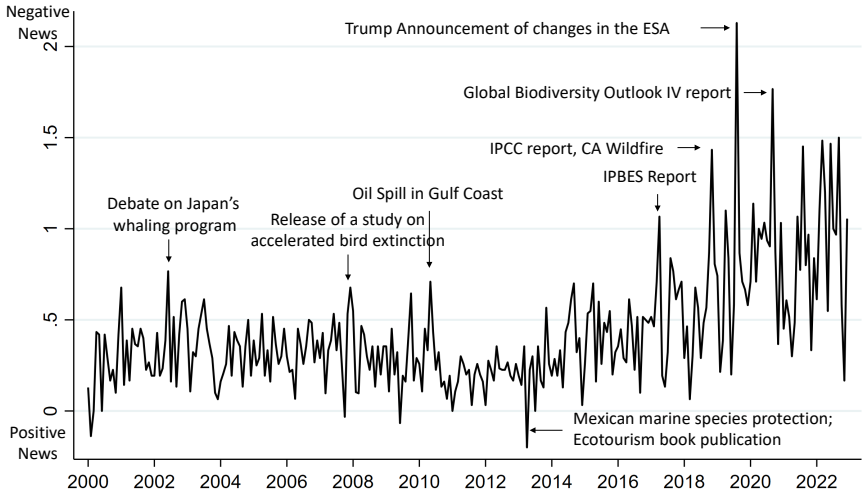
NYT Biodiversity News Index:

- Use a dictionary-based approach to identify NYT articles that cover biodiversity risk (terms include "ecosystem", "deforestation", "habitat", etc.)
- Article sentiment: Bidirectional Encoder Representations from Transformers (BERT)
- Index: Number of negative biodiversity articles minus the number of positive biodiversity articles.

Google Biodiversity Attention Index:

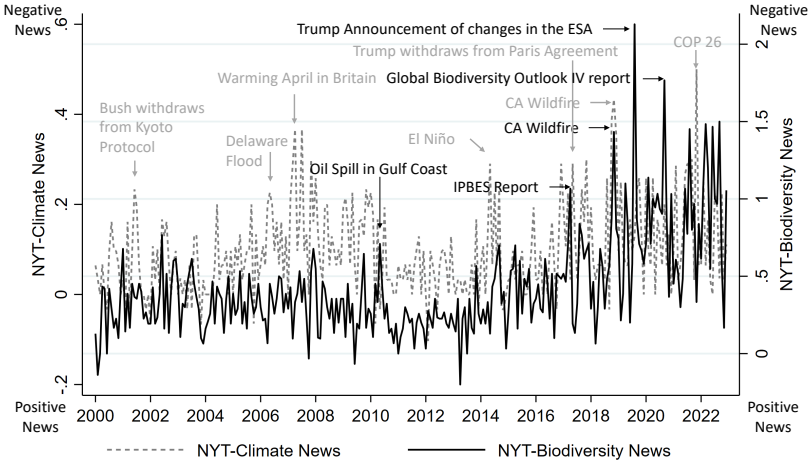
- Google search activity for terms like "biodiversity loss" and "species loss"
- The index is constructed as the sum of the search index series for each term

NYT-Biodiversity News Index



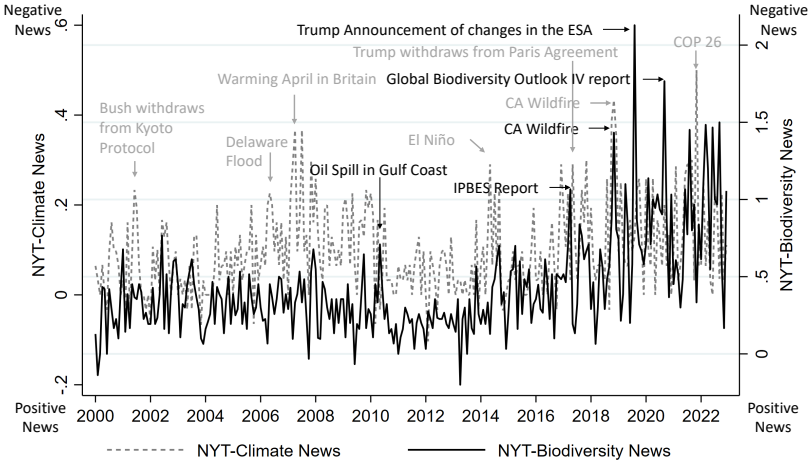
Note: Monthly NYT-Biodiversity News Index from 2000 to 2022, annotated with biodiversity-relevant news announcements. ESA: Endangered Species Act; IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; IPCC: Intergovernmental Panel on Climate Change.

NYT-Biodiversity News vs. NYT-Climate News



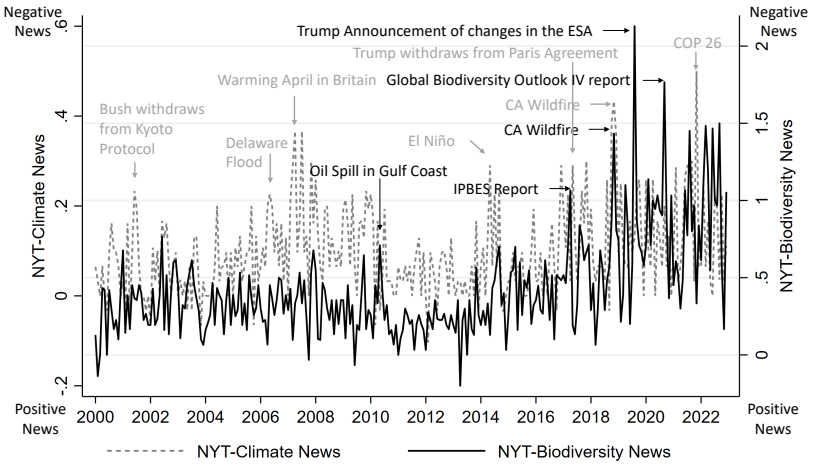
- Biodiversity-related events (e.g., Trump's Announcement of changes in the ESA, Oil Spill in the Gulf Coast) did not result in spikes in the climate index.

NYT-Biodiversity News vs. NYT-Climate News



- Climate-related events (e.g., Bush's withdrawal from the Kyoto Protocol, Delaware flood) did not result in spikes in the biodiversity news index.

NYT-Biodiversity News vs. NYT-Climate News



- Some common events (e.g., wildfires). Monthly correlation: 0.22

Measures of Biodiversity Risk Exposures

- Different sectors vary in their dependence on natural capital (physical risk) and their effects on the environment (regulation risk)
- The absence of standardized disclosure frameworks for biodiversity risks makes quantifying these exposures hard.
- We propose several ways to measure firms' and industries' biodiversity exposures:
  - Firms' 10-K statements: textual analysis
  - Expert Survey
  - Portfolio holdings of biodiversity funds

Firm-Level Measures of Biodiversity Risk Exposures

10K-Biodiversity-Count Score

- We identify biodiversity-related sentences in 10-K statements using a dictionary-based approach
- Firms that mention at least two sentences related to biodiversity are assigned a Score of "1"

10K-Biodiversity-Negative Score

- Separate mentions of biodiversity as both a risk and an opportunity for firms by .
- Classify the sentiment of each biodiversity-related sentence with the BERT model.
- The Score = #is constructed as # negative biodiversity sentences -minus # positive sentences.

10K-Biodiversity-Regulation Score

- Explicitly measure regulation biodiversity risks faced by firms
- We select biodiversity risk sentences that also contain at least one of the following terms: law(s), regulation, Act, ESA, discharge, or restriction.
- We assign a Score of "1" if the 10-K statement contains at least two biodiversity risk sentences and at least one of them is a biodiversity regulation risk sentence.

Industry-Level Measures of Biodiversity Risk Exposures

Survey-Based Measures of Biodiversity Risk Exposures

- Participants were asked to select the industries that they believe to be most negatively affected by (i) physical risks, and (ii) transition risks.
- An industry's physical and transition biodiversity risk exposures are quantified as the share of survey respondents who select each industry as being particularly affected by the risk.

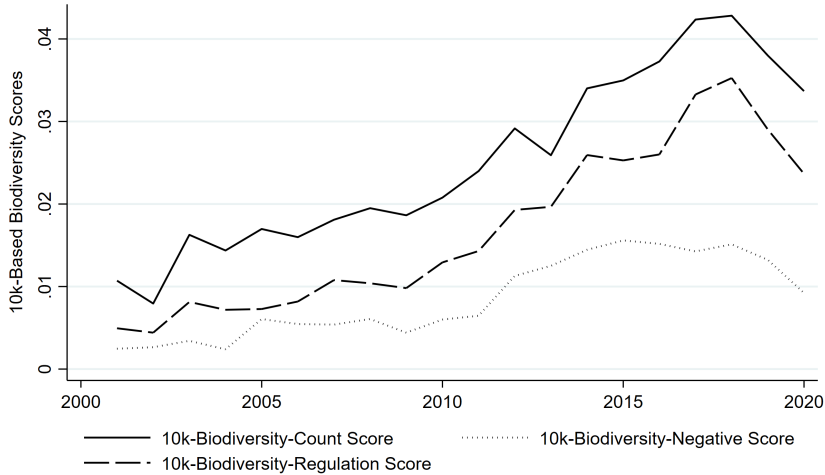
Holding-Based Measure of Biodiversity Risk Exposures

- Four biodiversity-related funds: HSBC ESG Biodiversity Screened Equity ETF, AXA Biodiversity Equity ETF, Ossiam Food for Biodiversity ETF, and Trillium ESG Global Equity Fund.
- The score of fund f for industry I is defined as:

$$HoldingScore^{I}_{t,f} = w_{I,t,M} - w_{I,t,f}$$

where $w_{I,t,M}$ is weight of industry I in market portfolio, and $w_{I,t,f}$ is weight in fund's portfolio.

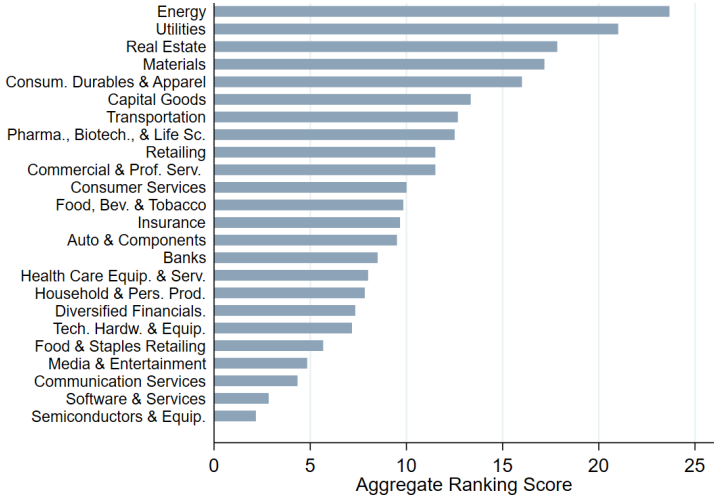
Biodiversity Risk Exposures Over Time



Self-reported biodiversity risk exposures have been growing over time.

Biodiversity Risk Exposures Across Industries

- Sectors with the highest biodiversity risk exposures include energy, utilities, and real estate
- Semiconductor, software, and communication services sectors have minimal exposures.



Variation Across Industries

Energy Sector

- Reputational and legal risks: drilling activities → oil spills & habitat destruction
- Regulatory risk: environmental regulations to prevent further biodiversity loss

"If one of our LNG terminals or pipelines may adversely affect a protected species or its habitat, we may be required to develop and follow a plan to avoid those impacts" (Cheniere Energy)

Utilities Sector

- Physical Risk: degradation of watersheds → water utility operations
- Regulatory Risk: regulations on species and habitat protection → limit utility firms' operations
- Regulatory Risk: regulations on waste discharges → elevate utility firms' costs

"The Company is also subject to laws regarding the protection of wildlife, including migratory birds, eagles, threatened and endangered species. Federal and state environmental laws have historically become more stringent over time, although this trend could change in the future" (Clearway Energy)

Variation Across Industries

Real Estate Sector

- Regulatory Risk: regulations to minimize habitat destruction → increased costs and delays to projects in areas with high biodiversity

"The sale or development of properties may also be restricted due to environmental concerns, the protection of endangered species, or the protection of wetlands" (St Joe Co.)

Materials Sector

- Physical Risk: availability and quality of raw materials → paper & forest products subsector
- Regulations and reputational risks: construction materials and metal mining subsectors

"Federal and state requirements to protect habitat for threatened and endangered species have imposed restrictions on timber harvest on some of our timberlands, and these protections may be expanded in ways that further affect our operations. These actions may increase our operating costs; further restrict timber harvests or reduce available acres; and adversely affect supply and demand more broadly across our markets" (Pope Resources Ltd Partnership)

Variation Across Industries

Pharma and Biotech. Sector

- Physical Risk: reduced potential pharmaceutical development options

"We focus on the use of biodiversity as a means of natural product drug discovery, while also using traditional chemical discovery and development techniques" (Cubist Pharmaceuticals Inc.)

Capital Goods Sector

- Building materials: the availability of wood and other raw material, shift of consumer preference
- Distributors: the use of chemical refrigerants
- Industrial and construction: environmental protection and waste disposal regulations

"As another example, many consumers demand certified sustainably harvested wood products as concerns about deforestation have become more prevalent" (Jeld-Wen Holding Inc.)

Variation Across Industries

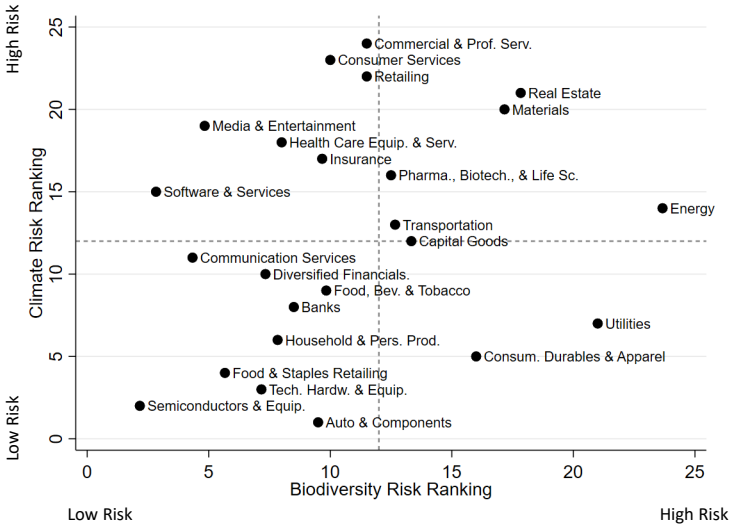
Transportation Sector

- Regulations related to the protection of marine species → adjust the speed and route of vessels
- Regulations to reduce marine pollution → install new equipment and limit the type of fuels used by ships

"Protection of endangered and threatened species may include restrictions on the speed of vessels in certain ocean waters and may require the Company to change the routes of the Company's vessels during particular periods. [...] The reduced speed and special routing along the Atlantic Coast results in the use of additional fuel, which affects the Company's results of operations." (Seacor Holdings)

Industry Ranking by Biodiversity Risk and Climate Risk

Industry Ranking by Biodiversity Risk and Climate Risk



Climate Risk Exposures vs. Biodiversity Risk Exposures

Biodiversity risk exposures are distinct from climate risk exposures.

- An industry may be highly exposed to biodiversity risk because its operations are dependent on particular ecosystems or species that are not necessarily affected by climate change
- From a regulatory perspective, some industries might have a more significant direct impact on ecosystems and habitats rather than contributing to climate change

Example: Renewable Energy

- Windfarms and birds
- Hydropower and fish
- Land use requirements for solar
- Offshore winds and whale death

Climate Risk Exposures vs. Biodiversity Risk Exposures

The New York Times

The Energy Transition

The Clean Energy Future Is Roiling Both Friends and Foes

Resistance to wind and solar projects from environmentalists is among an array of impediments to widespread conversion to renewables.

Share full article

"In Atlantic City, N.J., groups have protested and sued to stop federal approval of as many as 98 turbines in close offshore waters. They cite hits to tourism and claim damage to whales, with no firm scientific evidence behind them " (The New York Times, 08/14/2023)

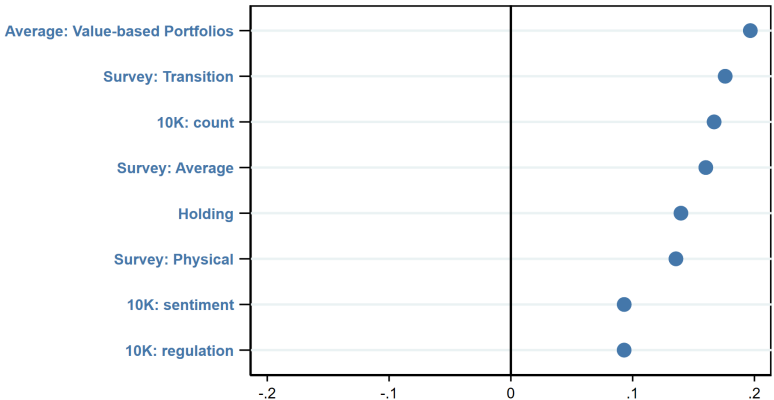
Pricing in Equity Markets

Pricing in Equity Markets

- We form equity portfolios of industries sorted by their biodiversity risk exposures
- The portfolios hold long positions in industries with low biodiversity risk exposures and short positions in industries with high biodiversity risk exposures
- If biodiversity risk is priced, the return of these biodiversity-risk-sorted portfolios should covary with the aggregate biodiversity news index
  - Behave like a hedging portfolio
- We compare the hedge performance of our biodiversity risk measures with that of hedge portfolios constructed using other firm characteristics

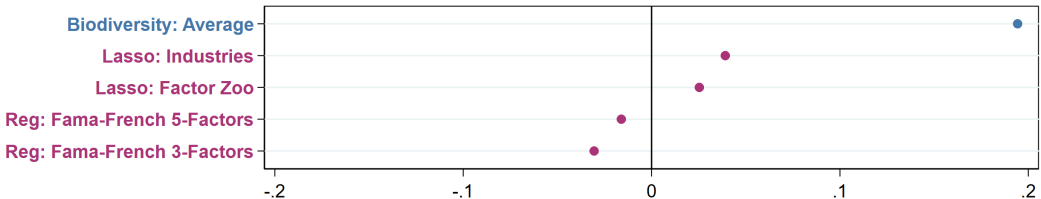
Biodiversity Hedge Performance of Various Portfolios

- All the correlations are positive, with magnitudes from around 0.1-0.2.
- Observed correlations are comparable to those obtained by climate hedging portfolios when evaluated against aggregate climate news



Biodiversity Hedge Performance of Various Portfolios

A natural question is whether our measures of biodiversity risk exposure are simply recasting information from other firm characteristics.



The portfolio built on the average biodiversity exposure measure has the highest correlation with innovations in the NYT-Biodiversity Risk Index.

Hedging Biodiversity Risk vs. Climate Risk

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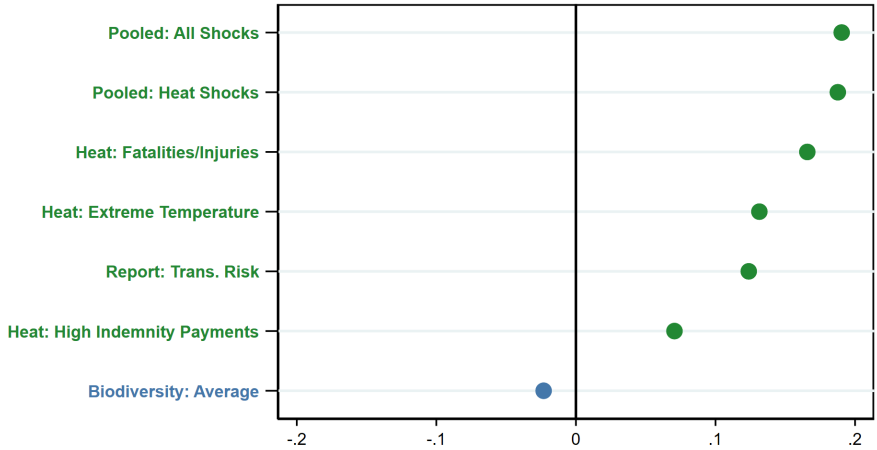


Portfolios designed to hedge climate risks perform better than biodiversity hedge portfolios, which, on average, have zero correlation with climate news realizations.

Hedging Biodiversity Risk vs. Climate Risk: Summary

- Biodiversity risk exposures vary substantially across firms and industries
- Variation is economically sensible
- Long-short portfolios on this characteristic covary with aggregate realizations of biodiversity risk $\rightarrow$ Risks are being priced

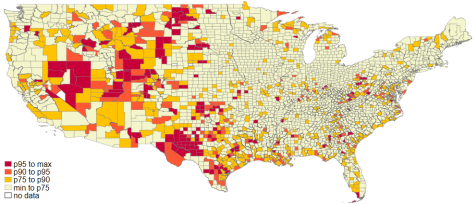
Hedging Biodiversity Risk vs. Climate Risk: Summary

- Biodiversity risk exposures vary substantially across firms and industries
- Variation is economically sensible
- Long-short portfolios on this characteristic covary with aggregate realizations of biodiversity risk → Risks are being priced
- Are they priced adequately?
  - Very hard to say, needs structural model, research frontier for 'climate finance'
  - Survey respondents on pricing in stock market

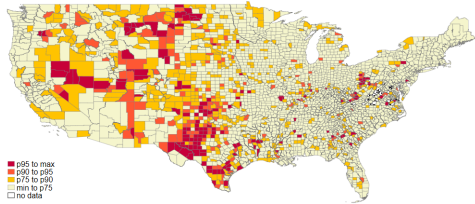
		Role			Location				Biodiversity Concern			
	Pooled	Academic Institution	Private Sector	Public Sector	North America	Europe	Asia	ROW	Very High	High	Low	No Concern
Stock Market (%)												
Not enough	48	43	53	61	45	53	60	69	71	53	30	6
Correct	17	23	11	15	18	17	13	23	11	26	33	23
Too much	3	3	5	3	5	1	2	0	2	2	8	29
No opinion	32	31	32	21	33	28	25	9	16	19	29	42

The spatial variation in biodiversity risk across different U.S. counties.

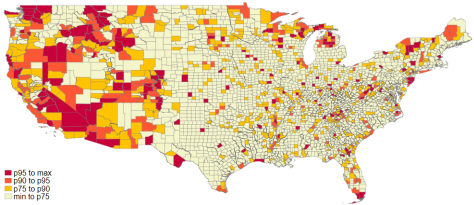
Employment-Based Biodiversity Score



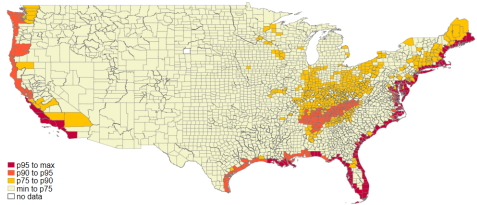
GDP-Based Biodiversity Score



Protected Area Score

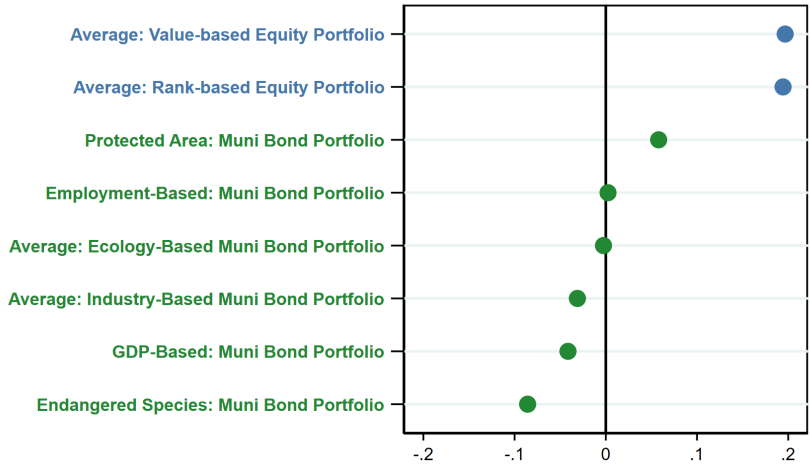


Endangered Species Score



Pricing in Municipal Bond Markets

We form long-short portfolios of municipal bonds sorted on biodiversity risk exposures and test if their return covaries with the aggregate biodiversity risk news series.



Pricing in Municipal Bond Markets

We find essentially no correlation, which is consistent with a range of interpretations:

- Our exposure measures do not capture biodiversity risk exposures of muni bonds
- The illiquidity of the underlying bonds makes the return series problematic
- Biodiversity risk is not (yet?) priced in the municipal bond market

Conclusion

- Introduce measures of aggregate biodiversity risk as well as measures of firms', industries', counties', and countries' exposures to biodiversity risks
- Study the pricing of biodiversity risks in financial markets (equity and muni bond)
- Release biodiversity risk exposure measures at `www.biodiversityrisk.org` to facilitate more research on this important topic.
- Hope that many of you will join us.