Kicking Away the Green Ladder: The Asymmetric Sovereign Risk from Nature Degradation

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Version: January 2026
Submission for the NBER Conference on Climate and Nature Finance
Reference system: APA 7th Edition

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Abstract

This paper investigates the uneven consequences of nature and biodiversity loss for the cost of sovereign government borrowing. A growing literature documents the adverse economic consequences of climate change. However, little attention has been devoted to the influence of nature degradation on sovereign bond yield spreads, which determine government's funding costs and fiscal policy space. Employing panel interactive fixed effects and quantile regressions with latent factors, we extend the literature to the nature context with three proxies for countries' nature-related financial vulnerability. Across 28 advanced and 25 emerging economies over the 2000-2020 period and 2, 5, and 10-year bond maturities, our results indicate substantial average impacts from within-country degradation for sovereign borrowing costs whilst controlling for conventional economic and institutional determinants, and common global financial factors. Our second-stage heterogeneity analysis reveals significant variation in impacts. We find that countries with elevated sovereign risk are disproportionally impacted by nature vulnerability, up to three times the average marginal effect of forty-to-fifty basis points for countries in the 90^{th} percentile of borrowing costs. Our novel empirical results underline the asymmetric macro-criticality of nature for sovereign borrowing costs with disproportional effects that exacerbate existing macro-financial fragilities. Yet the financial effects are unlikely to be confined to debt-distressed and high-risk countries, considering the interwovenness of global supply chains and co-moving nature of sovereign debt markets.

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1 Introduction

Anthropogenic climate change and nature loss are increasing at an alarming pace globally and are already affecting human livelihoods and economic development. 2024 was the first calendar year to surpass the 1.5°C target above pre-industrial levels alongside a growing frequency and severity of extreme weather events(Copernicus Climate Change Service, 2025; IPCC, 2023). Simultaneously, fourteen of eighteen ecosystem services have decreased to critical levels since the 1970s, and the planetary boundary for biospheric integrity has been transgressed in roughly two-thirds of the global land area (IPBES, 2019; Richardson et al., 2023; Stenzel et al., 2025). Beyond these thresholds the biophysical systems essential to life on Earth are likely to react in a non-linear and irreversible manner with systemic consequences threatening global economic stability (NGFS, 2023).

The financial consequences will and already are felt across the world as our analysis highlights. The environmental changes are pronounced and overlap with a looming debt crisis in developing and other vulnerable countries whose levels and cost of debt have risen to historical levels since the early 1980s (Songwe et al., 2025). Lingering external shocks from the Covid-19 pandemic and recent inflation in critical resources and foods, environmental disasters, capital flight, surging interest rates and US dollar appreciation accelerated the deterioration of many countries' external and fiscal positions (IMF, 2024). The external debt stock doubled and debt interest payments quadrupled since 2012 amongst the poorest, the 78 IDA-eligible countries. In 2012, 16% were in debt distress relative to 45% in 2023 (World Bank, 2024b). This triple crisis is not just locally but globally important. Developing countries house key stabilising ecosystems and biodiversity hotspots for the global climate, yet it is also where ecological disruption has progressed to levels critically compromising their biospheric integrity (Stenzel et al., 2025).

A large body of literature has documented significant negative consequences from climate change on the economy (Dell et al., 2012; Nordhaus, 1991, 2006). The implications for the cost of government borrowing and sovereign risk are a recent addition (Beirne et al., 2021; Boitan, 2023; Cevik & Jalles, 2022; Collender et al., 2023). However, research on the consequences from nature degradation for borrowing costs remains scarce despite the sizeable magnitude of nature-related financial risks. In 2020, roughly half of global GDP was estimated as moderately to highly dependent on ecosystem services (WEF, 2020). In the nature context, very few have empirically examined the implications for sovereign debt dynamics (Wang, 2021), unlike the climate-sovereign nexus. This is despite the systemic importance of sovereign debt, money borrowed by governments through issuing bonds and loans, for global financial stability, public expenditure, and supporting a low-emission, climate-resilient and nature-positive development trajectory (CPI, 2024; UNEP, 2024a, 2024b). Government debt amounts to over half of global outstanding debt securities (BIS, 2024). Government bond yields directly influence the cost of government borrowing and thus fiscal policy space, and indirectly, affect the risk-free rate and cost of capital in the private sector, making them the most critical asset class (Volz et al., 2020).

In this paper, we provide the first empirical analysis for the impacts of nature degradation on the pricing of sovereign bond yield spreads across 28 advanced and 25 developing countries over the 2000-2020 period. We leverage recent advances in biodiversity and ecosystem integrity data to develop three proxies for nature-related financial vulnerability, and build on recent approaches in the macro-finance literature addressing concerns for cross-sectional dependence and distributional heterogeneity – critical characteristics of sovereign debt markets. The first-stage interactive fixed effects regression suggests statistically and economically significant impacts on sovereign borrowing costs, from around 25 to 70 basis points for 5- and 2-year tenors on average, whilst controlling for the conventional domestic economic determinants and global factors affecting government bond yields. Appreciating the uneven reality of economic conditions and existing debt pressures, our second stage quantile regression investigates whether

these asymmetries are reflected in how bond markets priced countries' financial vulnerability to nature degradation. For the top, 90^{th} percentile of borrowing costs, which tend to be lower income countries in Africa and Asia, the effect can be up to three times that at the mean and even surpass effects from heightened climate vulnerability. These results are robust to a battery of robustness checks, including varying the number of global factors and lagged dependent variables, for both quarterly and annual data.

Against growing academic and policy-related attention on the magnitude of financial risks from nature loss and growing debt burden in developing and other vulnerable countries, we fill a crucial gap with empirical evidence for one of the main macroeconomic transmission mechanisms, to sovereign bonds and the cost of government borrowing. The remainder of this paper is structured as follows. Section 2 briefly reviews the related literature, Section 3 outlines the data sources and provides descriptive statistics, Section 4 discusses the econometric estimation strategy, interactive fixed effects and quantile regressions. Section 5 presents empirical results followed by Section 6 discussing their implications for the literature and policymakers.

2 Related Literature

We contribute to the merger between the literatures on the determinants of sovereign risk, and the economic consequences of climate change and nature loss. A comprehensive body of research has studied the economic impacts of climate change, yet a gap remains for the asymmetric fiscal consequences of nature-related risks. Although impact magnitudes vary between earlier canonical assessments from Nordhaus (1991, 2006) to recent studies, the impacts from climate change on economic growth, productivity, and output are now well documented (Batten et al., 2016; Burke et al., 2015; Dell et al., 2012; Feyen et al., 2020). For instance, global warming to date already decreased global output since 1960 by 19% (Bilal & Känzig, 2024). Macro-fiscal and sovereign bond impacts are a vital transmission mechanism of direct and expected impacts as they directly affect the costliness and capacity for governments to borrow to finance expenditures, and their impact on the cost of capital in the private sphere (Volz et al., 2020). Yet literature examining these consequences for government borrowing costs from climate change "is a newly emerged strand [...] and still not receiving adequate attention" as stressed in a recent review (Boitan, 2023, p. 65).

Originating from the macro-finance literature examining the 'extra-financial impacts' for sovereign bond yields from variations in national ESG performance (Berg, 2016; Capelle-Blancard et al., 2019; Hoepner et al., 2016), the strand has grown in scope over recent years. Kling et al. (2018)'s seminal analysis found greater sovereign borrowing costs from higher climate vulnerability, and while early studies found mixed results (Margaretic & Pouget, 2018), there is growing consensus for a positive association (Boitan, 2023). The studies use indices proxying physical climate risks and financial vulnerability, the ND-GAIN or Climate Risk Index (Beirne et al., 2021; Bingler, 2022; Cevik & Jalles, 2022; Kling et al., 2021), temperature anomalies (Boehm, 2022), and proxies for transition-related risks such as policies and economic dependency on carbon-intensive activities and resources (Cheng et al., 2023; Collender et al., 2023). Their results consistently show a positive association across maturities and for both local (Collender et al., 2023; Kling et al., 2018), and foreign currency-denominated sovereign bond yield spreads (Cevik & Jalles, 2022). Panel data regressions were employed initially (Berg, 2016), with most using country-fixed effects (FE) (Bingler, 2022; Cheng et al., 2023; Collender et al., 2023), and some supplementing with structural vector autoregressions, system generalised method of moments, or local projections methods (Anyfantaki et al., 2025; Cevik & Jalles, 2022), with quarterly or monthly data (Boehm, 2022; Wang, 2021).

Yet despite these refinements, a fixation on average impacts has remained despite the heterogeneous

reality of climate change and nature loss. Gomez-Gonzalez et al. (2025) employ a quantile regression to formally investigate the difference in impacts earlier studies found between sub-samples of advanced and developed economy groups (Cevik & Jalles, 2022), between credit ratings (Bingler, 2022; Wang, 2021), and debt-to-GDP ratios (Anyfantaki et al., 2025). Crucially, quantile regression offers a set of advantages over splitting the analysis across sub-samples. Chiefly, it avoids imposing arbitrary and static categorizations into, e.g. advanced and developing countries and minimizes information loss from splitting samples whose means would be estimated via standard OLS. Instead, quantile regression leverages the full sample and estimates coefficients across different quantiles of the distribution (Koenker, 2004). In turn, they find higher coefficient magnitudes for countries in higher quantiles of the borrowing cost distribution, which also tend to be developing countries, yet without ex-ante and fixed assignment.

Unlike the growing attention on climate change, the empirical consequences for borrowing costs from nature degradation has faced little to no attention. Whilst nature and finite natural capital played a significant role in the canonical environmental resources literature (Malthus, 1789), resurfacing in importance in the limits to growth literature as production factor (Meadows et al., 1972; Nordhaus, 1991), the financial risks from nature loss is a recent addition. Where nature has been the focus, a deterministic model-based approach is often implemented (Johnson et al., 2021; Ranger et al., 2023), and the sovereign debt context remains rare. For instance, Agarwala et al. (2022) projected the future consequences of degradation in ecosystem services for sovereign creditworthiness using a CGE and random forest model, focusing on fisheries, tropical timber and pollination, but focusing neither on empirical data nor sovereign borrowing costs.

To date and the best of our knowledge, Wang (2021) is the only empirical natural capital and sovereign risk analysis, but with crucial omissions. Harnessing the World Bank's Changing Wealth of Nations (CWON) dataset World Bank (2024a), losses in countries' natural capital, specifically natural resources - fossil fuels and minerals – and renewable ecosystem assets - such as agricultural land and forests - are found to raise monthly sovereign borrowing cost. However, the valuations in the dataset restrict the value of nature to the extrinsic and tradeable value of the 'goods' they provide. Furthermore, biodiversity is not covered. This omission leaves a significant gap considering that biodiversity conditions the economic value of renewable ecosystem assets (Wang, 2021, p. 24), as its integrity affects the provision of ecosystem services linking nature to economic activity (NGFS, 2023). Strong evidence in the ecology literature for the critical role of biodiversity for the resilience, adaptability, and productivity of ecosystems and ecosystem services with economic consequences (Dasgupta, 2021; Giglio et al., 2024; IPBES, 2019), motivates our focus on the potential macro-financial consequences of biodiversity loss in the sovereign context.

In sum, recent studies made headway in examining the empirical macro-financial consequences of climate change and their asymmetry, which we extend to the context of degradation in nature and biodiversity.

3 Data

Our panel data spans $N = 53$ countries, with 28 advanced economies (AE) and 25 emerging market and developing economies (EMDEs) following the most recent IMF country classifications, and $T = 84$ quarters from 2000 to 2020. Country selection was limited to countries with available sovereign bond yield data, limiting the sample to middle- and high-income countries with established debt capital markets.

The dependent variable, sovereign borrowing cost, is measured through end-of-quarter and year yield spreads on generic local currency 10, 5, and 2-year maturity government bonds vis-à-vis the U.S. benchmark, drawn from Bloomberg. We follow this approach for consistency with the literature, and implement

the widely used calculation of yield spreads by taking a country's sovereign bond yield less the US benchmark sovereign bond yield of equal maturity (Capelle-Blancard et al., 2019; Cevik & Jalles, 2022). We use spreads to standardise yields across countries and adequately gauge the effects for countries whose yields may be affected by US Treasury bond yields serving as benchmark rates. Yields affect the funding costs of governments. As yields move inversely to prices, rising perceived risks to a country's creditworthiness, ceteris paribus, are associated with greater borrowing costs for sovereign governments. Finally, we use local currency spreads which allow for broader data coverage and consistency with earlier research (Boitan, 2023; Wang, 2021).

Environmental Data

For comparability of our analysis with existing studies we include a measure of climate-related financial vulnerability, the Notre-Dame Global Adaptation Initiative Index (ND-GAIN) with growing use in financial markets (Boitan, 2023; Monnin et al., 2024). The ND-GAIN's 36 indicators across countries' exposure, sensitivity and adaptive capacity to climate change contribute to a composite vulnerability score across six sectors; food, water, health, ecosystem services, human habitat, and infrastructure. It is designed for consistency with the IPCC risk framework, with values between 0-100 implying greater levels of vulnerability, (Chen et al., 2024), characteristics we also scale and invert the three proxies for nature to such that higher values indicate greater financial vulnerability for comparability.

To proxy countries' financial vulnerability to nature degradation, we combine publicly available data to develop three metrics, one broad-based covering multiple ecosystem asset categories, and two focused on biodiversity. We focus on vulnerability for comparability with the literature on economic consequences from climate vulnerability. Natural capital encompasses renewable ecosystem assets and non-renewable natural resources. The intactness of ecosystem assets, such as biodiversity, affect the provision of ecosystem services that humans, natural systems, and economies rely on (UNEP WCMC, 2014). Focusing on the intactness of biodiversity and ecosystem assets, therefore, complements recent studies estimating the macroeconomic value at risk from a deterioration in ecosystem services (Ranger et al., 2023; UNEP WCMC, 2014). Ecosystem assets are also analytically appealing as they exhibit higher temporal variation compared to natural resources. For instance, the decline in ecosystem assets is most pronounced for terrestrial and marine biodiversity and in low- and middle-income countries that house global biodiversity hotspots (World Bank, 2024a).

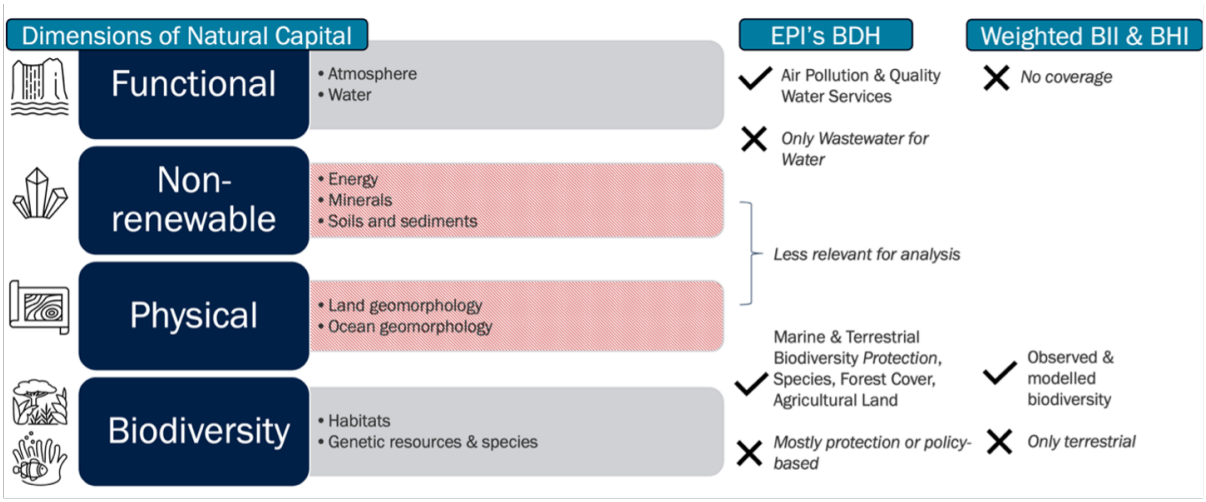


Figure 1: Mapping Nature-related Financial Vulnerability Indicators to UNEP WCMC's Natural Capital Framework (Leach et al., 2019)

The composite nature vulnerability proxy is based on the Environmental Performance Index (EPI) co-developed by Yale and Columbia University. It covers most of the ecosystem asset categories in UNEP-WCMC's natural capital framework of interest for our analysis, namely the functional and biodiversity-related dimensions (Block et al., 2024)[1]. As the EPI is published biannually with minor changes to the indicators used across versions, we follow the authors' recommendations and manually construct an annual, consistent time-series from those included in the 2024 version with sufficient temporal coverage since 2000 (Block et al., 2024). Consistent with the gap for biodiversity-related analyses (Wang, 2021), we focus on the EPI's biodiversity and habitat sub-index (BDH), composed of 9 indicators spanning the intactness and protection of marine and terrestrial ecosystems, to capture the functional and biodiversity ecosystem asset dimensions of the natural capital framework, see Table 6 for specifics. As most sub-indicators apart from the Red List and Species Habitat Index cover policy implementation, e.g. protection extent of key biodiversity areas (KBA), it proxies transition-related vulnerability (NGFS, 2023).

Countries' physical vulnerability to nature degradation is proxied via the weighted degradation of biodiversity and habitats. These are the main focus of our analysis and measure countries' financial vulnerability to physical changes in nature as opposed to policies, as the variation in biodiversity and habitat intactness affects the provision of ecosystem services human societies and economies depend on (NGFS, 2023). Indicator selection is crucial as, according to a recent review, there are more than 570 biodiversity-related metrics and indicators yield conflicting results for the same concept (Burgess et al., 2024). We follow their review and use the Biodiversity Intactness Index (BII) to capture the state and intactness of biodiversity (ibid, p. 686). The BII estimates the remaining assemblage and abundance of native terrestrial species since 1970 compared to the absence of human impacts and land-use change (De Palma et al., 2021), key drivers of biodiversity loss in this period (Jaureguiberry et al., 2022; Pereira et al., 2024). The BII combines ecological modelling with observed data based on the PREDICTS database of around 58,000 species and over 4 million species-site observations (Hudson et al., 2017).

As additional biodiversity indicator, we use the Biodiversity Habitat Index (BHI). Similarly based on the PREDICTS database, the BHI uses remotely-sensed biologically-scaled environmental mapping and modelling to estimate the impacts of habitat loss and disruption on terrestrial biodiversity (Harwood et al., 2016). The model-adjusted BII and BHI help mitigate the taxonomic bias in observed biodiversity indicators where well-studied groups and regions are overrepresented at the expense of data-poorer regions where biodiversity may be declining more rapidly (McRae et al., 2017). The combination of modelling and observed data is also analytically appealing as not all that is countable is valuable for biodiversity, and not all that is valuable can be directly observed (Strange et al., 2024). Therefore, both offer analytical advantages as proxies for integrity over other indicators, such as mean species abundance, by capturing both alpha and beta diversity, i.e. species richness and compositional similarity. This focus complements the policy-heavy EPI for our analysis.

However, for the BII and BHI to be comparable with the climate vulnerability metric and vulnerability definition (IPCC, 2023), we combine this 'exposure' dimension with information on how sensitive economies are to changes in biodiversity. Indeed, high levels in the raw BHI or BII series does not inherently imply economic vulnerability. For instance, the level of original biodiversity intactness can be negligible, or degradation insignificant for economies. Therefore, we weigh the BII by the economic share of natural capital to the overall economy as measured by the terrestrial renewable natural capital obtained via the CWON database also used by Wang (2021). In practice, countries such as Norway with high raw BII/BHI scores receive lower vulnerability scores as the economic significance of renewable

[1]Originally capturing five, the UNEP-WCMC framework has since been expanded to nine ecosystem asset categories across three levels. The abiotic category has 3 dimensions, *functional* (atmosphere, water), *non-renewable* (energy, minerals, soils and sediments), and *physical* (land and ocean geomorphology), with the biotic category covering one dimension, *biodiversity* (habitats and species) (Leach et al., 2019). See appendix for further detail.

natural capital is lower in relative terms.[2] This transformation is consistent with earlier work connecting natural capital with sovereign credit risk, decomposing the analysis into the change in nature and its economic significance (Hill Clarvis et al., 2014). Figure 1 provides a visual summary of the relation between our proxies and the natural capital framework, and Figures 2–5 the distribution of the climate and nature-related financial vulnerability proxies across our sample countries.

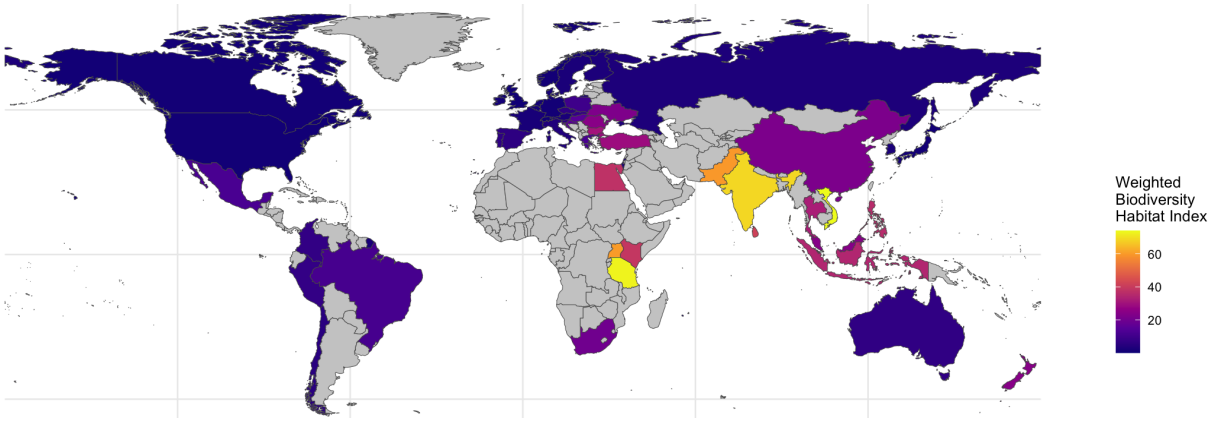


Figure 2: Weighted Biodiversity Degradation (BHI), Avg. 2015-2020

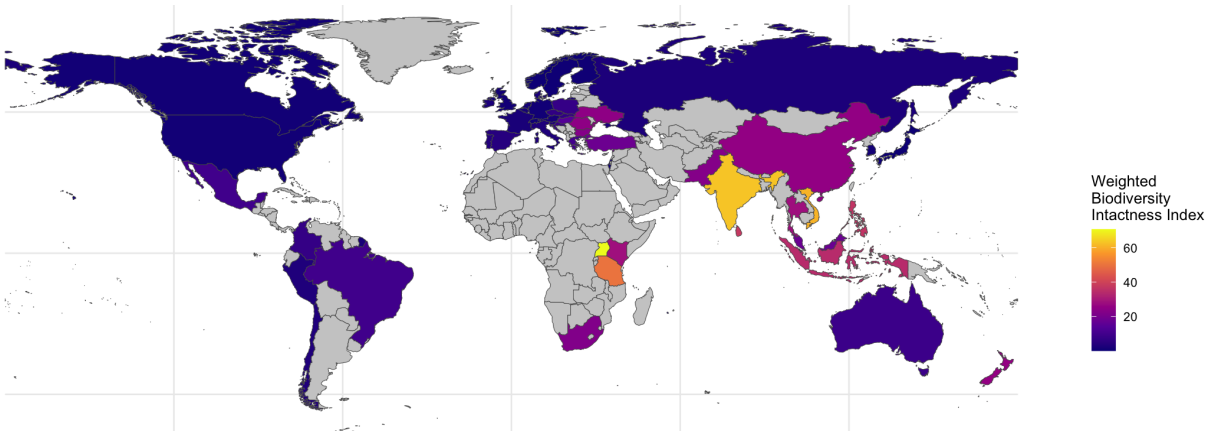


Figure 3: Weighted Biodiversity Degradation (BII), Avg. 2015-2020

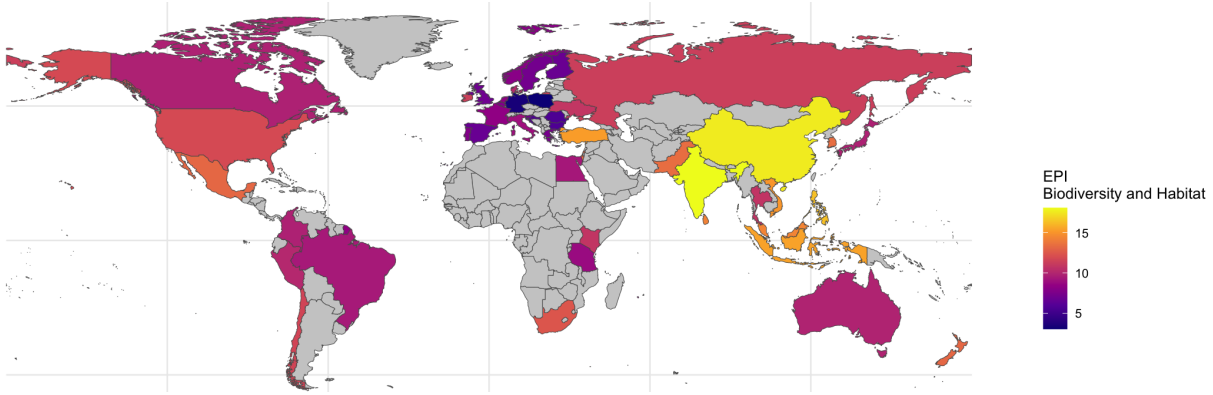


Figure 4: Environmental Performance Biodiversity & Habitat Subindex, Avg. 2015-2020

[2]Whilst CWON data is employed as robustness check, we focus on the EPI's BDH, BII, and BHI, as CWON only captures the extrinsic value of ecosystem assets and lacks biodiversity-related data.

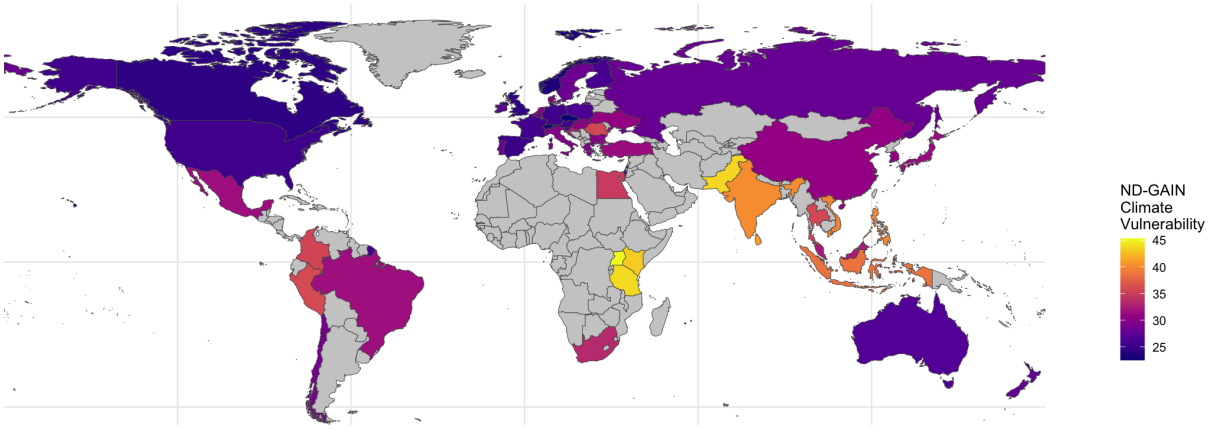


Figure 5: ND-GAIN Climate Vulnerability, Avg. 2015-2020

Macroeconomic and financial variables

To control for alternative explanations of the variation in borrowing costs, we include seven traditional domestic economic and institutional variables. Consistent with the macro-finance literature (Ballard-Rosa et al., 2021; Cevik & Jalles, 2022), we control for conventional sovereign credit risk drivers such as the primary balance (PB), the difference between fiscal revenue and expenses excluding interest payments, and the current account (CA) balance. Higher PB and CA deficits are associated with higher default risk, bond sales, dropping their market prices, raised default risk, yields, yield spreads and governments' borrowing costs (De Grauwe & Ji, 2013; Gruber & Kamin, 2012). These are measured in % of GDP for cross-country comparability, sourced from the IMF. Alongside these, we also proxy for countries' capital market depth via the World Bank's (WB) financial market depth index (Čihák et al., 2012). We also include period-end inflation and CPI food price inflation, GDP growth, and debt-to-GDP ratios from the WB as controls, following (Koepke, 2019). To proxy for institutional quality, we include the widely used rule of law indicator from the WB's World Governance Indicators (Ballard-Rosa et al., 2021). As we use local currency spreads, these crucially account for alternative explanations for spread movements from inflationary and economic pressures and institutional factors. Quarterly values for the environmental variables and countries' primary balance, and debt-to-GDP ratios were interpolated via cubic spline interpolation from the annual series; results are robust to using linear interpolation.

4 Descriptive statistics

Figures 6 and 7 respectively present the evolution of the environmental and market-based key variables from 2000 to 2020. They illustrate the triple crisis. EMDEs tend to exhibit higher levels of nature- and climate-related financial vulnerability, as well as higher borrowing costs relative to AEs. Over the last two decades, the financial vulnerability of EMDEs to climate and nature has been declining more relative to AEs, from over 40 in 2000 to around 30 in 2020 for BHI, 35 to around 25 for the BII, and 38 to less than 35 for climate. However, policy stringency for nature protection improved more for AEs, as indicated by a greater decline in the EPI's subindex.

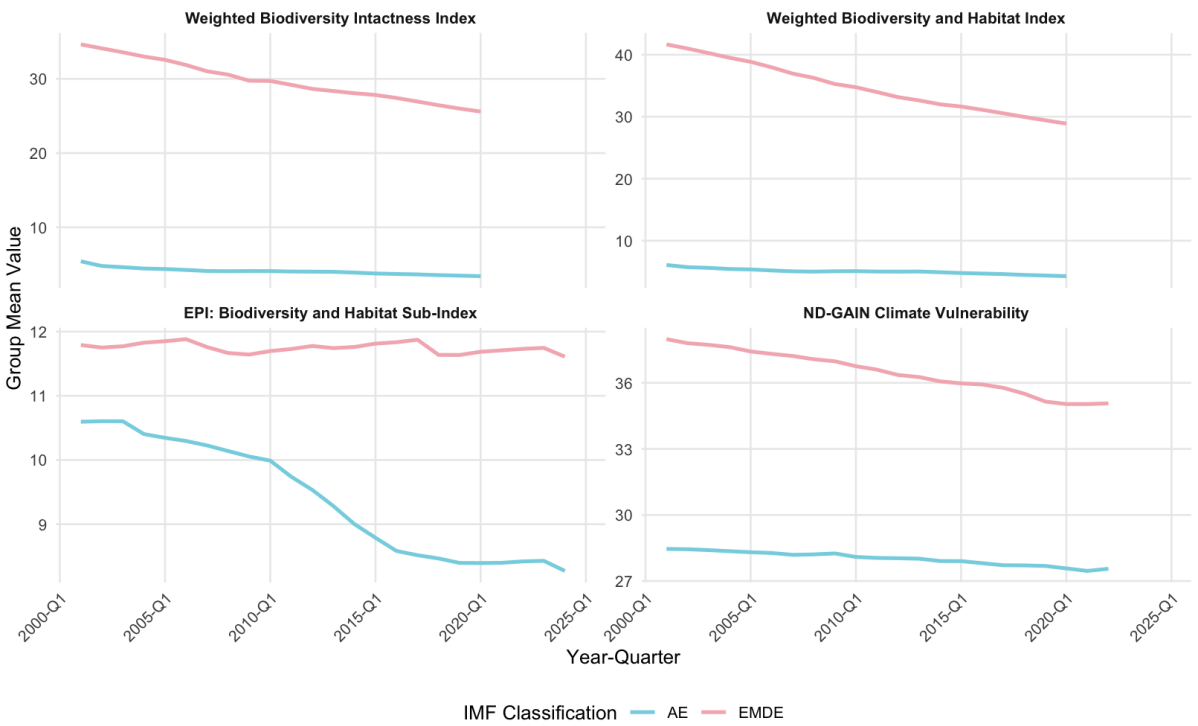


Figure 6: Evolution of Environmental Proxies from 2000 to 2020

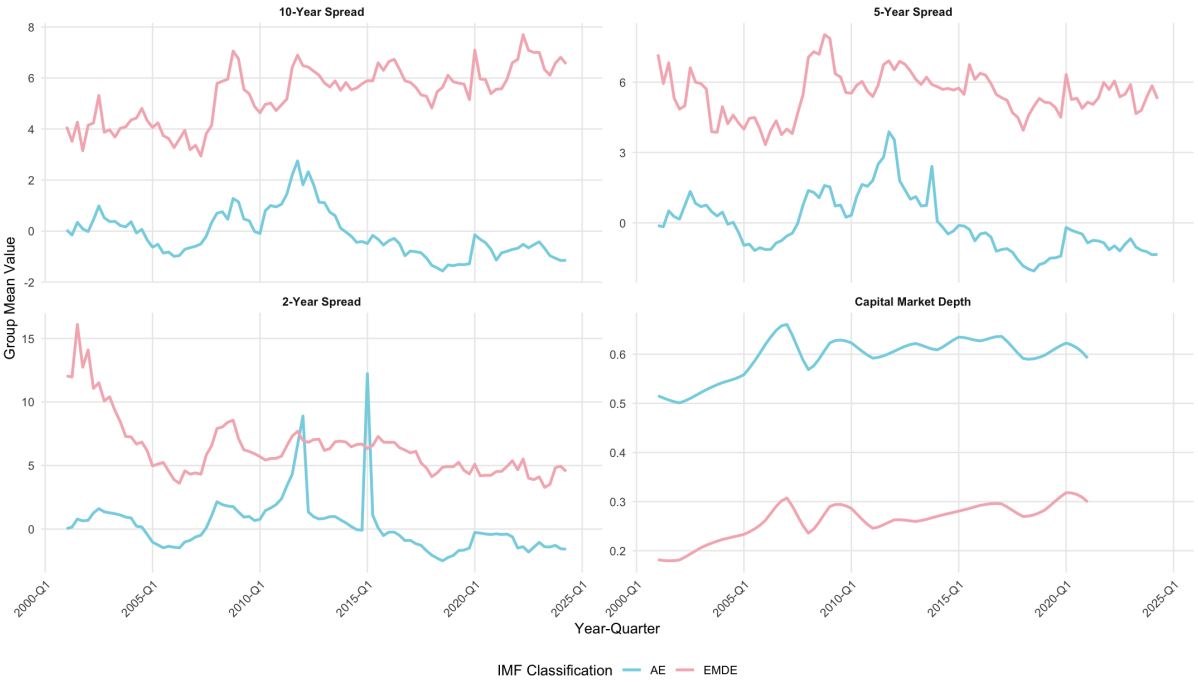


Figure 7: Evolution of Sovereign Bond Yield Spreads from 2000 to 2020

On the financial side, average bond yield spreads declined more for EMDEs over the same period, mostly across the 2- and 5-year maturities and increased again in the post-2020 inflationary period. Outliers heavily influence observations for quarters with spikes in spreads in crisis periods such as Greece and Ireland in the Eurozone crisis, or Sri Lankan debt crisis, which we remove from the sample consistent

with (Cevik & Jalles, 2022; Gomez-Gonzalez et al., 2025). The trends ensure that the regression captures more than static country differences.

Tables 1 and 2 present detailed descriptive statistics echoing the above visualisations. On average, EMDEs exhibit greater movements in nature and climate vulnerability, spreads, higher CA and PB deficits, higher inflation and lower capital market depth. Table 3 below shows a more detailed summary for each country in our analysis and select key variables.

Table 1: Descriptive Statistics for Advanced Economies (AEs)

Variable	Obs	Mean	Std Dev	Minimum	Maximum
Ten Year Spread	2542	-0.18	1.12	-4.77	10.91
Five Year Spread	2711	-0.21	1.43	-5.41	14.13
Two Year Spread	2652	-0.20	1.62	-6.02	15.99
ND-GAIN	3028	27.91	0.49	21.70	35.21
Weighted BII	2248	4.11	0.64	0.14	57.53
Weighted BHI	2248	4.77	0.54	0.08	46.75
EPI	2211	9.81	1.05	3.37	13.91
Inflation	3225	0.59	0.79	-2.99	6.91
GDP Growth	3287	0.58	1.68	-20.33	16.79
Current Account	3186	0.01	0.04	-0.25	0.36
Primary Balance	2919	0.49	2.95	-28.17	25.71
Debt-to-GDP	3088	63.45	16.75	6.07	226.65
CPI Food	3202	2.63	3.48	-14.25	28.67
Capital Market Depth	2916	0.59	0.11	0.02	1.00

Table 2: Descriptive Statistics for Emerging Market and Developing Economies (EMDEs)

Variable	Obs	Mean	Std Dev	Minimum	Maximum
Ten Year Spread	1875	5.24	2.17	-2.19	33.85
Five Year Spread	1899	5.51	2.27	-2.93	27.06
Two Year Spread	1582	5.56	2.98	-3.15	85.21
ND-GAIN	2687	36.39	1.10	26.02	50.01
Weighted BII	1906	28.37	3.18	2.53	100.00
Weighted BHI	1987	34.89	4.09	2.78	100.00
EPI	2195	11.59	0.51	3.00	18.22
Inflation	2532	1.99	3.39	-5.53	385.39
GDP Growth	2582	1.17	2.38	-24.66	26.94
Current Account	2434	-0.01	0.04	-0.30	0.19
Primary Balance	2579	-0.15	2.25	-12.62	9.41
Debt-to-GDP	2604	41.00	11.25	3.67	113.84
CPI Food	2320	11.15	19.23	-13.66	1824.73
Capital Market Depth	2587	0.27	0.08	0.00	0.96

Countries exhibit consistent scores across the nature- and climate-related financial vulnerability measures. On average across the period and the BII, BHI, EPI and ND-GAIN respectively, Uganda, Tanzania, Vietnam, Pakistan, India, Indonesia, Kenya, Sri Lanka, the Philippines exhibit high vulnerability. Advanced, smaller economies tend to be on the other end, such as Scandinavian countries, Singapore, and the Baltics. We exclude the US serving as baseline for spreads.

Table 3: Country Overview: Average Values of Key Variables

ISO	Country	IMF Group	BII	BHI	EPI	ND-GAIN	10-Year	5-Year	2-Year Spread
AUS	Australia	AE	3.45	2.05	10.93	27.75	0.88	1.11	1.39
AUT	Austria	AE	0.65	0.59	NA	26.15	-0.62	-0.69	-0.64
BEL	Belgium	AE	0.46	0.38	9.80	30.01	-0.48	-0.60	-0.63
CAN	Canada	AE	0.35	0.31	10.06	24.52	-0.05	0.02	0.13
HRV	Croatia	AE	2.24	3.87	9.46	33.06	0.13	1.68	0.79
CZE	Czech Republic	AE	2.11	1.50	NA	22.57	0.07	0.05	0.22
DNK	Denmark	AE	0.68	0.36	11.13	29.17	-0.59	-0.64	-0.63
FIN	Finland	AE	0.24	0.72	7.90	26.49	-0.63	-0.68	-0.79
FRA	France	AE	0.66	0.52	9.72	26.08	-0.54	-0.71	-0.74
DEU	Germany	AE	0.30	0.27	3.66	26.15	-0.84	-0.93	-0.88
GRC	Greece	AE	3.37	3.18	8.64	29.63	2.06	1.36	1.22
IRL	Ireland	AE	0.74	0.34	11.75	28.10	0.23	0.12	0.12
ISR	Israel	AE	0.18	0.72	12.81	27.23	0.29	-0.05	-0.15
ITA	Italy	AE	1.03	0.92	9.75	29.69	0.37	0.13	-0.07
JPN	Japan	AE	0.12	0.26	10.15	31.12	-2.61	-2.64	-2.48
KOR	Korea	AE	0.46	0.79	13.39	31.40	0.73	1.12	1.34
NLD	The Netherlands	AE	0.39	0.31	9.90	29.15	-0.73	-0.80	-0.72
NZL	New Zealand	AE	10.35	7.84	13.31	28.34	1.27	1.54	1.81
NOR	Norway	AE	0.12	0.31	8.28	23.59	-0.09	0.21	0.41
PRT	Portugal	AE	1.26	1.62	9.23	29.85	0.75	0.77	0.42
SGP	Singapore	AE	0.07	0.03	NA	34.33	-0.41	-0.99	-0.93
SVK	Slovakia	AE	2.46	2.21	NA	30.51	-0.15	-0.16	-0.98
SVN	Slovenia	AE	1.08	1.47	8.56	28.04	0.09	0.12	0.28
ESP	Spain	AE	1.69	1.65	9.12	25.71	0.24	-0.01	-0.13
SWE	Sweden	AE	0.24	0.57	8.15	28.39	-0.44	-0.42	-0.36
CHE	Switzerland	AE	0.24	0.17	NA	24.43	-1.90	-1.92	-1.87
GBR	United Kingdom	AE	0.36	0.17	8.56	24.01	-0.03	0.14	0.30
USA	United States	AE	0.33	0.25	11.42	26.14	NA	NA	NA
BRA	Brazil	EMDE	3.47	3.43	9.20	32.88	8.67	8.96	8.90
BGR	Bulgaria	EMDE	7.83	8.47	6.97	31.25	0.87	0.50	0.31
CHL	Chile	EMDE	1.22	1.52	11.53	30.28	2.31	2.50	2.54
CHN	China	EMDE	9.56	6.58	17.18	31.57	0.62	0.76	0.85
COL	Colombia	EMDE	2.81	2.17	9.63	36.76	6.11	5.99	5.33
EGY	Egypt	EMDE	NA	10.35	9.36	35.92	14.64	14.66	NA
HUN	Hungary	EMDE	5.50	4.40	NA	31.27	2.89	3.07	NA
IND	India	EMDE	23.05	19.94	17.69	42.41	5.54	4.63	4.68
IDN	Indonesia	EMDE	10.94	9.33	14.62	40.14	4.35	5.67	5.54
KEN	Kenya	EMDE	10.31	12.04	10.56	44.61	10.26	10.21	9.62
MYS	Malaysia	EMDE	6.17	6.72	14.53	33.30	0.78	5.68	5.59
MEX	Mexico	EMDE	3.74	3.76	13.11	32.26	4.62	5.00	4.77
PAK	Pakistan	EMDE	7.44	16.39	12.93	45.15	7.77	8.46	8.87
PER	Peru	EMDE	1.14	2.37	9.87	37.46	3.26	2.54	2.55
PHL	Philippines	EMDE	11.83	9.93	15.84	41.18	3.81	5.04	3.77
POL	Poland	EMDE	3.34	2.96	3.92	26.56	2.02	2.54	3.07
ROU	Romania	EMDE	8.21	6.65	6.86	36.64	2.78	2.70	2.60
RUS	Russia	EMDE	0.84	0.73	11.37	28.86	5.88	6.45	6.76
ZAF	South Africa	EMDE	8.22	5.59	12.71	34.11	6.15	5.95	5.56
LKA	Sri Lanka	EMDE	11.41	11.20	14.30	41.24	9.46	9.49	9.69
TZA	Tanzania	EMDE	14.34	20.79	8.43	45.91	11.71	9.81	9.85
THA	Thailand	EMDE	8.03	8.09	10.35	35.81	0.32	0.23	0.21
TUR	Türkiye	EMDE	7.21	9.11	15.15	32.28	10.14	11.19	15.68
UGA	Uganda	EMDE	26.92	18.91	NA	47.81	13.26	13.20	11.86
VNM	Vietnam	EMDE	19.78	21.16	14.92	41.14	4.14	4.00	3.99

The spearman's correlation matrix, used due to the non-normal distribution of variables, suggests a positive bivariate relation between the vulnerability measures and spreads (see Fig. 14 in the appendix). Figures 8–11 also visualise this positive relation, that countries with higher nature-related financial vulnerability tend to exhibit higher borrowing costs and also lower capital market depth, highlighted via smaller dot sizes of observations in the upper right quadrant. We've added a linear trend capturing this pattern across the scatter plots. The pattern is also consistent across bond maturities and proxies for nature vulnerability and climate vulnerability, visually describing the triple crisis.



Figure 8: Sovereign Bond Yield Spreads vs Nature Vulnerability: Weighted Biodiversity Habitat Index



Figure 9: Sovereign Bond Yield Spreads vs Nature Vulnerability: Weighted Biodiversity Intactness Index

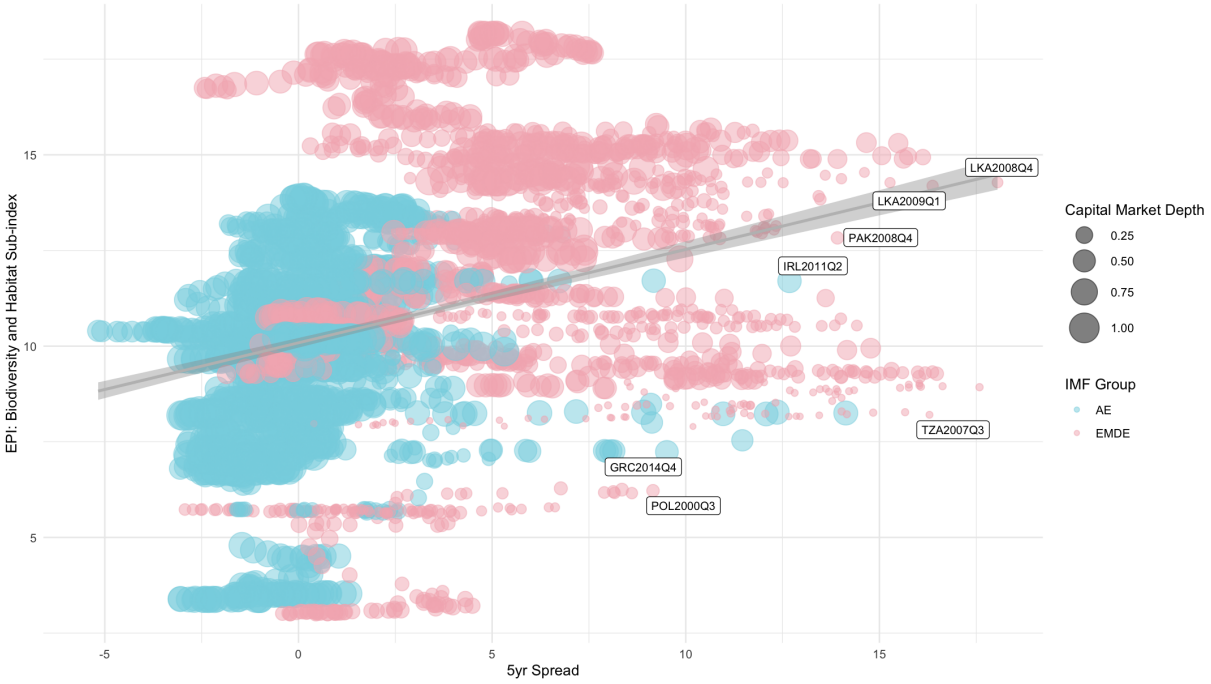


Figure 10: Sovereign Bond Yield Spreads vs Nature Vulnerability: Environmental Performance Index

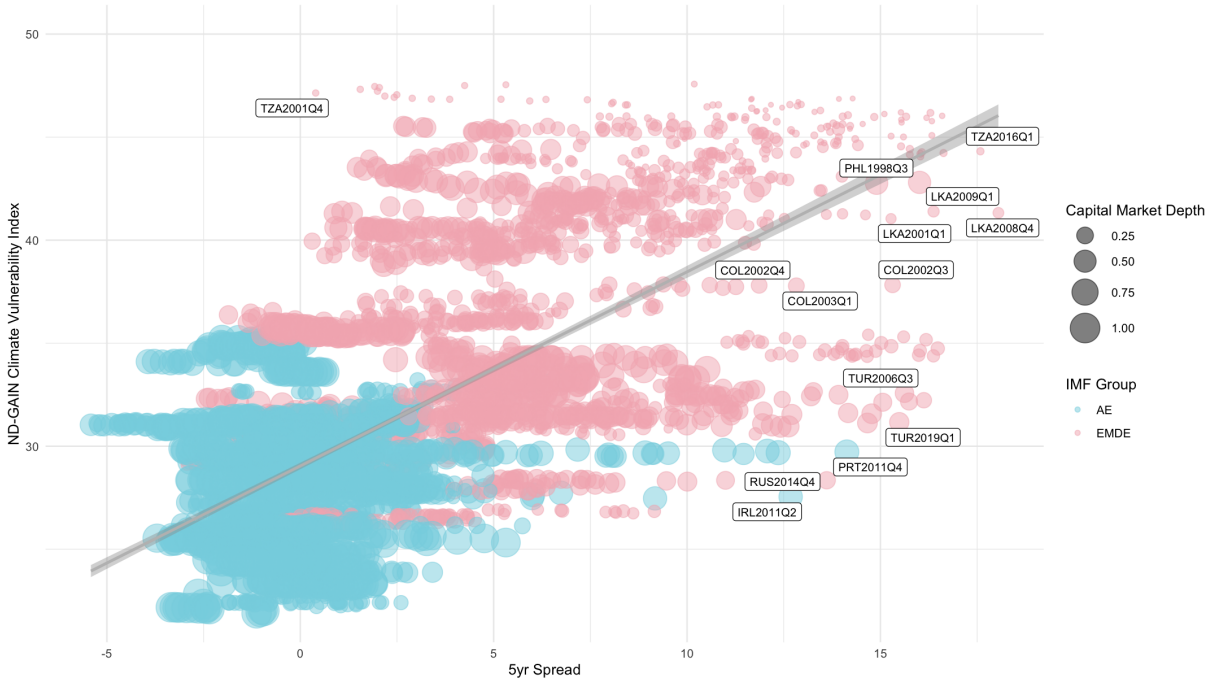


Figure 11: Sovereign Bond Yield Spreads vs Climate Vulnerability: ND-GAIN

The picture, however, is slightly more mixed for the EPI, with some EMDEs (AEs) evidencing lower (higher) levels of transition-related vulnerability. We now turn to investigating this pattern formally.

5 Estimation strategy

5.1 Interactive fixed effects panel model

We implement a twofold approach to estimate this visual positive association more rigorously; the choices and challenges are discussed in this section. First, we employ a dynamic panel interactive fixed effects (IFE) specification to assess the macro-financial effects of nature vulnerability, followed by second, a quantile IFE regression to investigate potential asymmetry. The first, baseline specification captures the impact of environmental, nature- or climate-related financial vulnerability (EV_{it-1}), on the dependent variable, sovereign bond yield spreads for country i at time t Y_{it}. $EV_{it-1}$is lagged once to mitigate endogeneity concerns (Bingler, 2022), resulting in:

$$Y_{it} = \beta EV_{it-1} + \gamma X_{it} + \alpha_i + u_{it} \qquad with \quad u_{it} = F_t\lambda_i + \varepsilon_{it} \tag{1}$$

Where X_{it} denotes the set of domestic economic and institutional controls; inflation, the CA, PB, GDP growth, the debt-to-GDP ratio, capital market depth and food price inflation, and u_{it} the idiosyncratic error terms clustered at the country level with the latent factor component we discuss below. Considerable variation in spreads and economic specificities necessitate the inclusion of country fixed-effects α_i, which are justified over random effects by the Hausman test. These can be interpreted as constant country-specific risk premia. The intuition is to account for unobservable heterogeneities that are plausibly time-invariant and may bias our estimation by affecting both sides of the equation.

Crises and market turmoil can equivalently result in unobserved time-specific shocks and bias, which former studies attempted to mitigate with time fixed-effects (Cevik & Jalles, 2022; Collender et al., 2023; Volz et al., 2020). However, this approach would be problematic considering the implausible assumption that global financial cycles and common crises affect countries equally, as our descriptive statistics above evidenced. Furthermore, the mis-specification is aggravated by the significant serial correlation in bond yields with an AR(1) coefficient above 0.9 for all tenors, resulting in uncaptured autocorrelation in the residuals. In addition, the highly integrated nature of sovereign debt markets leads to cross-sectional dependence, which the Pesaran test highlights at the 1% level when specified in a standard panel fixed effects framework. The strong co-movement, especially during periods of market turbulence such as the Global Financial Crisis and European Debt Crisis, and associated changes in US and European interest rates affected both the global market uncertainty and financial cycles (Gilchrist et al., 2022; Miranda-Agrippino & Rey, 2021; Rey, 2015), i.e. common factors across all countries. As they plausibly affect both spreads and macroeconomic controls X_{it}, omitting them likely results in bias. In combination, these concerns concretely suggest that u_{it} may be correlated with u_{it-1} and u_{jt-1} which few earlier studies accounted for. Time fixed-effects and our controls X_{it} would fall short of fully explaining these concerns and dynamics, particularly the unobservable common factors that influence bond yields and spreads Y_{it}.

These characteristics lead us to consider the IFE estimator, similar to (Wang, 2021). Relative to the existing literature on the determinant of borrowing costs (Boitan, 2023), the novel addition lies in the latent factor component $F_t\lambda_i$ of the IFE approach pioneered by Bai (2009). This approach explicitly models that the error term in the estimation may contain global common financial factors F_t that affect countries with different sensitivities, the factor loadings λ_i. We draw inspiration for this approach from the macro-econometric literature dedicated to inference under cross-sectional dependence and time-varying common factors (Harding & Lamarche, 2014; Moon & Weidner, 2017; Wang, 2021; Xu, 2017). Compared to time fixed-effects with implausible assumptions in our context, we believe it's more insightful to explicitly model unobserved variables where possible instead of eliminating them. Furthermore, the latent factor structure mitigates concerns for uncaptured autocorrelation in the residuals and cross-sectional dependency through the latent factor and unit loadings. Combined, the term $F_t\lambda_i$ models

the cross-country heterogeneity that is allowed to vary over time. Omitting the possibility of these unobserved common factors also violates the strict exogeneity assumption.

The IFE approach offers a parsimonious alternative to explicitly including proxies such as the volatility index(VIX) or JP Morgan Government Bond Index (GBI) as barometers for equity and bond market uncertainty. However, this is only insofar as they adequately capture the variation in common dynamics affecting sovereign bond yields, and a sufficient number of factors is included. Consistent with Wang (2021), we used the eigenvalue-ratio test (Ahn & Horenstein, 2013), suggesting the use of $K = 1$ factor. It is strongly correlated with e.g. the GBI $\rho > 80\%$ across all specifications. We use up to 2 factors for robustness, as the literature suggests overfitting too many factors is a greater concern than the reverse (Moon & Weidner, 2017). Note also that we include a nonparametric block bootstrap for the IFE estimation for robustness (Xu, 2017), resulting in clustered standard errors at the country level that are robust to serial correlation and heteroskedasticity. As an imperfect robustness check, we also add up to two lags of the dependent variable, discussed further in the limitations and appendix.

5.2 Quantile IFE panel model

Second, we employ a quantile IFE mixture model to investigate the potential asymmetry in the financial impact of nature-related vulnerability. Where the above IFE estimator provides a robust baseline estimate of the average marginal effect, it may mask heterogenous dynamics. Put simply, the impact may not be uniform, but higher for countries with elevated sovereign risk as found in the climate vulnerability context (Gomez-Gonzalez et al., 2025). We build on their approach and retain the latent factors to address both the cross-sectional dependence and distributional heterogeneity of sovereign debt markets. It is also well-suited for nature risks, given the uneven spatial distribution of degradation. This analysis builds on the extension of panel quantile models into longitudinal contexts (Koenker, 2004), with interactive effects (Harding & Lamarche, 2014), and estimates impacts conditional on τ-quantiles of the dependent variable, spreads:

$$Q_\tau\left(Y_{it} \mid X_{it}, \alpha_i, F_t, \lambda_i\right) = \beta_\tau EV_{it-1} + \gamma_\tau X_{it} + \alpha_i + F_t\lambda_i + \varepsilon_{it}, \quad with\ \tau \in (0,1) \tag{2}$$

Where β_τ captures the marginal impact of environmental vulnerability EV_{it-1} not on average but at τ quantile of the conditional spread distribution. The second stage analysis necessitates factor estimation in a preliminary step, such as PCA on the observed cross-section of yield spreads. This is both consistent with Gomez-Gonzalez et al. (2025) and ensures that we use factor consistency across quantiles. Similar to their analysis, our first factor explains roughly 46% of the variance across the spread series, which increases to 78% with a second which validates our factor approach. The first latent factor captures well global financial and bond market dynamics consistent with (Wang, 2021). For example, it is highly correlated with the the GFD World Government Bond GDP-Weighted Index $\rho = 90\%$ and J.P. Morgan Global Bond Index for Emerging Markets (GBI-EMBI) $\rho = 85\%$, and equity market dynamics such as the MSCI World Index with $\rho = 69\%$ and moderately with the Volatility Index (VIX) $\rho = 41\%$. Whilst the second factor is uncorrelated with bond market dynamics and moderately with equity markets, it correlates more with the IMF's Global Commodity Price Index $\rho = 60\%$ and Oil Price Index ($\rho = 48\%$, and negatively with US Federal Funds Rate (FFR) $\rho = -54\%$, suggesting it relates more to real economy and commodity dynamics. Figure 15 & 16 visualise these in the appendix. We interpret these patterns as evidence of common financial trends that must be accounted for, with F_t of dimensionality $K = 1$ in our parsimonious baseline, and we test for robustness with $K = 2$.

Specifically, we estimate the model using the linear quantile mixture model (LQMM) approach (Alfò

et al., 2017; Geraci & Bottai, 2014) analogous to (Gomez-Gonzalez et al., 2025). The LQMM's likelihood-based approach offers advantages over the distribution-free approach for handling country unobserved heterogeneity in quantile regressions, as a large number of fixed effects can introduce the incidental parameters problem. In the latter, fixed individual-specific intercepts treated as location shift parameters identical across all quantiles were introduced (Koenker, 2004), and with penalization or shrinkage to mitigate the incidental parameters problem and asymptotic variance (Lamarche, 2010).

Instead, the likelihood-based approach treats the unit-specific parameters as random variables that are allowed to vary across quantiles, a more flexible approach. The LQMM approach is well-suited to model the unobserved country-specific heterogeneity with minimal ex-ante assumptions about their distribution. It follows a data-driven flexible assignment, modelling the panel as a finite mixture of G latent distributions of country groups sharing unobserved characteristics and random group-specific intercepts (Alfó et al., 2025). Information criteria suggest using $G = 4$ groups as baseline, and we test for robustness with 3 and 5 groups, and 1-2 factors. Standard errors are computed using a non-parametric block bootstrap with replacement. Further details are included in the appendix.

6 Results

6.1 Interactive fixed effects model:

The results from the panel interactive fixed effects estimation, the first stage of our analysis from equation (1), are provided in Table 4 below. Each table presents the results per specification in 12 separate columns across the 10, 5, and 2-year borrowing horizons, with the key explanatory variables in the top rows. First the proxies for countries' physical vulnerability to biodiversity degradation (BHI & BII), then the transition-related EPI, and in the fourth row the widely used climate vulnerability ND-GAIN index for comparison.

Across most of our specifications, the results clearly evidence a macro-criticality of nature vulnerability for the cost of sovereign borrowing. The positive associations hold at the 1% to 5% level for the 5- and 2-year bond maturities, and range from around 16 to 70 basis points (bps) on average across the sample. Each specification controls for domestic economic and institutional fundamentals and cross-sectional dependence in the integrated government bond universe via the latent factor structure. The positive coefficients are statistically and economically more significant for shorter maturities, and are of similar magnitude to the ND-GAIN climate vulnerability index included as comparison and are consistent with the existing literature (Boitan, 2023; Cevik & Jalles, 2022; Kling et al., 2021). This broad picture is robust to varying the factor structure with 0, 1, or two factors and likewise with lagged dependent variables over 108 specifications in total. Each specification is estimated with block-bootstrapped standard errors clustered at the country level with 1000 replications.

The direction and magnitude of effects of the domestic economic conditions also follow intuition and earlier studies, such as a strongly significant positive impact of inflation and negative of GDP growth across all maturities. Variables such as the Debt/GDP ratio and capital market depth have negative signs, following our expectations. These are weakly significant for the 10-Year maturities, suggesting a stronger relevance of these slower-moving structural variables for markets in the long-term, as opposed to inflation, economic growth, and environmental variables, which are more significant for 2-year horizon.

Table 4: Interactive Fixed Effects (2 Factors) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	−0.107				0.242**				0.474			
	(0.135)				(0.212)				(0.242)			
Biodiversity Degradation (BHI)		−0.166				0.398***				0.699**		
		(0.137)				(0.175)				(0.231)		
EPI			0.129				0.162**				0.429***	
			(0.168)				(0.138)				(0.122)	
Climate Vulnerability				0.192***				0.679***				0.756***
				(0.049)				(0.065)				(0.075)
Inflation	0.103***	0.108***	0.120**	0.109***	0.133***	0.129***	0.146***	0.137***	0.148***	0.142***	0.159***	0.176***
	(0.041)	(0.040)	(0.037)	(0.039)	(0.046)	(0.044)	(0.040)	(0.041)	(0.046)	(0.046)	(0.043)	(0.042)
Primary Balance (PB)	−0.050	−0.047	−0.080	−0.055**	−0.053	−0.057	−0.065	−0.050*	0.021	0.020	0.045	−0.058
	(0.034)	(0.033)	(0.032)	(0.028)	(0.039)	(0.038)	(0.037)	(0.035)	(0.048)	(0.049)	(0.044)	(0.043)
Current Account (CA)	−0.103	−0.149	0.172	0.436	−0.823	−0.779	0.057	−0.176	0.473	0.648	0.315	−1.976
	(0.959)	(0.940)	(1.377)	(0.987)	(1.171)	(1.198)	(1.249)	(1.372)	(1.451)	(1.462)	(1.495)	(1.612)
GDP Growth	−0.044**	−0.044**	−0.020***	−0.018***	−0.041*	−0.046*	−0.033**	−0.025**	−0.034	−0.035	−0.044**	−0.027**
	(0.015)	(0.016)	(0.008)	(0.007)	(0.022)	(0.021)	(0.011)	(0.010)	(0.029)	(0.028)	(0.015)	(0.016)
Debt/GDP Ratio	0.023	0.023	0.021**	0.027**	0.011	0.009	0.025**	0.015	0.031	0.030	0.036	0.002
	(0.014)	(0.014)	(0.012)	(0.009)	(0.015)	(0.015)	(0.011)	(0.011)	(0.019)	(0.020)	(0.014)	(0.015)
FM Depth	−1.521	−1.698*	−1.611	−1.505	−0.417	−0.288	0.235	0.368	0.073	0.217	−0.258	−0.274
	(1.151)	(1.103)	(1.183)	(0.993)	(1.367)	(1.289)	(1.385)	(1.091)	(1.551)	(1.697)	(1.573)	(1.314)
Rule of Law (WGI RL)	−0.280	−0.179	0.222	0.688	−0.730**	−0.602*	−0.598	0.205	−1.661*	−1.591*	−0.938	0.529
	(0.293)	(0.298)	(0.469)	(0.439)	(0.431)	(0.408)	(0.495)	(0.689)	(0.564)	(0.570)	(0.554)	(0.815)
CPI Food	0.041**	0.039**	0.044***	0.034**	0.057**	0.055***	0.062***	0.049***	0.064**	0.064**	0.080***	0.070**
	(0.017)	(0.016)	(0.015)	(0.014)	(0.020)	(0.018)	(0.017)	(0.018)	(0.026)	(0.028)	(0.027)	(0.025)
Constant	2.692***	2.846***	−0.138	−6.841***	3.091***	2.082***	1.330	−20.140***	3.624***	2.385***	−0.769**	−23.110***
	(0.466)	(0.496)	(0.597)	(0.398)	(0.658)	(0.649)	(0.627)	(0.552)	(0.637)	(0.760)	(0.706)	(0.635)
Within R^2	0.760	0.755	0.741	0.742	0.769	0.760	0.726	0.732	0.749	0.747	0.750	0.729
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	60.3	59.8	64.1	66.1	61.5	60.9	65.0	67.6	59.5	59.5	63.6	66.2
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	2	2	2	2	2	2	2	2	2	2	2	2
Observations	2,955	2,988	2,822	3,304	3,015	3,047	2,859	3,379	2,857	2,857	2,733	3,178

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

The average impact of domestic nature degradation on borrowing costs increases in magnitude and statistical significance as the borrowing horizon shortens. Taking the 2-factor specification shown above, a one-unit increase in biodiversity degradation (BHI) in the preceding quarter is associated with a nearly 40 bps average increase in 5-year spreads, but nearly 70bps for 2-year spreads (columns 6 & 10). In comparison, a one-unit increase in the EPI (ND-GAIN) is associated with 16 bps higher 5-year borrowing costs (68 bps) and 43 bps higher 2-year spreads (76 bps). These coefficients suggest substantial increases in the cost of government borrowing, considering that the within-country standard deviation for biodiversity degradation (BHI) is 1.46 and 5-year spreads averaged 4.11 for EMDEs across 2000-2020. Overall, the sign and magnitude of coefficients is consistent between physical vulnerability measures, biodiversity degradation (BII and BHI) and similar to the ND-GAIN, suggesting that markets have historically priced these directly or indirectly in similar magnitude over the period of our analysis. However, where climate vulnerability seems to have a statistically significant impact across all maturities, nature vulnerability is insignificant throughout for 10-year spreads.

These results are consistent across varying the factor structure. Table 5 summarises results for the 1-factor specification below, which documents higher impact magnitudes. On 5-year spreads, the average marginal impact from the BHI increases to 69bps, from the BII to 54bps, and from ND-GAIN to 75bps, all significant at the 1% level. The marginal effects from transition-related vulnerability of the EPI remain lower but substantial, as a one-unit increase is associated with 34bps higher sovereign borrowing costs on the 5-year and 43bps on the 2-year horizon. Nevertheless, the lower explanatory power of the variation in borrowing costs from the 1-factor specification suggests we draw our focus on the 2-factor as baseline. Specifically, it increases from a within R^2 of around 0.6 for $K = 1$ and R^2 around 0.75 for $K = 2$ specifications. Compared to a within R^2 around 0.2 for the country-fixed effect specification (see Table 10), these strong improvements in explanatory power highlight the importance of the IFE approach. Whereas adding LDVs similarly increases the within R^2 it raises other correlation concerns as we note below, though the direction and effect magnitude remain robust as shown in the appendix. We interpret the asymmetric effect magnitudes over time as evidence suggesting that markets, over the sample countries and period, have viewed nature-vulnerability, where significant, as a short-term risk to sovereign creditworthiness. However, it is unlikely that markets were directly monitoring ecological integrity directly, as opposed to an indirect transmission mechanism as we discuss below.

Table 5: Interactive Fixed Effects (1 Factor) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	−0.105				0.534***				0.358*			
	(0.161)				(0.209)				(0.283)			
Biodiversity Degradation (BHI)		−0.208				0.685***				0.623**		
		(0.207)				(0.180)				(0.249)		
EPI			0.542				0.337*				0.427***	
			(0.237)				(0.197)				(0.131)	
Climate Vulnerability				0.263***				0.753***				0.788***
				(0.069)				(0.073)				(0.081)
Inflation	0.083*	0.095**	0.079**	0.096**	0.150***	0.139***	0.134***	0.144***	0.173***	0.165**	0.179***	0.189***
	(0.052)	(0.047)	(0.042)	(0.042)	(0.056)	(0.051)	(0.048)	(0.045)	(0.068)	(0.068)	(0.062)	(0.058)
Primary Balance (PB)	−0.031	−0.025	−0.021	−0.049	−0.012	−0.011	0.013	−0.009	0.007	0.001	0.016	0.016
	(0.041)	(0.040)	(0.036)	(0.041)	(0.036)	(0.039)	(0.037)	(0.042)	(0.039)	(0.039)	(0.040)	(0.044)
Current Account (CA)	1.066	0.999	−2.121	1.594	0.728	0.919	1.442	1.358	−1.509	−1.363	−0.647	−1.319
	(1.440)	(1.356)	(2.102)	(1.627)	(1.299)	(1.321)	(1.750)	(1.813)	(1.415)	(1.414)	(1.540)	(1.672)
GDP Growth	−0.051***	−0.050***	−0.028***	−0.030***	−0.065***	−0.066***	−0.050***	−0.048***	−0.053**	−0.049**	−0.050***	−0.046***
	(0.020)	(0.019)	(0.010)	(0.010)	(0.030)	(0.028)	(0.017)	(0.015)	(0.035)	(0.032)	(0.022)	(0.021)
Debt/GDP Ratio	0.036*	0.037**	0.021**	0.030**	0.038**	0.037**	0.040**	0.028	0.032*	0.030*	0.041**	0.023
	(0.014)	(0.014)	(0.014)	(0.011)	(0.012)	(0.013)	(0.015)	(0.013)	(0.014)	(0.013)	(0.014)	(0.015)
FM Depth	−0.439	−0.661	−2.122	0.098	−0.612	−0.134	−1.410	0.734	0.513	0.962	−0.280	0.501
	(1.107)	(1.030)	(1.212)	(1.095)	(1.415)	(1.458)	(2.005)	(1.784)	(1.850)	(1.841)	(2.189)	(2.239)
Rule of Law (WGI RL)	−0.734	−0.601	−0.903	−0.313	−1.650***	−1.586***	−1.366*	−1.024	−1.509**	−1.523**	−1.078	−0.468
	(0.438)	(0.451)	(0.530)	(0.801)	(0.445)	(0.438)	(0.563)	(0.875)	(0.519)	(0.522)	(0.617)	(0.974)
CPI Food	0.051***	0.048***	0.060***	0.036***	0.071***	0.069***	0.077***	0.061***	0.084***	0.085***	0.090***	0.080***
	(0.016)	(0.015)	(0.015)	(0.014)	(0.021)	(0.020)	(0.021)	(0.021)	(0.029)	(0.030)	(0.030)	(0.029)
Constant	3.512***	3.786***	−0.782	−6.336***	3.535***	2.648***	1.782	−19.619***	3.776***	2.534**	−0.839	−22.521***
	(0.616)	(0.608)	(1.056)	(0.408)	(0.781)	(0.818)	(1.045)	(0.610)	(0.865)	(0.974)	(0.880)	(0.724)
Within R^2	0.585	0.584	0.561	0.553	0.622	0.614	0.583	0.561	0.605	0.605	0.601	0.564
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	60.3	59.8	64.1	66.1	61.5	60.9	65.0	67.6	59.5	59.5	63.6	66.2
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	1	1	1	1	1	1	1	1	1	1	1	1
Observations	2,955	2,988	2,822	3,304	3,015	3,047	2,859	3,379	2,857	2,857	2,733	3,178

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

6.2 Quantile IFE panel model

The quantile results support the first stage analysis and reveal considerable heterogeneity. Marginal impacts are elevated substantially to around 75bps at the top quantile of sovereign borrowing costs, compared with around 25bps at the middle. Figure 12 presents these results with 2 factors in a visual format, with the columns indicating the nature- or climate-related financial vulnerability explanatory variable and rows the borrowing horizon. Within each plot, the leftmost point represents the β_τ coefficient at the 10^{th} quantile, followed by the 25^{th}, 50^{th}, 75^{th}, and 90^{th} quantile. Not only are the coefficient magnitudes consistently elevated for higher quantiles, the inter-quantile differences are also statistically significant and elevated for shorter maturities. At the top two quantiles, the marginal impact of biodiversity degradation, BHI and BII, as well as the EPI is strongly significant and surpasses the magnitude of the ND-GAIN. However, nature vulnerability tends to be insignificant for the lowest quantiles, at times negative with weak significance. Therefore we can reject the null hypothesis of no association between nature vulnerability and borrowing costs on average, and for most quantiles too, as our results show elevated marginal impacts for higher quantiles at the 1% level. That these patterns also hold for climate vulnerability, visualised in the right-hand column that replicates results consistent with Gomez-Gonzalez et al. (2025), highlights the robustness of our specification and approach.

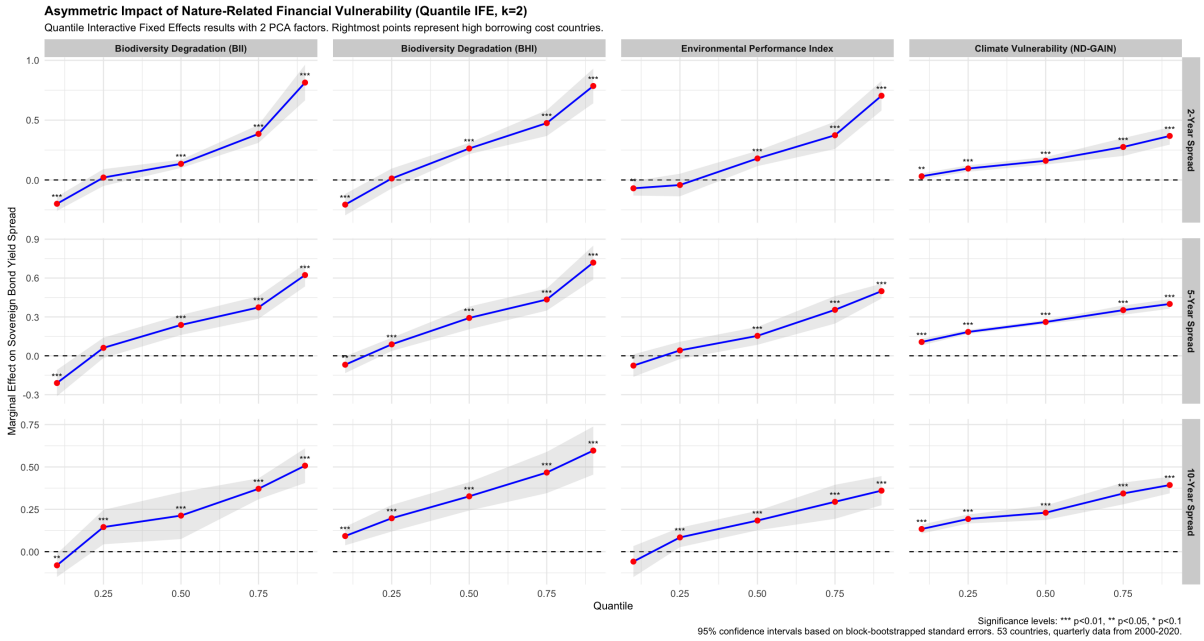


Figure 12: Asymmetric Impact of Nature Vulnerability on Borrowing Costs, 2 Factors, 4 Groups

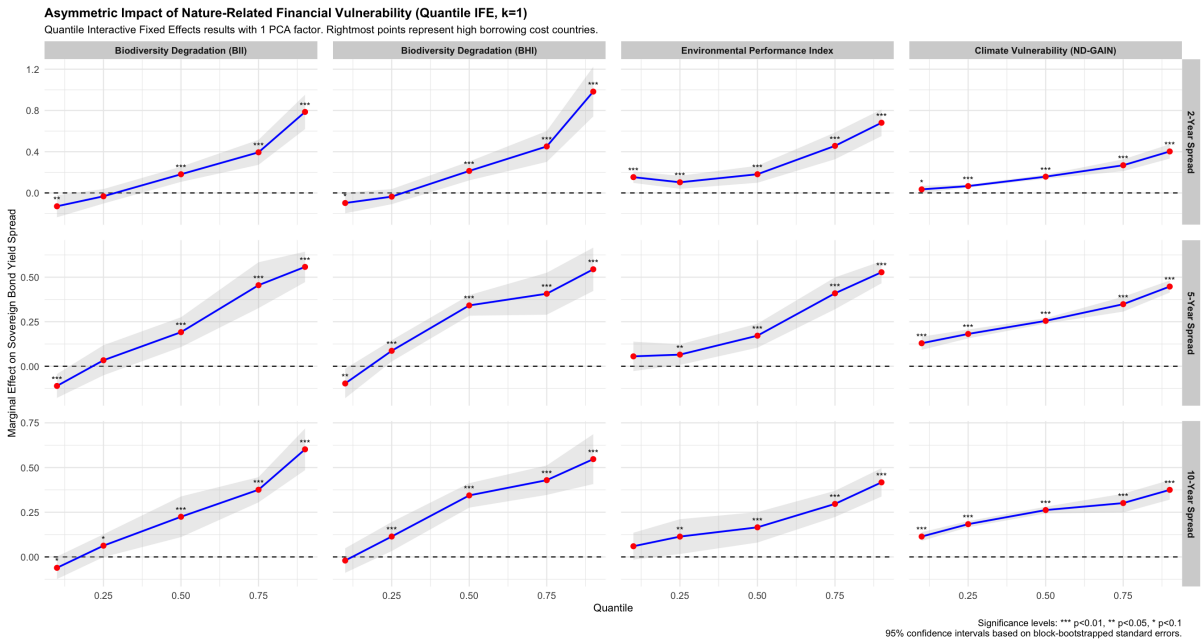


Figure 13: Asymmetric Impact of Nature Vulnerability on Borrowing Costs, 1 Factor, 4 Groups

In detail, where the average marginal impact on 2-year spreads from one-unit greater weighted biodiversity degradation (BHI) was associated with 54 higher bps in the 2-factor specification above, this magnitude grows to over 75bps for the top quantile. This pattern is identical to the BII as robustness check. Yet unlike the first-stage IFE above, the quantile results point to a greater impact magnitude on sovereign borrowing costs from nature than climate-related financial vulnerability, which is around 40bps for the top quantile and 20 for the 50^{th}. The physical nature-vulnerability proxies exhibit, as in the average IFE, impact magnitudes slightly above the transition-risk and policy-focused EPI. And in addition, the change in effect magnitude is much steeper for the nature proxies than for climate vulnerability. These dynamics, robust across varying the number of factors and groups, substantiate the asymmetrical sovereign risk from nature-related financial vulnerability, both physical and transition-related, that is distinct and more disproportional than from climate change.

Taken at face value, our results suggest that when and where sovereign risk was elevated, markets priced increased financial, physical vulnerability to nature loss more than for countries with average sovereign risk. However, the effects from climate vulnerability remain positive and strongly significant for bottom quantiles, the effects via our nature proxies tend to become insignificant. Considering that AEs and other high-income countries such as Switzerland, Germany, France, Japan and the Netherlands tend to populate the bottom quantile, where ecosystem-dependent sectors such as agriculture contribute little to overall GDP, these results are broadly in line with econommic intuition. EMDEs and other low-income countries such as Egypt, Kenya, Sri Lanka, Turkey, Tanzania and Uganda tend to populate the top quantile of the sovereign risk distribution, with Brazil, Colombia, Indonesia, Pakistan, South Africa, Malaysia, and Mexico tending to have above average spreads.

To summarize, our results point to a substantial difference in the premium to sovereign borrowing from greater nature-related financial vulnerability. This is up to three times higher for countries grouped at the 90^{th} compared to the 50^{th} quantile, and controls for domestic economic fundamentals and common market factors also affecting differences in country creditworthiness. As the magnitude is also higher for shorter borrowing maturities, this suggests that like climate vulnerability, nature vulnerability is also predominantly factored into short-term considerations and for high-risk countries. However, the stronger association for the top quantile also suggests that a reversal in, for example, biodiversity degradation

or improvement in environmental policies that the EPI captures, is associated with greater potential reductions in sovereign borrowing costs than for bottom quantiles. This points to a more pronounced transmission channel for top vis-à-vis bottom quantiles, as we discuss below.

A note of caution is needed on our results. The analysis seeks to isolate the marginal financial impact of within-country nature degradation by examining the extent to which it was priced by bond markets. We are thus unable to claim whether these adequately reflect the magnitude of climate and nature risks. And more importantly, it does not account for the interconnectedness of global bond markets, and supply chains via which nature-dependent goods are traded, whereby upstream degradation can affect countries in the bottom quantile of our analysis for which the results find no statistically significant direct impact, such as via food price inflation (Kotz et al., 2024; Wegner et al., 2025).

6.3 Limitations:

The analysis takes several steps to strengthen internal validity, yet important limitations remain. First, we control for alternative explanations and omitted variable bias by including conventional macroeconomic determinants, country fixed effects, and up to two latent global bond market factors similar to recent studies (Gomez-Gonzalez et al., 2025; Wang, 2021). In addition, the latent factor structure addresses unobserved common shocks and concerns for cross-sectional dependence considering the co-moving nature of the sovereign bond market, threatening strict exogeneity. Further, the block bootstrapping procedure provides heteroskedasticity and autocorrelation-consistent standard errors clustered at the country level bootstrap for both the IFE and quantile models. Nonetheless, the IFE estimator remains subject to asymptotic bias from cross-sectional heteroskedasticity and serial dependence in the error term (Bai, 2009). Yet given the panel model dimensions, this potential bias is likely within the magnitude of the standard errors. Further, we test for robustness by alternating the factor structure and including LDVs. This introduces Nickell Bias (Moon & Weidner, 2017; Nickell, 1981), though in a magnitude marginal given the panel dimensions. More problematically, the addition of LDVs introduces autocorrelation with the persistent factor, wherefore we only use them as imperfect robustness check.

A second set of limitations concerns external validity. The 25 EMDEs in our 53-country sample comprise primarily middle- and high-income economies with debt capital markets sustaining government borrowing of a magnitude and consistency sufficient for inclusion in Bloomberg databases. Sample selection bias, in other words, is an issue, equivalent to the existing literature. Yet we position that increasing the representation of low-income countries, which tend to have higher ecosystem dependence, would increase rather than diminish the magnitude and robustness of our results. Furthermore, the nature proxies focus on terrestrial biodiversity and habitat intactness and do not fully capture marine ecosystems or local ecosystem services that may be critical in other contexts, echoing Wang (2021)'s concern that aggregated metrics mask important spatial and sectoral heterogeneity.

Our reduced-form design is also not fully suited for causal impacts, considering that unobserved residual confounders may always remain. Moreover, we can only partially rule out reverse causality. High borrowing costs may themselves accelerate nature degradation and policies as tighter fiscal spaces may incentivise activities and resource extraction destructive to ecosystem intactness. While possible, we deem this less of a concern considering that it's more probable for slow-moving ecosystem intactness and nature variables to steer fast-moving bond prices, than rapid fluctuations in borrowing costs to drive degradation at a similarly rapid pace and extent. In the two decades of our analysis, this concern is also less plausible as the trends are contained in the country-specific fixed effects α_i and common latent factor and country sensitivities $F_t\lambda_i$. Finally, the analysis focused on the impacts of domestic biodiversity degradation and does not capture the spillover to other countries.

7 Discussion, concluding remarks and policy implications

Summary of findings

In this paper, we find robust evidence for the macro-criticality of nature. Alongside climate change surpassing the 1.5-degree target in 2024, nature degradation has been intensifying and surpassed critical thresholds in over 60% of the global land area (Stenzel et al., 2025). As most existing studies fixated on the former, we assessed the financial effects of nature degradation on the cost of government borrowing across 53 countries and quarterly data from the 2000-2020 period. Our results showed strongly significant and sizeable effects that are higher for shorter borrowing horizons, 5- and 2-year tenors in our sample, even when controlling for conventional economic and institutional determinants of sovereign risk, unobserved country fixed-effects, and common global market factors. At a glance, we find that countries with greater weighted biodiversity degradation pay a sovereign borrowing cost penalty, from around 40-75bps for 5- and 2-year maturities respectively. Our first stage results are robust across 108 different specifications of varying factor structure, borrowing horizon, and lagged yield spreads.

Recognising the uneven reality of nature loss and debt distress, our second-stage quantile regression delivers robust evidence for asymmetric marginal effects from nature degradation. Put simply, they suggest that markets have priced bond yield spreads differently to nature degradation as well as macroeconomic fundamentals, depending on whether spreads are already elevated at the 90^{th} percentile or low at the 10^{th} of the spread distribution. For countries grouped at the top, which tend to be low-income countries, degradation in biodiversity is associated with up to three times higher borrowing cost consequences relative to the 50^{th} quantile. This picture of asymmetric macro-criticality is also robust across maturities, whether we use one or two global factors, and mirrors those from Gomez-Gonzalez et al. (2025) for climate vulnerability. Disproportionally affecting high quantiles of the spread distribution, continued degradation is thus likely to exacerbate macro-financial fragility in low-income countries dependent on nature where the planetary boundary for ecosystem integrity surpassed critical thresholds (Stenzel et al., 2025).

Contributions

These results offer multiple contributions to the nascent literature on the financial materiality of nature. Methodologically, the three proxies for nature-related financial vulnerability leverage recent geospatial data developments and follow recommendations in ecological research for measuring biodiversity and habitat intactness weighted by the economic significance of natural capital (Burgess et al., 2024). The two biodiversity-focused proxies for physical vulnerability, and the annualised policy-focused Environmental Performance Index for transition-related vulnerability (Block et al., 2024; De Palma et al., 2021; Pereira et al., 2024), can serve as inspiration for future research. Crucially, they align with the UNEP-WCMC natural capital and IPPC's risk frameworks. Integrating these advancements fundamentally highlights the value of closer interdisciplinary collaboration for environmental economics.

Empirically, our novel results directly contribute to filling the gap in the related literature that so far has fixated on the fiscal consequences from climate change (Boitan, 2023). These empirics also substantiate a key transmission mechanism as outlined conceptually by the NGFS (2023), via government borrowing costs. The findings also align with Wang (2021)'s results that lower renewable ecosystem assets, particularly in agriculture and forests, also raises borrowing costs, as biodiversity intactness affects the provision of ecosystem services these sectors, and lower income countries depend on economically. This aligns with canonical environmental economics highlighting an asymmetrical economic value of natural capital and biodiversity, with collapse disproportionally affecting low-income countries (Costanza et al., 1997; Dasgupta, 2021; Giglio et al., 2024). We complement this strand of research by documenting that nature loss is not merely a concern for economic growth but a material driver of sovereign risk.

Policy implications Whilst our analysis does not reveal concrete mechanisms, the pattern of results offers initial suggestions for future research. The impacts are asymmetric in space and time, with stronger borrowing penalties from degradation at the 2-year horizon and lower income countries. A commonality for low-income economies which populate the top quantiles is a higher dependency on ecosystem services (Ranger et al., 2023), and higher economic contribution from sectors dependent on them, such as agriculture and forestry. As ecological and biodiversity intactness affect the productivity of provisioning ecosystem services such as biomass, our results may pick up the indirect via food price inflation due to disruptions in agricultural yields similar to (Wegner et al., 2025), or Kotz et al. (2024) in the climate context. Agricultural and nature-dependent exports are also a plausible mechanism. Overall, it is more plausible for bond markets to have directly observed food price inflation and exports when monitoring downside fiscal risks, as opposed to monitoring domestic biodiversity intactness. Furthermore, this might explain why we obtain insignificant or even negative effects for the lowest quantile, where nature-dependent sectors such as agriculture contribute marginally. However, high income countries are unlikely to be insulated, as effects can cascade via interconnected supply chains. Nevertheless, we leave it for future research to investigate the detailed steps in the transmission chain further.

Aside academic audiences, our novel evidence for the macro-financial effects from nature degradation concern not just highly indebted, ecosystem-dependent nations. Chiefly, the impacts are unlikely to be confined to borrowing cost penalties given the systemic importance of sovereign debt for global financial stability. Amounting to over half of global outstanding debt securities, sovereign bond yields also affect the risk-free rate in the private sector (BIS, 2024). Upward pressure is thus felt across government's fiscal policy space with spillovers to the cost of capital, and future mitigation and adaptation spending, aside from ordinary public expenditure. Sovereign bonds further represent a large part in portfolios of pension funds and central banks, where they anchor interest rates and credit provision, and treated specially in e.g. the Basel framework, allowing national jurisdictions to apply a 0% risk weight for domestic local currency bonds (Augustin et al., 2018; BIS, 2018). Our evidence points to disproportional direct fiscal consequences for lower-income countries coinciding with a problematic increase in debt burdens over recent years. Yet considering that many of these countries house global biodiversity hotspots, interconnectivity of nature-dependent trade, and sovereign debt markets, the impacts clearly warrant global attention.

To summarize, our evidence for borrowing cost impacts suggests nature-related financial risks can be 'macro-critical' in the IMF's language with substantial asymmetrical consequences that warrant closer integration and attention in macroeconomic frameworks such as the debt sustainability analyses employed by Bretton-Woods institutions, monetary policy by central banks, and other economic and regulatory frameworks by ministries of finance, credit rating agencies and financial institutions. Considering the systemic interconnection of global sovereign debt markets, our results highlight the importance of understanding nature as a systemic risk factor as degradation rates reach and already surpass critical levels in many areas across the world

CRediT authorship contribution statement

Alexander Wollenweber: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Validation, Visualisation, Writing - original draft, Writing - review & editing.

Dieter Wang: Formal analysis, Methodology, Validation, Writing - review & editing.

Nicola Ranger: Supervision, Writing - review & editing.

Acknowledgements

Alexander J. Wollenweber acknowledges support by the German Federal Ministry for Research and Education, via the Friedrich Naumann Foundation.

The opinions expressed herein are those of the authors and not necessarily those of their employers or affiliated institutions.

8 Appendix

8.1 Data

We fill the gap in indicator weights that arises from removing the indicators with insufficient temporal coverage of the EPI, by standardising weights according to their initial weight to not affect the author's original choices when creating the EPI (Block et al., 2024).

Table 6: Environmental Performance Subindex for Biodiversity and Habitat

Abbreviation	Full Name	Year	Weight	Norm. Weight	Category
MKP	Marine KBA Protection	2010	0.12	0.146	BDH
MHP	Marine Habitat Protection	2010	0.12	0.146	BDH
MPE	Marine Protection Stringency	2012	0.02	0.024	BDH
SPI	Species Protection Index	1995	0.16	0.195	BDH
TBN	Terrestrial Biome Protection	1995	0.10	0.122	BDH
TKP	Terrestrial KBA Protection	2010	0.10	0.122	BDH
RLI	Red List Index	1999	0.12	0.146	BDH
SHI	Species Habitat Index	2000	0.08	0.098	BDH

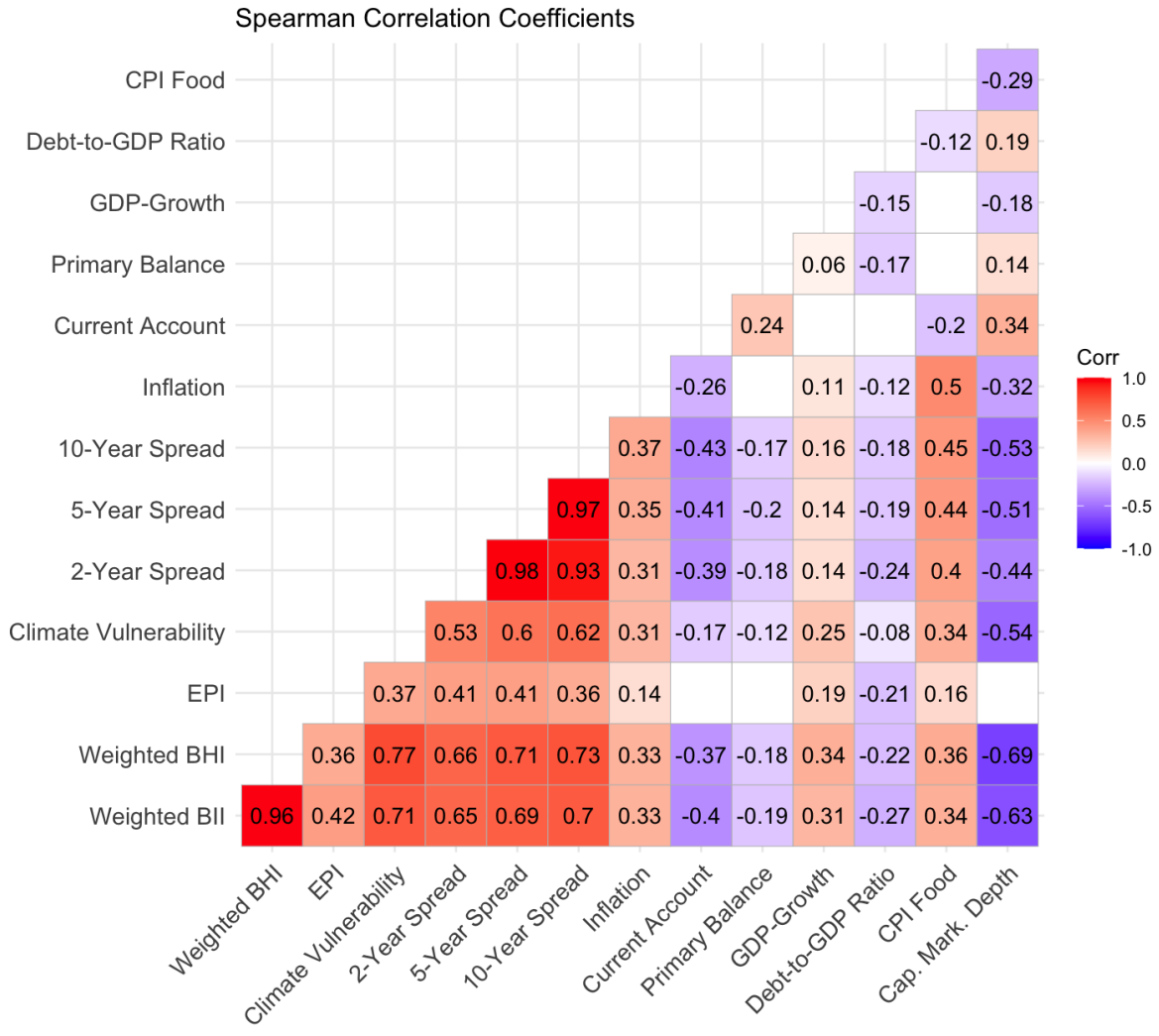


Figure 14: Matrix with Spearman's Correlation Coefficients

8.2 Methodology & results

Factor analysis

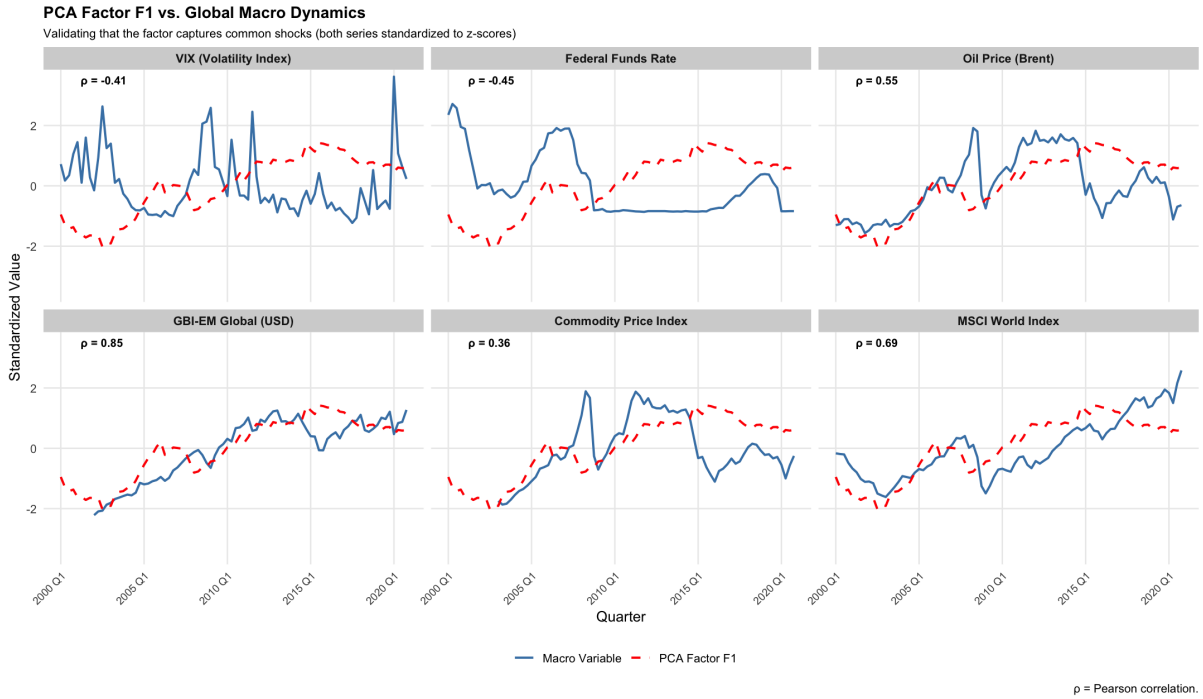


Figure 15: Correlation Between PCA Factor 1 and Market Dynamics

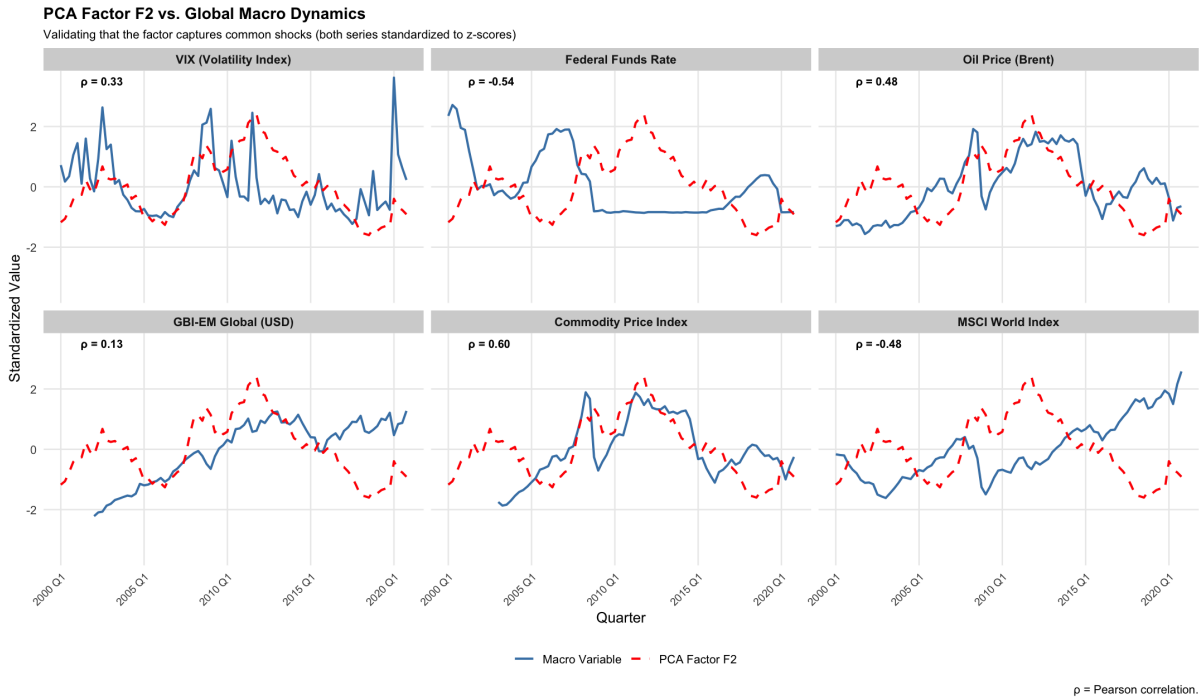


Figure 16: Correlation Between PCA Factor 1 and Market Dynamics

Further details on linear quantile mixture models

The LQMM approach models the panel as a finite mixture of G latent distributions of country groups that share similar unobserved characteristics. The distribution of countries is left unspecified by the researchers but via a data-driven non-parametric maximum likelihood approach assigning countries to the portion of the the quantile-specific discrete mixing distribution best fitting their characteristics subject to the set of locations $\{\zeta_1, \ldots, \zeta_{g,\tau}\}$ and mixture probabilities $\pi_{g,\tau} = Pr(\alpha_i = \zeta_{g,\tau}),\ i = 1, \ldots, n,\ \ g = 1, \ldots, G_\tau,\ \&\ G_\tau \leq n$ (Alfò et al., 2017; Geraci & Bottai, 2014). In other words, these groups are characterised by their specific and observed spread dynamics, individual intercepts α_i, and sensitivity to the common factors via group loadings λ_i. These features, the latent factor and finite mixtures of random group-specific intercepts, are particularly valuable in our context to examine the hypothesis that increased nature vulnerability imposes steeper penalties at the tail end of the spread distribution. They capture unobserved heterogeneity both between safer and riskier groups of countries and quantiles with minimal ex-ante assumptions about the underlying distribution of effects.

Estimates are obtained by maximising the log-likelihood of an asymmetric laplace regression, whose location parameter is modelled as a function of fixed coefficients and time-constant random coefficients capturing the group-specific intercepts and factor loadings which address the aforementioned concerns for risk commonality. Optimisation follows an expectation-maximisation (EM) algorithm that iterates via the NPML between estimating the posterior probabilities of countries belonging to each group and updating the quantile-specific coefficients conditional on these assignments (Alfó et al., 2025). As mentioned above, information criteria suggest using $G = 4$ groups as baseline, and show the results for the robustness check with 3 and 5 groups, and 1-2 factors below. Standard errors are computed using a non-parametric block bootstrap with replacement.

Table 7: Interactive Fixed Effects (2 Factors & 0 LDVs) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	−0.107				0.242**				0.474			
	(0.135)				(0.212)				(0.242)			
Biodiversity Degradation (BHI)		−0.166				0.398***				0.699**		
		(0.137)				(0.175)				(0.231)		
EPI			0.129				0.162**				0.429***	
			(0.168)				(0.138)				(0.122)	
Climate Vulnerability				0.192***				0.679***				0.756***
				(0.049)				(0.065)				(0.075)
Inflation	0.103***	0.108***	0.120**	0.109***	0.133***	0.129***	0.146***	0.137***	0.148***	0.142***	0.159***	0.176***
	(0.041)	(0.040)	(0.037)	(0.039)	(0.046)	(0.044)	(0.040)	(0.041)	(0.046)	(0.046)	(0.043)	(0.042)
Primary Balance (PB)	−0.050	−0.047	−0.080	−0.055**	−0.053	−0.057	−0.065	−0.050*	0.021	0.020	0.045	−0.058
	(0.034)	(0.033)	(0.032)	(0.028)	(0.039)	(0.038)	(0.037)	(0.035)	(0.048)	(0.049)	(0.044)	(0.043)
Current Account (CA)	−0.103	−0.149	0.172	0.436	−0.823	−0.779	0.057	−0.176	0.473	0.648	0.315	−1.976
	(0.959)	(0.940)	(1.377)	(0.987)	(1.171)	(1.198)	(1.249)	(1.372)	(1.451)	(1.462)	(1.495)	(1.612)
GDP Growth	−0.044**	−0.044**	−0.020***	−0.018***	−0.041*	−0.046*	−0.033**	−0.025**	−0.034	−0.035	−0.044**	−0.027**
	(0.015)	(0.016)	(0.008)	(0.007)	(0.022)	(0.021)	(0.011)	(0.010)	(0.029)	(0.028)	(0.015)	(0.016)
Debt/GDP Ratio	0.023	0.023	0.021**	0.027**	0.011	0.009	0.025**	0.015	0.031	0.030	0.036	0.002
	(0.014)	(0.014)	(0.012)	(0.009)	(0.015)	(0.015)	(0.011)	(0.011)	(0.019)	(0.020)	(0.014)	(0.015)
FM Depth	−1.521	−1.698*	−1.611	−1.505	−0.417	−0.288	0.235	0.368	0.073	0.217	−0.258	−0.274
	(1.151)	(1.103)	(1.183)	(0.993)	(1.367)	(1.289)	(1.385)	(1.091)	(1.551)	(1.697)	(1.573)	(1.314)
Rule of Law (WGI RL)	−0.280	−0.179	0.222	0.688	−0.730**	−0.602*	−0.598	0.205	−1.661*	−1.591*	−0.938	0.529
	(0.293)	(0.298)	(0.469)	(0.439)	(0.431)	(0.408)	(0.495)	(0.689)	(0.564)	(0.570)	(0.554)	(0.815)
CPI Food	0.041**	0.039**	0.044***	0.034**	0.057**	0.055***	0.062***	0.049***	0.064**	0.064**	0.080***	0.070**
	(0.017)	(0.016)	(0.015)	(0.014)	(0.020)	(0.018)	(0.017)	(0.018)	(0.026)	(0.028)	(0.027)	(0.025)
Constant	2.692***	2.846***	−0.138	−6.841***	3.091***	2.082***	1.330	−20.140***	3.624***	2.385***	−0.769**	−23.110***
	(0.466)	(0.496)	(0.597)	(0.398)	(0.658)	(0.649)	(0.627)	(0.552)	(0.637)	(0.760)	(0.706)	(0.635)
Within R^2	0.760	0.755	0.741	0.742	0.769	0.760	0.726	0.732	0.749	0.747	0.750	0.729
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	60.3	59.8	64.1	66.1	61.5	60.9	65.0	67.6	59.5	59.5	63.6	66.2
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	2	2	2	2	2	2	2	2	2	2	2	2
Observations	2,955	2,988	2,822	3,304	3,015	3,047	2,859	3,379	2,857	2,857	2,733	3,178

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

Table 8: Interactive Fixed Effects (2 Factors & 1 LDV) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.007				0.049				0.027			
	(0.024)				(0.039)				(0.036)			
Biodiversity Degradation (BHI)		0.004				0.074**				0.096**		
		(0.029)				(0.045)				(0.046)		
EPI			0.042***				0.048**				0.064**	
			(0.017)				(0.021)				(0.022)	
Climate Vulnerability				0.031***				0.223***				0.125***
				(0.009)				(0.014)				(0.012)
Spreads (Lag 1)	0.896***	0.893***	0.886***	0.892***	0.872***	0.875***	0.876***	0.888***	0.868***	0.872***	0.868***	0.881***
	(0.016)	(0.015)	(0.018)	(0.019)	(0.018)	(0.018)	(0.019)	(0.017)	(0.021)	(0.021)	(0.022)	(0.019)
Inflation	0.053***	0.055***	0.056***	0.065***	0.068***	0.069***	0.063***	0.069***	0.065***	0.065***	0.073***	0.068***
	(0.018)	(0.017)	(0.017)	(0.017)	(0.025)	(0.022)	(0.025)	(0.023)	(0.028)	(0.028)	(0.030)	(0.030)
Primary Balance (PB)	−0.015**	−0.016**	−0.011	−0.011*	−0.021*	−0.020**	−0.015	−0.014	−0.028	−0.028	−0.017	−0.018
	(0.008)	(0.007)	(0.007)	(0.007)	(0.010)	(0.010)	(0.009)	(0.008)	(0.012)	(0.012)	(0.009)	(0.009)
Current Account (CA)	−0.867**	−0.819**	−0.926**	−0.823**	−0.894***	−0.835**	−0.819***	−0.750**	−0.903***	−0.849**	−0.846**	−0.889***
	(0.327)	(0.339)	(0.339)	(0.331)	(0.361)	(0.362)	(0.398)	(0.407)	(0.428)	(0.421)	(0.471)	(0.401)
GDP Growth	0.006	0.008	−0.003	−0.001	0.007	0.009	−0.004	−0.002	0.025*	0.025*	0.009	0.008
	(0.016)	(0.014)	(0.013)	(0.012)	(0.015)	(0.014)	(0.012)	(0.011)	(0.010)	(0.010)	(0.009)	(0.009)
Debt/GDP Ratio	0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.000	−0.001	−0.001	0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FM Depth	0.048	0.046	−0.144	0.001	0.153	0.158	0.283	0.264	0.273	0.281	0.260	0.412
	(0.238)	(0.245)	(0.228)	(0.202)	(0.278)	(0.272)	(0.245)	(0.236)	(0.296)	(0.298)	(0.275)	(0.221)
Rule of Law (WGI RL)	−0.081	−0.055	−0.082*	0.079	−0.304***	−0.228***	−0.198	0.024	−0.057	−0.049	−0.053	−0.058
	(0.057)	(0.071)	(0.072)	(0.106)	(0.067)	(0.069)	(0.097)	(0.150)	(0.069)	(0.075)	(0.093)	(0.124)
CPI Food	−0.001	−0.001	0.001	−0.002	0.008*	0.008**	0.013***	0.009**	0.024***	0.024**	0.028***	0.024***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	0.409***	0.363***	0.087	−1.038***	0.973***	0.640**	0.207	−7.032***	0.258	−0.083	−0.399***	−3.770***
	(0.103)	(0.099)	(0.102)	(0.051)	(0.233)	(0.234)	(0.173)	(0.179)	(0.147)	(0.182)	(0.138)	(0.099)
Within R^2	0.912	0.908	0.908	0.907	0.910	0.907	0.904	0.903	0.914	0.914	0.914	0.915
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	59.7	59.1	63.5	65.3	60.8	60.2	64.3	66.8	58.6	58.6	62.6	65.1
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	2	2	2	2	2	2	2	2	2	2	2	2
Observations	2,926	2,957	2,794	3,265	2,981	3,012	2,829	3,339	2,814	2,814	2,691	3,126

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

Table 9: Interactive Fixed Effects (2 Factors & 2 LDVs) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.009				0.032				0.037			
	(0.023)				(0.032)				(0.032)			
Biodiversity Degradation (BHI)		0.005				0.061				0.071**		
		(0.027)				(0.038)				(0.038)		
EPI			0.039***				0.046**				0.064***	
			(0.017)				(0.019)				(0.021)	
Climate Vulnerability				0.032***				0.092***				0.080***
				(0.009)				(0.012)				(0.012)
Spreads (Lag 1)	0.876***	0.866***	0.869***	0.855***	0.844***	0.847***	0.857***	0.861***	0.925***	0.928***	0.921***	0.936***
	(0.048)	(0.048)	(0.046)	(0.046)	(0.043)	(0.041)	(0.040)	(0.037)	(0.039)	(0.039)	(0.041)	(0.038)
Spreads (Lag 2)	0.022	0.030	0.019	0.040	0.007	0.007	−0.003	0.005	−0.073**	−0.074**	−0.074**	−0.075**
	(0.045)	(0.045)	(0.042)	(0.042)	(0.036)	(0.034)	(0.035)	(0.032)	(0.030)	(0.030)	(0.031)	(0.029)
Inflation	0.053***	0.057***	0.057***	0.065***	0.074***	0.076***	0.066**	0.071**	0.095***	0.094***	0.090***	0.099***
	(0.018)	(0.017)	(0.017)	(0.017)	(0.026)	(0.024)	(0.025)	(0.025)	(0.027)	(0.024)	(0.028)	(0.027)
Primary Balance (PB)	−0.017**	−0.018**	−0.013*	−0.013*	−0.011	−0.011	−0.005	−0.004	0.002	0.002	0.005	0.001
	(0.008)	(0.007)	(0.007)	(0.007)	(0.010)	(0.009)	(0.008)	(0.007)	(0.013)	(0.013)	(0.011)	(0.009)
Current Account (CA)	−0.847**	−0.803**	−0.921**	−0.817**	−0.810***	−0.753**	−0.742***	−0.771**	−0.831**	−0.805**	−0.874**	−0.874**
	(0.331)	(0.341)	(0.339)	(0.335)	(0.353)	(0.374)	(0.416)	(0.372)	(0.446)	(0.445)	(0.467)	(0.408)
GDP Growth	0.006	0.007	−0.004	−0.002	0.009	0.012	0.001	0.001	0.019	0.019	0.008	0.019
	(0.016)	(0.014)	(0.013)	(0.012)	(0.016)	(0.015)	(0.012)	(0.011)	(0.012)	(0.011)	(0.010)	(0.011)
Debt/GDP Ratio	0.000	0.001	0.001	0.001	0.000	−0.001	0.000	0.000	0.002	0.002	0.003	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
FM Depth	−0.038	−0.047	−0.237	−0.078	0.206	0.193	0.181	0.207	−0.225	−0.205	−0.108	−0.061
	(0.234)	(0.242)	(0.233)	(0.200)	(0.285)	(0.278)	(0.279)	(0.225)	(0.303)	(0.303)	(0.298)	(0.224)
Rule of Law (WGI RL)	−0.043	−0.013	−0.047	0.121	−0.214***	−0.181**	−0.264**	−0.167	−0.126	−0.108	−0.186	−0.095
	(0.056)	(0.070)	(0.075)	(0.103)	(0.066)	(0.072)	(0.094)	(0.118)	(0.067)	(0.071)	(0.085)	(0.108)
CPI Food	−0.001	−0.001	0.001	−0.001	0.009*	0.010*	0.014***	0.011**	0.016***	0.016***	0.021***	0.017***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.007)	(0.006)
Constant	0.318***	0.263***	0.048	−1.166***	0.853***	0.642***	0.622***	−2.145***	0.374**	0.169	0.032	−2.201***
	(0.103)	(0.099)	(0.100)	(0.050)	(0.148)	(0.148)	(0.123)	(0.079)	(0.127)	(0.149)	(0.124)	(0.078)
Within R^2	0.912	0.908	0.908	0.907	0.914	0.911	0.908	0.909	0.924	0.924	0.923	0.923
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	59.1	58.5	62.9	64.6	60.1	59.5	63.6	66.0	57.8	57.8	61.6	64.1
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	2	2	2	2	2	2	2	2	2	2	2	2
Observations	2,897	2,927	2,767	3,228	2,947	2,977	2,799	3,300	2,772	2,772	2,650	3,075

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

Table 10: Interactive Fixed Effects (1 Factor & 0 LDVs) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	−0.105				0.534***				0.358*			
	(0.161)				(0.209)				(0.283)			
Biodiversity Degradation (BHI)		−0.208				0.685***				0.623**		
		(0.207)				(0.180)				(0.249)		
EPI			0.542				0.337*				0.427***	
			(0.237)				(0.197)				(0.131)	
Climate Vulnerability				0.263***				0.753***				0.788***
				(0.069)				(0.073)				(0.081)
Inflation	0.083*	0.095**	0.079**	0.096**	0.150***	0.139***	0.134***	0.144***	0.173***	0.165**	0.179***	0.189***
	(0.052)	(0.047)	(0.042)	(0.042)	(0.056)	(0.051)	(0.048)	(0.045)	(0.068)	(0.068)	(0.062)	(0.058)
Primary Balance (PB)	−0.031	−0.025	−0.021	−0.049	−0.012	−0.011	0.013	−0.009	0.007	0.001	0.016	0.016
	(0.041)	(0.040)	(0.036)	(0.041)	(0.036)	(0.039)	(0.037)	(0.042)	(0.039)	(0.039)	(0.040)	(0.044)
Current Account (CA)	1.066	0.999	−2.121	1.594	0.728	0.919	1.442	1.358	−1.509	−1.363	−0.647	−1.319
	(1.440)	(1.356)	(2.102)	(1.627)	(1.299)	(1.321)	(1.750)	(1.813)	(1.415)	(1.414)	(1.540)	(1.672)
GDP Growth	−0.051***	−0.050***	−0.028***	−0.030***	−0.065***	−0.066***	−0.050***	−0.048***	−0.053**	−0.049**	−0.050***	−0.046***
	(0.020)	(0.019)	(0.010)	(0.010)	(0.030)	(0.028)	(0.017)	(0.015)	(0.035)	(0.032)	(0.022)	(0.021)
Debt/GDP Ratio	0.036*	0.037**	0.021**	0.030**	0.038**	0.037**	0.040**	0.028	0.032*	0.030*	0.041**	0.023
	(0.014)	(0.014)	(0.014)	(0.011)	(0.012)	(0.013)	(0.015)	(0.013)	(0.014)	(0.013)	(0.014)	(0.015)
FM Depth	−0.439	−0.661	−2.122	0.098	−0.612	−0.134	−1.410	0.734	0.513	0.962	−0.280	0.501
	(1.107)	(1.030)	(1.212)	(1.095)	(1.415)	(1.458)	(2.005)	(1.784)	(1.850)	(1.841)	(2.189)	(2.239)
Rule of Law (WGI RL)	−0.734	−0.601	−0.903	−0.313	−1.650***	−1.586***	−1.366*	−1.024	−1.509**	−1.523**	−1.078	−0.468
	(0.438)	(0.451)	(0.530)	(0.801)	(0.445)	(0.438)	(0.563)	(0.875)	(0.519)	(0.522)	(0.617)	(0.974)
CPI Food	0.051***	0.048***	0.060***	0.036***	0.071***	0.069***	0.077***	0.061***	0.084***	0.085***	0.090***	0.080***
	(0.016)	(0.015)	(0.015)	(0.014)	(0.021)	(0.020)	(0.021)	(0.021)	(0.029)	(0.030)	(0.030)	(0.029)
Constant	3.512***	3.786***	−0.782	−6.336***	3.535***	2.648***	1.782	−19.619***	3.776***	2.534**	−0.839	−22.521***
	(0.616)	(0.608)	(1.056)	(0.408)	(0.781)	(0.818)	(1.045)	(0.610)	(0.865)	(0.974)	(0.880)	(0.724)
Within R^2	0.585	0.584	0.561	0.553	0.622	0.614	0.583	0.561	0.605	0.605	0.601	0.564
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	60.3	59.8	64.1	66.1	61.5	60.9	65.0	67.6	59.5	59.5	63.6	66.2
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	1	1	1	1	1	1	1	1	1	1	1	1
Observations	2,955	2,988	2,822	3,304	3,015	3,047	2,859	3,379	2,857	2,857	2,733	3,178

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

Table 11: Interactive Fixed Effects (1 Factor & 1 LDV) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.003				0.095*				0.095**			
	(0.027)				(0.043)				(0.045)			
Biodiversity Degradation (BHI)		0.000				0.122**				0.156**		
		(0.033)				(0.044)				(0.046)		
EPI			0.045***				0.069**				0.080***	
			(0.019)				(0.024)				(0.024)	
Climate Vulnerability				0.040***				0.219***				0.125***
				(0.010)				(0.015)				(0.013)
Spreads (Lag 1)	0.883***	0.881***	0.885***	0.889***	0.852***	0.850***	0.853***	0.852***	0.859***	0.855***	0.859***	0.866***
	(0.016)	(0.015)	(0.020)	(0.017)	(0.020)	(0.020)	(0.020)	(0.022)	(0.021)	(0.022)	(0.021)	(0.021)
Inflation	0.060***	0.061***	0.060***	0.068***	0.050**	0.049**	0.056**	0.053**	0.095***	0.091***	0.107***	0.105***
	(0.020)	(0.018)	(0.018)	(0.017)	(0.030)	(0.028)	(0.029)	(0.028)	(0.030)	(0.030)	(0.033)	(0.033)
Primary Balance (PB)	−0.020**	−0.020**	−0.015*	−0.014*	−0.023***	−0.022***	−0.013*	−0.017***	−0.017*	−0.018**	−0.007	−0.005
	(0.008)	(0.008)	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)	(0.007)	(0.011)	(0.011)	(0.010)	(0.010)
Current Account (CA)	−1.116***	−1.085***	−1.108***	−1.054***	−1.062***	−0.997***	−0.870***	−0.783**	−1.117***	−1.032***	−1.134***	−1.269***
	(0.347)	(0.349)	(0.337)	(0.333)	(0.422)	(0.430)	(0.482)	(0.448)	(0.516)	(0.485)	(0.563)	(0.482)
GDP Growth	−0.003	0.001	−0.008	−0.005	0.008	0.007	0.004	−0.001	0.027**	0.025**	0.016	0.021
	(0.015)	(0.014)	(0.013)	(0.012)	(0.012)	(0.012)	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Debt/GDP Ratio	0.001	0.001	0.001	0.000	−0.001	−0.001	0.001	0.001	−0.001	−0.001	0.002	0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FM Depth	0.098	0.084	0.039	0.151	−0.398	−0.378	−0.527	0.118	−0.465	−0.386	−0.606	−0.113
	(0.260)	(0.252)	(0.250)	(0.207)	(0.345)	(0.346)	(0.408)	(0.199)	(0.346)	(0.342)	(0.382)	(0.234)
Rule of Law (WGI RL)	−0.123*	−0.092	−0.174**	−0.041	−0.237***	−0.170**	−0.136	0.101	−0.047	−0.036	−0.016	−0.014
	(0.059)	(0.069)	(0.077)	(0.112)	(0.078)	(0.078)	(0.106)	(0.159)	(0.079)	(0.079)	(0.106)	(0.134)
CPI Food	0.002	0.001	0.003	0.000	0.027**	0.023**	0.025***	0.022**	0.033***	0.032***	0.034***	0.029***
	(0.005)	(0.004)	(0.005)	(0.004)	(0.010)	(0.009)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.007)
Constant	0.539***	0.486***	0.226*	−0.999***	0.818***	0.513**	0.156	−7.040***	0.069	−0.226	−0.491***	−3.795***
	(0.127)	(0.126)	(0.126)	(0.056)	(0.256)	(0.259)	(0.188)	(0.190)	(0.183)	(0.204)	(0.177)	(0.105)
Within R^2	0.878	0.875	0.871	0.873	0.861	0.857	0.856	0.854	0.877	0.878	0.878	0.879
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	59.7	59.1	63.5	65.3	60.8	60.2	64.3	66.8	58.6	58.6	62.6	65.1
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	1	1	1	1	1	1	1	1	1	1	1	1
Observations	2,926	2,957	2,794	3,265	2,981	3,012	2,829	3,339	2,814	2,814	2,691	3,126

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

Table 12: Interactive Fixed Effects (1 Factor & 2 LDVs) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.005				0.028				0.037*			
	(0.026)				(0.038)				(0.035)			
Biodiversity Degradation (BHI)		0.004				0.026				0.088**		
		(0.029)				(0.042)				(0.040)		
EPI			0.039***				0.038**				0.058***	
			(0.019)				(0.021)				(0.024)	
Climate Vulnerability				0.042***				0.092***				0.095***
				(0.009)				(0.012)				(0.012)
Spreads (Lag 1)	0.823***	0.816***	0.818***	0.810***	0.873***	0.876***	0.884***	0.882***	0.938***	0.948***	0.958***	0.962***
	(0.046)	(0.045)	(0.054)	(0.046)	(0.039)	(0.036)	(0.039)	(0.034)	(0.041)	(0.041)	(0.044)	(0.040)
Spreads (Lag 2)	0.066	0.073*	0.074	0.087*	−0.006	−0.006	−0.010	−0.004	−0.073**	−0.074***	−0.074**	−0.075***
	(0.039)	(0.038)	(0.042)	(0.038)	(0.030)	(0.028)	(0.028)	(0.026)	(0.033)	(0.033)	(0.035)	(0.032)
Inflation	0.064***	0.067***	0.065***	0.072***	0.085***	0.086***	0.082***	0.090***	0.089***	0.087***	0.078***	0.085***
	(0.019)	(0.018)	(0.017)	(0.017)	(0.026)	(0.024)	(0.026)	(0.024)	(0.028)	(0.028)	(0.028)	(0.027)
Primary Balance (PB)	−0.022**	−0.022**	−0.017**	−0.016**	−0.020	−0.019	−0.015	−0.014	−0.019	−0.022	−0.018	−0.019
	(0.008)	(0.008)	(0.007)	(0.007)	(0.012)	(0.011)	(0.010)	(0.009)	(0.015)	(0.015)	(0.013)	(0.011)
Current Account (CA)	−1.122***	−1.090***	−1.134***	−1.076***	−1.165***	−1.145***	−1.163**	−1.143***	−1.189***	−1.137***	−1.017***	−1.127***
	(0.350)	(0.354)	(0.342)	(0.340)	(0.471)	(0.490)	(0.522)	(0.458)	(0.457)	(0.449)	(0.481)	(0.418)
GDP Growth	−0.003	0.000	−0.009	−0.006	0.004	0.006	−0.006	−0.003	0.017*	0.018*	0.001	0.004
	(0.014)	(0.013)	(0.012)	(0.011)	(0.016)	(0.015)	(0.012)	(0.011)	(0.011)	(0.011)	(0.013)	(0.011)
Debt/GDP Ratio	0.001	0.001	0.001	0.000	0.003	0.003	0.003	0.001	0.003	0.002	0.003	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
FM Depth	0.093	0.070	0.033	0.143	0.027	−0.005	0.069	0.074	−0.120	−0.163	−0.109	0.014
	(0.274)	(0.261)	(0.275)	(0.219)	(0.340)	(0.324)	(0.389)	(0.279)	(0.341)	(0.335)	(0.348)	(0.275)
Rule of Law (WGI RL)	−0.100	−0.069	−0.147**	−0.026	−0.262***	−0.203**	−0.300**	−0.207*	−0.164	−0.135	−0.188	−0.206
	(0.060)	(0.068)	(0.078)	(0.109)	(0.066)	(0.068)	(0.101)	(0.126)	(0.068)	(0.068)	(0.094)	(0.114)
CPI Food	0.001	0.001	0.003	0.001	0.004	0.004	0.008***	0.005*	0.015***	0.016***	0.022***	0.018**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.007)	(0.007)	(0.007)	(0.006)
Constant	0.458***	0.392***	0.206	−1.126***	0.873***	0.717***	0.656***	−2.118***	0.443**	0.205	0.074	−2.256***
	(0.127)	(0.121)	(0.125)	(0.054)	(0.171)	(0.179)	(0.143)	(0.086)	(0.139)	(0.166)	(0.136)	(0.086)
Within R^2	0.879	0.876	0.871	0.874	0.885	0.883	0.877	0.882	0.893	0.893	0.893	0.895
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	59.1	58.5	62.9	64.6	60.1	59.5	63.6	66.0	57.8	57.8	61.6	64.1
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	1	1	1	1	1	1	1	1	1	1	1	1
Observations	2,897	2,927	2,767	3,228	2,947	2,977	2,799	3,300	2,772	2,772	2,650	3,075

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

Table 13: Standard Fixed Effects (No Factors & 0 LDVs) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.182				0.828***				0.693***			
	(0.172)				(0.207)				(0.288)			
Biodiversity Degradation (BHI)		0.148				0.931***				0.958***		
		(0.227)				(0.160)				(0.195)		
EPI			0.450***				0.566***				0.661***	
			(0.118)				(0.088)				(0.094)	
Climate Vulnerability				0.308***				0.799***				0.866***
				(0.084)				(0.079)				(0.095)
Inflation	0.115**	0.112**	0.098**	0.130***	0.188***	0.162***	0.160***	0.175***	0.213***	0.186***	0.234***	0.233***
	(0.049)	(0.043)	(0.048)	(0.045)	(0.056)	(0.050)	(0.056)	(0.052)	(0.063)	(0.063)	(0.067)	(0.068)
Primary Balance (PB)	−0.082***	−0.077**	−0.065**	−0.063**	−0.110***	−0.100***	−0.056*	−0.073***	−0.112***	−0.111***	−0.048	−0.077***
	(0.031)	(0.031)	(0.030)	(0.028)	(0.035)	(0.035)	(0.033)	(0.030)	(0.039)	(0.038)	(0.038)	(0.032)
Current Account (CA)	−1.694	−1.673	−0.736	−1.522	−1.991	−1.468	−0.916	−1.022	−3.880**	−3.266**	−2.585*	−2.264
	(1.606)	(1.562)	(1.646)	(1.509)	(1.620)	(1.643)	(1.608)	(1.575)	(1.711)	(1.780)	(1.821)	(1.687)
GDP Growth	−0.033**	−0.036**	−0.043***	−0.049***	−0.026	−0.036*	−0.052***	−0.061***	0.009	−0.001	−0.046***	−0.053***
	(0.017)	(0.016)	(0.012)	(0.011)	(0.021)	(0.021)	(0.015)	(0.013)	(0.019)	(0.019)	(0.014)	(0.015)
Debt/GDP Ratio	0.014	0.014	0.023**	0.014*	0.018	0.017	0.029***	0.016*	0.018	0.016	0.034**	0.016
	(0.008)	(0.007)	(0.008)	(0.007)	(0.010)	(0.010)	(0.008)	(0.008)	(0.012)	(0.012)	(0.010)	(0.010)
FM Depth	−1.273	−1.339	−1.358	−1.108	−1.698	−1.478	−2.887***	−0.495	−2.754*	−2.334	−3.719***	0.001
	(1.098)	(1.045)	(1.010)	(0.743)	(1.347)	(1.403)	(1.236)	(0.817)	(1.624)	(1.765)	(1.520)	(0.939)
Rule of Law (WGI RL)	−0.508	−0.429	−0.832	−0.161	−1.363**	−1.158**	−1.400**	−0.859	−1.187*	−1.148*	−1.004	−0.799
	(0.459)	(0.483)	(0.574)	(0.861)	(0.543)	(0.511)	(0.591)	(0.830)	(0.645)	(0.627)	(0.708)	(1.020)
CPI Food	0.090***	0.084***	0.083***	0.067***	0.125***	0.114***	0.122***	0.109***	0.158***	0.151***	0.161***	0.147***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)	(0.017)	(0.018)	(0.017)	(0.022)	(0.023)	(0.022)	(0.021)
Constant	2.671***	2.830***	−0.530	−7.118***	2.497**	1.588	0.409	−20.733***	2.946**	1.666	−2.036*	−23.579***
	(1.001)	(0.993)	(1.114)	(0.550)	(1.103)	(1.096)	(1.158)	(0.669)	(1.215)	(1.144)	(1.207)	(0.740)
Within R^2	0.130	0.123	0.175	0.122	0.211	0.202	0.212	0.186	0.202	0.212	0.220	0.193
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	60.3	59.8	64.1	66.1	61.5	60.9	65.0	67.6	59.5	59.5	63.6	66.2
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	0	0	0	0	0	0	0	0	0	0	0	0
Observations	2,955	2,988	2,822	3,304	3,015	3,047	2,859	3,379	2,857	2,857	2,733	3,178

Note: Fixed effects estimates with country-clustered standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 14: Standard Fixed Effects (No Factors & 1 LDV) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.029				0.308***				0.139***			
	(0.026)				(0.167)				(0.069)			
Biodiversity Degradation (BHI)		0.033				0.331***				0.209***		
		(0.035)				(0.162)				(0.063)		
EPI			0.050***				0.223***				0.112***	
			(0.022)				(0.116)				(0.045)	
Climate Vulnerability				0.044***				0.277***				0.128***
				(0.011)				(0.055)				(0.020)
Spread LDV	0.864***	0.862***	0.866***	0.869***	0.609***	0.613***	0.599***	0.631***	0.804***	0.801***	0.803***	0.816***
	(0.014)	(0.013)	(0.016)	(0.013)	(0.168)	(0.165)	(0.178)	(0.156)	(0.055)	(0.055)	(0.059)	(0.051)
Inflation	0.046**	0.047**	0.048**	0.056***	0.136***	0.126***	0.127***	0.130***	0.138***	0.132***	0.145***	0.147***
	(0.022)	(0.020)	(0.021)	(0.019)	(0.048)	(0.043)	(0.046)	(0.042)	(0.030)	(0.029)	(0.031)	(0.030)
Primary Balance (PB)	−0.027***	−0.027***	−0.020***	−0.018***	−0.055***	−0.050***	−0.034**	−0.036***	−0.034***	−0.035***	−0.020	−0.023**
	(0.007)	(0.006)	(0.006)	(0.006)	(0.021)	(0.019)	(0.015)	(0.014)	(0.014)	(0.013)	(0.012)	(0.011)
Current Account (CA)	−1.342***	−1.344***	−1.270***	−1.267***	−1.479***	−1.348**	−1.060*	−1.180**	−2.429***	−2.306***	−2.312***	−2.051***
	(0.370)	(0.367)	(0.372)	(0.345)	(0.696)	(0.715)	(0.746)	(0.706)	(1.095)	(1.048)	(1.204)	(0.960)
GDP Growth	0.010	0.009	0.001	−0.000	−0.001	−0.005	−0.013	−0.016	0.028***	0.026***	0.014	0.014
	(0.009)	(0.009)	(0.007)	(0.006)	(0.017)	(0.017)	(0.017)	(0.015)	(0.008)	(0.008)	(0.011)	(0.010)
Debt/GDP Ratio	0.000	0.001	0.001	−0.000	0.004	0.003	0.009	0.003	−0.000	−0.000	0.003	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)	(0.005)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
FM Depth	−0.195	−0.216	−0.207	0.130	−0.884*	−0.836*	−1.382***	−0.119	−0.800**	−0.702**	−0.991***	0.146
	(0.212)	(0.215)	(0.208)	(0.153)	(0.540)	(0.576)	(0.636)	(0.392)	(0.403)	(0.416)	(0.425)	(0.249)
Rule of Law (WGI RL)	−0.091	−0.064	−0.126	−0.036	−0.411***	−0.313**	−0.448	−0.223	0.005	0.005	0.001	0.008
	(0.067)	(0.077)	(0.097)	(0.116)	(0.253)	(0.240)	(0.356)	(0.412)	(0.114)	(0.113)	(0.140)	(0.177)
CPI Food	0.017***	0.014***	0.014***	0.012**	0.053***	0.047***	0.052***	0.044***	0.034***	0.033***	0.037***	0.034***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.020)	(0.019)	(0.021)	(0.017)	(0.009)	(0.009)	(0.009)	(0.008)
Constant	0.438***	0.379***	0.159	−1.096***	0.853**	0.526	0.036	−7.369***	−0.028	−0.334	−0.652***	−3.917***
	(0.148)	(0.146)	(0.153)	(0.073)	(0.440)	(0.435)	(0.408)	(0.317)	(0.215)	(0.219)	(0.256)	(0.150)
Within R^2	0.805	0.799	0.800	0.800	0.651	0.647	0.641	0.652	0.813	0.813	0.814	0.815
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	59.7	59.1	63.5	65.3	60.8	60.2	64.3	66.8	58.6	58.6	62.6	65.1
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	0	0	0	0	0	0	0	0	0	0	0	0
Observations	2,926	2,957	2,794	3,265	2,981	3,012	2,829	3,339	2,814	2,814	2,691	3,126

Note: Fixed effects estimates with country-clustered standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 15: Interactive Fixed Effects (No Factors & 2 LDVs) Results for 10-Year, 5-Year, and 2-Year Spreads

	Dependent variable: Sovereign Bond Spread											
	10-Year Spread				5-Year Spread				2-Year Spread			
	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability	BII	BHI	EPI	Vulnerability
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Biodiversity Degradation (BII)	0.029				0.080***				0.091***			
	(0.026)				(0.029)				(0.036)			
Biodiversity Degradation (BHI)		0.034				0.090***				0.144***		
		(0.033)				(0.034)				(0.029)		
EPI			0.046***				0.051***				0.063**	
			(0.020)				(0.021)				(0.022)	
Climate Vulnerability				0.046***				0.092***				0.082***
				(0.011)				(0.010)				(0.011)
Spreads (Lag 1)	0.803***	0.803***	0.793***	0.802***	0.881***	0.881***	0.880***	0.886***	0.946***	0.944***	0.948***	0.956***
	(0.037)	(0.036)	(0.038)	(0.034)	(0.036)	(0.033)	(0.036)	(0.031)	(0.041)	(0.041)	(0.042)	(0.039)
Spreads (Lag 2)	0.066**	0.065**	0.080**	0.073**	−0.015	−0.015	−0.011	−0.014	−0.071***	−0.071***	−0.071***	−0.072***
	(0.030)	(0.029)	(0.030)	(0.027)	(0.028)	(0.026)	(0.027)	(0.025)	(0.039)	(0.040)	(0.039)	(0.039)
Inflation	0.052**	0.051**	0.052***	0.057***	0.080***	0.078***	0.081***	0.082***	0.116***	0.112***	0.122***	0.124***
	(0.023)	(0.021)	(0.021)	(0.019)	(0.028)	(0.025)	(0.028)	(0.024)	(0.026)	(0.026)	(0.027)	(0.026)
Primary Balance (PB)	−0.028***	−0.028***	−0.020***	−0.018***	−0.026***	−0.024***	−0.016**	−0.016**	−0.022**	−0.023**	−0.012	−0.014**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.008)	(0.007)	(0.009)	(0.006)	(0.008)	(0.006)
Current Account (CA)	−1.355***	−1.361***	−1.273***	−1.291***	−1.363***	−1.353***	−1.305***	−1.213***	−1.428***	−1.345***	−1.383***	−1.163***
	(0.375)	(0.373)	(0.367)	(0.356)	(0.587)	(0.610)	(0.644)	(0.547)	(0.575)	(0.537)	(0.613)	(0.495)
GDP Growth	−0.005	0.004	−0.005	−0.005	0.013	0.012	0.005	0.002	0.030***	0.029***	0.019**	0.018**
	(0.006)	(0.009)	(0.007)	(0.006)	(0.011)	(0.010)	(0.008)	(0.007)	(0.010)	(0.010)	(0.012)	(0.011)
Debt/GDP Ratio	0.000	0.000	0.001	−0.000	0.001	0.001	0.002	0.000	0.001	0.000	0.002	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
FM Depth	−0.245	−0.268	−0.268	0.134	−0.449**	−0.461**	−0.582***	0.102	−0.581**	−0.511**	−0.657***	0.177
	(0.212)	(0.214)	(0.210)	(0.160)	(0.244)	(0.248)	(0.246)	(0.170)	(0.265)	(0.264)	(0.234)	(0.163)
Rule of Law (WGI RL)	−0.058	−0.031	−0.098	−0.019	−0.207***	−0.166**	−0.223**	−0.173	−0.059	−0.061	−0.059	−0.078
	(0.066)	(0.076)	(0.095)	(0.114)	(0.071)	(0.071)	(0.097)	(0.111)	(0.074)	(0.073)	(0.097)	(0.117)
CPI Food	0.017***	0.014***	0.014***	0.014**	0.022***	0.018***	0.019***	0.018***	0.024***	0.023***	0.026***	0.024***
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
Constant	0.358**	0.293*	0.136	−1.216***	0.635***	0.500**	0.549***	−2.217***	0.126	−0.100	−0.180	−2.347***
	(0.153)	(0.151)	(0.147)	(0.073)	(0.193)	(0.198)	(0.155)	(0.104)	(0.142)	(0.155)	(0.145)	(0.087)
Within R^2	0.806	0.800	0.801	0.800	0.831	0.826	0.824	0.826	0.854	0.855	0.856	0.855
N (Countries)	49	50	44	50	49	50	44	50	48	48	43	48
Avg T (Time periods)	59.1	58.5	62.9	64.6	60.1	59.5	63.6	66.0	57.8	57.8	61.6	64.1
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time factors	None	None	None	None	None	None	None	None	None	None	None	None
Observations	2,897	2,927	2,767	3,228	2,947	2,977	2,799	3,300	2,772	2,772	2,650	3,075

Note: Interactive fixed effects estimates with country-clustered standard errors in parentheses, block-bootstrapped with 1000 replications. *p<0.1; **p<0.05; ***p<0.01.

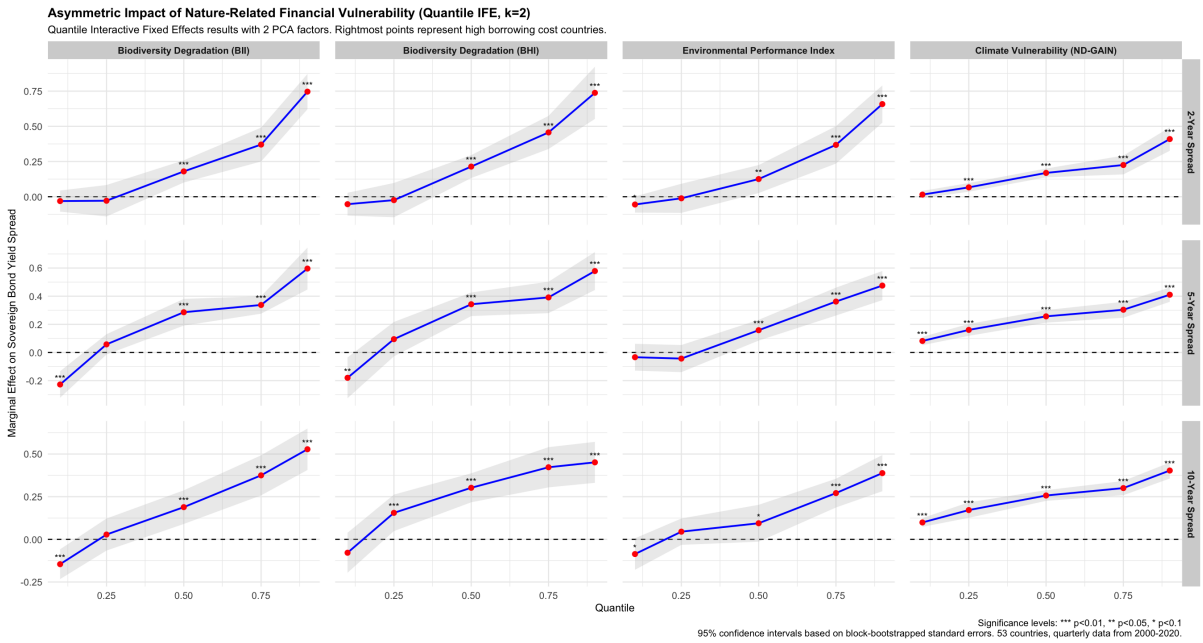


Figure 17: Quantile Regression Results, 2 Factors, 3 Groups

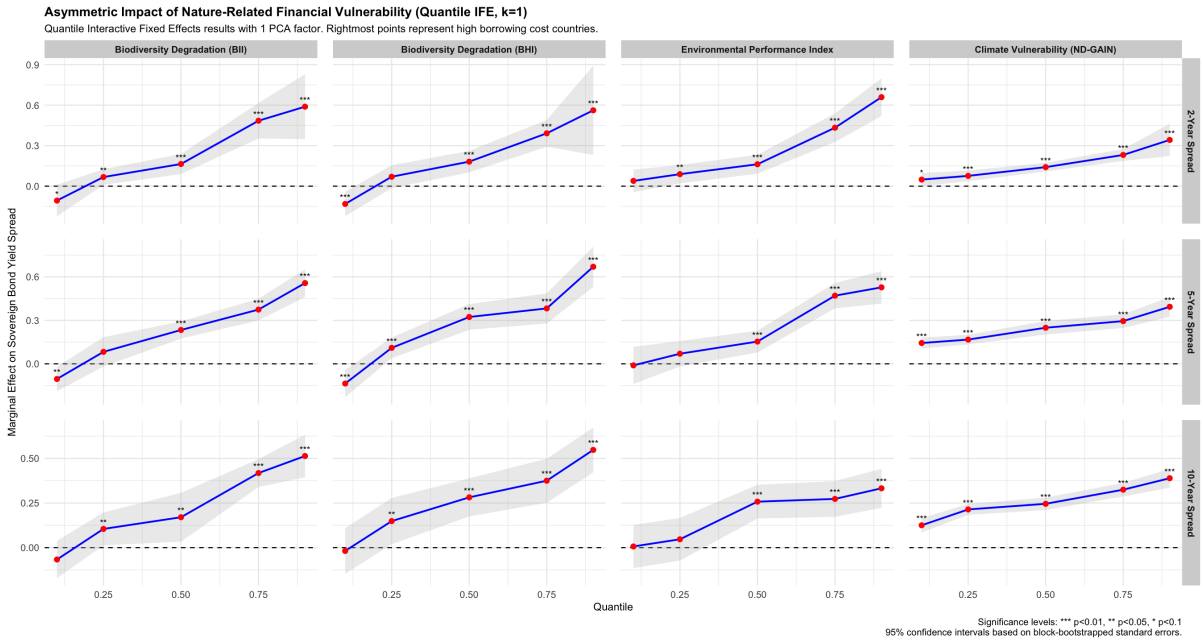


Figure 18: Quantile Regression Results, 1 Factor, 3 Groups

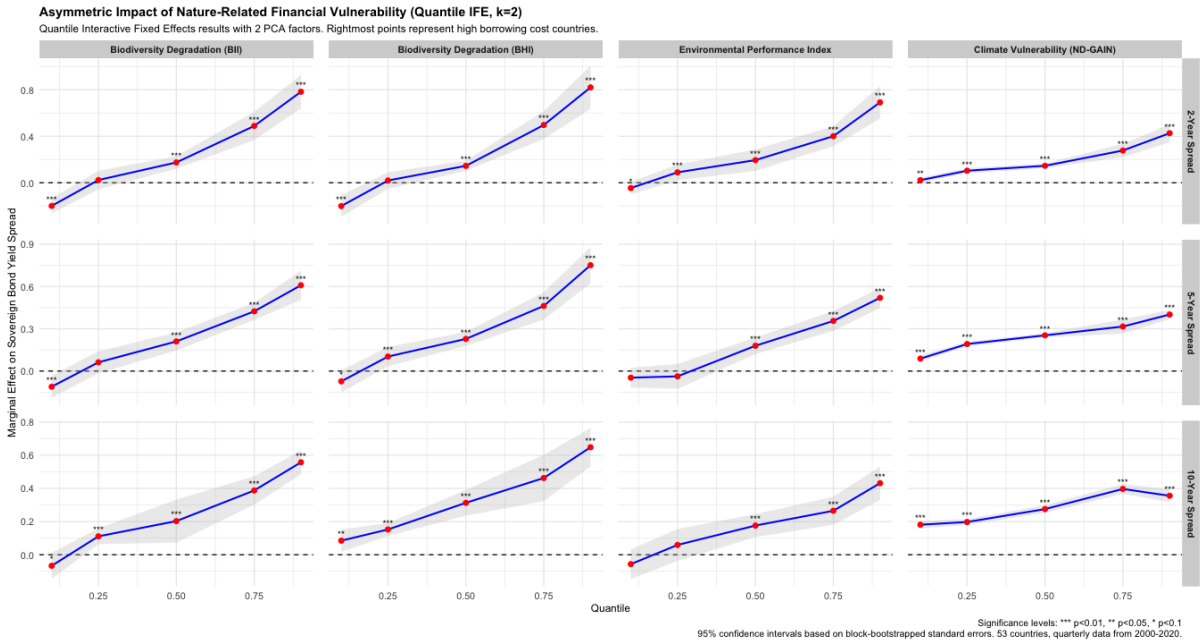


Figure 19: Quantile Regression Results, 2 Factors, 5 Groups

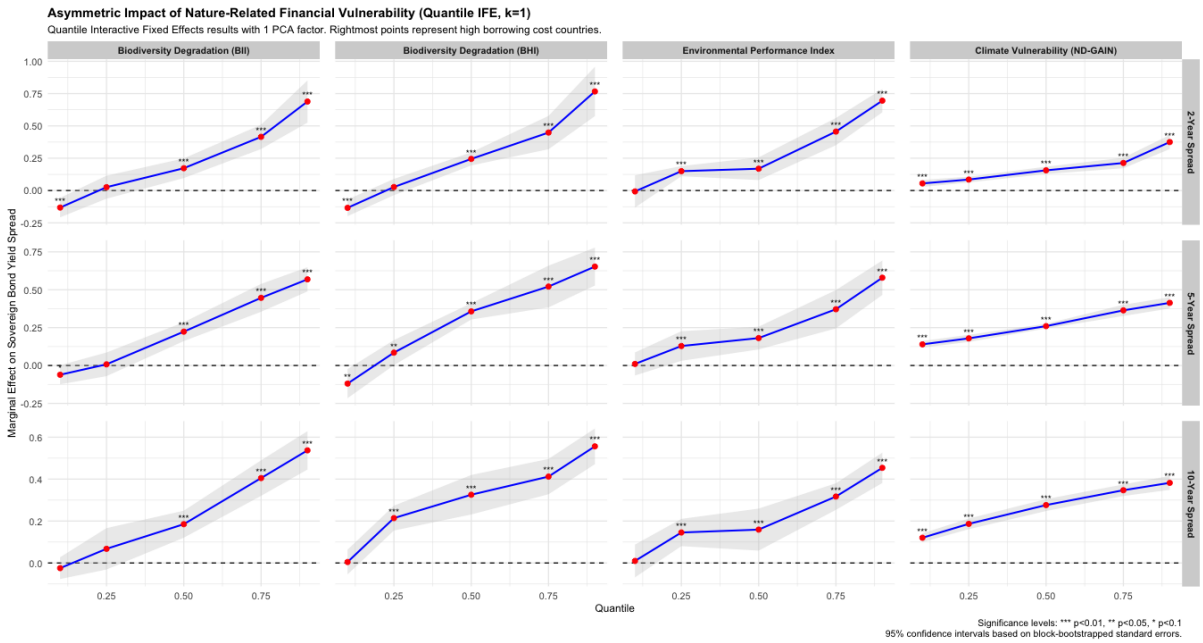


Figure 20: Quantile Regression Results, 1 Factor, 5 Groups

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