Climate risk

Sofia Anyfantaki
European Central Bank

AUEB 2025

18 December 2025

The views expressed here are those of the authors and not necessarily reflect those of the European Central Bank or the Eurosystem.

Why climate change matters

- **Global scale:** affects every region, sector, and generation
- **Multidimensional challenge:** beyond environmental science, climate change affects growth, investment, and financial stability
- **Economic impact:** damages infrastructure, agriculture, health, and productivity
- **Financial risk:** transition and physical risks reshape asset values, credit risk, and investment decisions
- **Policy urgency:** delayed action increases costs and deepens inequalities
- **Role of institutions:** governance and innovation systems are key to effective response

Breaking the tragedy of the horizon: Climate change and financial stability

The tragedy of the horizon refers to the misalignment between the long-term nature of climate risks and the short-term horizons of decision makers, businesses, regulators, and policymakers. This mismatch poses systemic threats to financial stability

The horizon for monetary policy extends out to two or three years. For financial stability, it is a bit longer, but typically only to the outer boundaries of the business cycle. In other words, once climate change becomes a defining issue for financial stability, it may already be too late

–Mark Carney, Bank of England (2015)

Key channels and responses

Three channels of climate-related financial risk:

- **Physical risks:** Damage from climate-related events (e.g. floods, storms) affecting assets and infrastructure
- **Liability risks:** Legal claims against firms for contributing to climate change
- **Transition risks:** Financial losses from the shift to a low-carbon economy, especially for carbon-intensive sectors

Call to action:

- Improve climate-related financial **disclosures**
- Integrate climate risk into **risk management frameworks**
- Support the transition by **financing green innovation**

Global coordination

EU climate goals – progressively more ambitious targets

by 2020

- 20%

(the actual cut was over 30%)

by 2030

- 55%

by 2050

net-zero

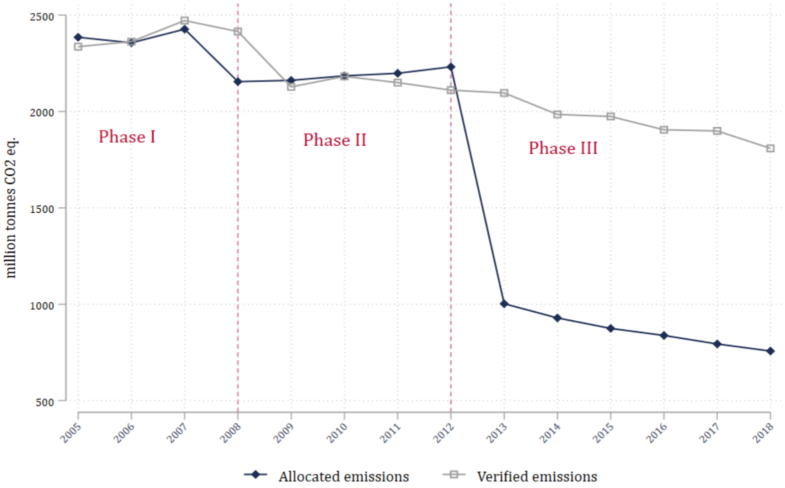
EU climate strategy: Green Deal and 2050 target

- **Climate neutrality by 2050:** legally binding target under the European Climate Law
- Endorsed by EU leaders in 2019 and rooted in the Paris Agreement (+1.5°C goal compared to pre-industrial levels)
- **European Green Deal:** the EU's growth strategy for a fair and competitive low-carbon economy
- Legislation adopted by the Council and Parliament turns strategy into binding rules across member states
- The transition brings opportunities for:
  - Economic growth
  - Markets and jobs
  - Technological development
- The green transition aims to be socially balanced and fair

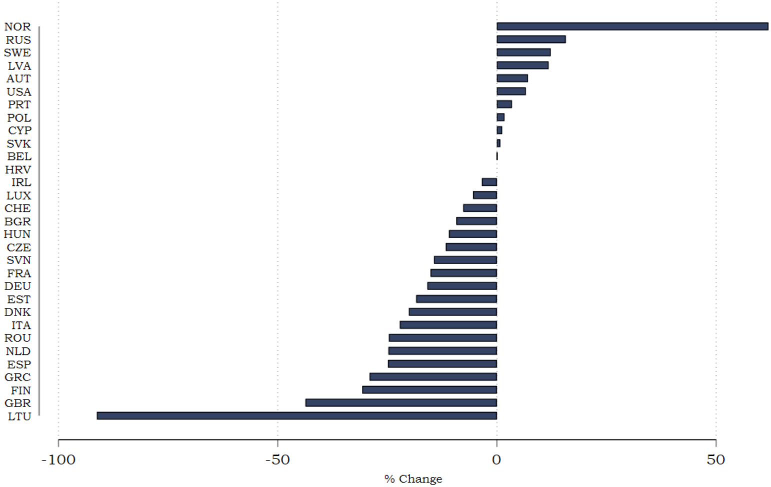
Fit for 55 and EU Emissions Trading System

- **Fit for 55 package:** comprehensive legislative plan to reduce EU greenhouse gas emissions by at least 55% by 2030 (vs. 1990)
- Covers energy, transport, buildings, land use, and industrial sectors
- Includes reforms to carbon pricing, energy taxation, and sectoral targets
- **EU Emissions Trading System (ETS):** cornerstone of EU climate policy
- Cap-and-trade system for CO_2 emissions – now expanded to maritime, aviation, and buildings
- Phase I: 2005-2007, Phase II: 2008-2012, Phase III: 2013-2020, Phase IV: 2021-2030
- Covering more than 11k manufacturing and power plants and about 45% of the EU GHG emissions in 31 countries
- **2005 $\rightarrow$ 2022 $\downarrow$ of GHG emissions by 38%**
  Phase IV 2030 target: $\downarrow$ 62% vs 2005

ETS GHG Emissions



Change in verified emissions by country 2005-18



First research question

- Do national indicators influence firm-level emissions reduction?
- Andreou, Anyfantaki, Cabolis, Dellis (2025) "Unveiling the enablers: Exploring country characteristics that encourage emissions reduction"

What we know

- Mixed evidence on the effects of the EU ETS on (green) innovation (Hoffman, 2007; Anderson et al., 2010; Borghesi et al., 2015); extra cost for firms (Deschenes, 2014; Andreou & Kellard, 2021)
- Institutional environments that foster knowledge accumulation & assimilation pivotal for green innovation (Aghion et al., 2016; Jaffe et al., 2005)
- Firm performance outcomes are primarily determined by the development of institutions (Henisz & Swaminathan 2008; Meyer & Peng 2005, Williamson 2000)
- Developing and fostering sound institutions affects public choice and matters for the enforcement and effectiveness of environmental policies (Halkos & Tzeremes, 2013; Abid, 2017; Lau et al., 2014; Ibrahim & Law, 2016)

What we do and what we find

- We link national structural characteristics with firms' emissions reduction
- Rich novel sample of 540 firms for 2005-2018
  1. EU ETS firm-level emissions per installation
  2. IMD competitiveness indicators
- Negative and significant relation controlling for firm characteristics, macroeconomic variables, sector and phase effects
- Factor analysis to unveil the precise country characteristics that stimulate emissions reduction endeavors within firms
- Skills and technological infrastructure play an important role for the success of environmental policies
- Overall, national policies can act as enablers, through the **fostering of technology infrastructure, skills development and stakeholders' cooperation**

Data - Emissions

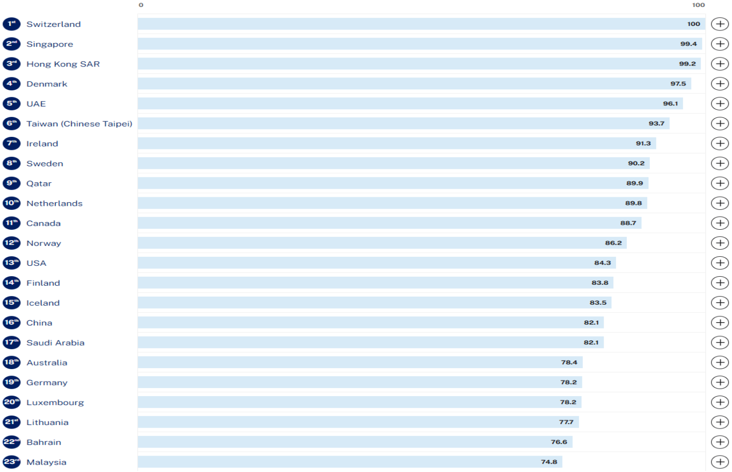
- Firm (verified) emissions from EU-ETS; 892 firms; 10,996 firm-year observations; 2005-2018
- Merge with ORBIS financial data
- **Final sample: 540 EU-ETS firms; 6,459 firm-year observations**
- Main dependent: Emissions for each firm divided by the number of its installations

A word on competitiveness

- An economy's competitiveness cannot be reduced to its GDP, productivity, or employment levels
- It can be gauged only by considering a complex matrix of political, social, and cultural dimensions.
- IMD World Competitiveness Center, with its flagship World Competitiveness Ranking

2025

Rankings out of 69 countries



COMPETITIVENESS LANDSCAPE

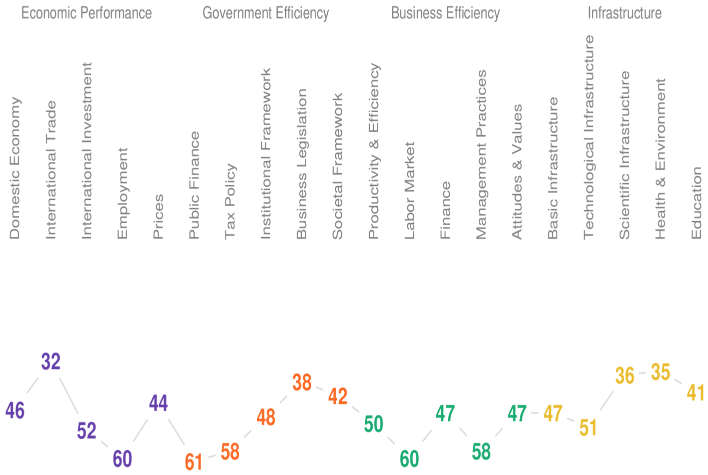


Table 1: Data - National indicators IMD

Economic performance	Government efficiency	Business efficiency
Domestic economy	Public finance	Product and Efficiency
International trade	Tax policy	**Labor market**
International investment	Institutional framework	Finance
Employment	Business legislation	Management practices
Prices	Societal framework	Attitudes and values

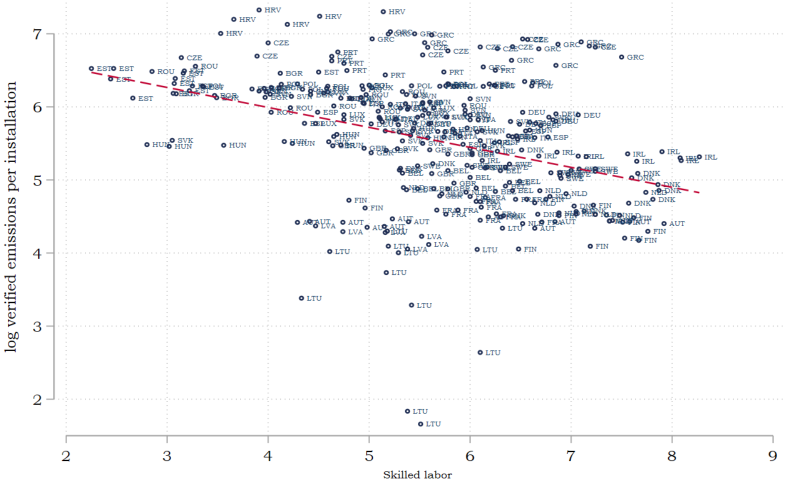
Infrastructure
Basic infrastructure
Technological infrastructure
Scientific infrastructure
Health and environment
Education

National indicators

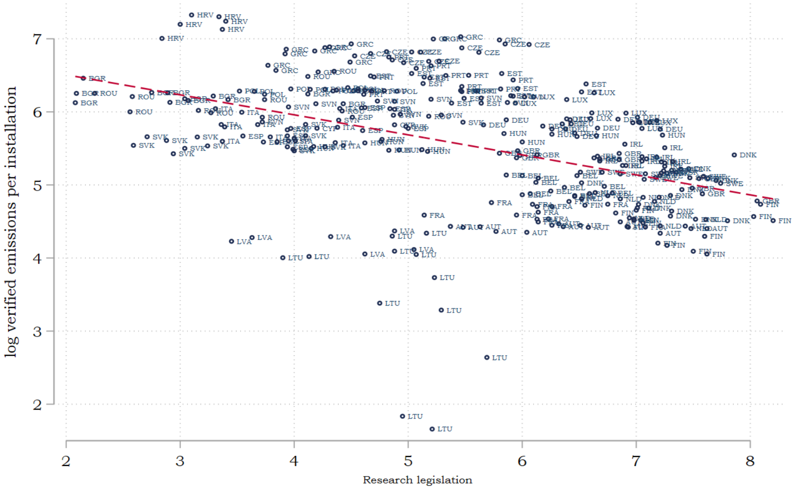
	IMD
Skilled labor	Skilled labor is readily available
Competent	Competent senior managers are readily available
Computers	Number of computers per 1000 people
Digital skills	Digital/Technological skills are readily available
PPP	Public and private sector ventures are supporting technological development
Tech development	Development and application of technology are supported by the legal environment
Research legislation	Laws relating to scientific research do encourage innovation

	WEF
Technological readiness	9th pillar from WEF Global Competitiveness Indicator Report
Business sophistication	11th pillar from WEF Global Competitiveness Indicator Report
Innovation capacity	12th pillar from WEF Global Competitiveness Indicator Report

Emissions and Skilled labor



Emissions and Research legislation



Control variables

Financial variables (ORBIS)	
Size	Natural logarithm of total assets in millions
Total assets change	Percentage change in total assets in millions between years t and t-1
ROE	The ratio of income before interests and taxes to book value of equity (%).
Cash flow	Operating income before depreciation divided by beginning of the year net assets
Intangibles	Intangible assets divided by beginning of the year net assets
Macroeconomic variables (Eurostat, OECD, World Bank)	
GFCF	Gross fixed capital formation as a percentage of GDP
Business R&D	Business R&D as a percentage of GDP
GDP growth	The country growth in GDP between years t and t-1 in %
Rate	Country short-term interest rates (average of commercial banks)

Empirical model

$$log(Installation\ emissions)_{isjt} = a + a_1 National\ indicator_{jt-1} + a_2 F_{isjt} + a_3 B_{jt} + a_4 S_s + a_5 T_t + u_{ijt} \quad (1)$$

where

- *Installation emissions*: verified emissions of a firm i operating in sector s in country j in year t divided by the number of installations of the firm i
- *National indicator*: each indicator taken from the IMD World Competitiveness (or the WEF) for country j in year *t-1* to address endogeneity that may arise from simultaneity bias
- F macroeconomic and B control variables
- S sector fixed effects to control for time-invariant sector characteristics that shape innovation and emissions given the architecture and implementation of the ETS
- T control for the three different phases of the scheme

Baseline regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Skilled labor	-0.187***									
	(0.051)									
Competent		-0.202***								
		(0.072)								
Computers			-0.002***							
			(0.000)							
Digital skills				-0.134**						
				(0.053)						
PPP					-0.142***					
					(0.054)					
Tech development						-0.116**				
						(0.054)				
Research legislation							-0.161***			
							(0.047)			
Technology readiness								-0.377***		
								(0.117)		
Business sophistication									-0.692***	
									(0.182)	
Innovation capacity										-0.483***
										(0.151)
Obs.	2,051	2,051	2,052	2,051	2,005	2,051	2,051	1,801	1,777	1,777
R-squared	0.203	0.201	0.208	0.200	0.197	0.199	0.201	0.196	0.199	0.197
1 SD effect	-0.156	-0.163	-0.377	-0.116	-0.137	-0.114	-0.227	-0.231	-0.433	-0.425

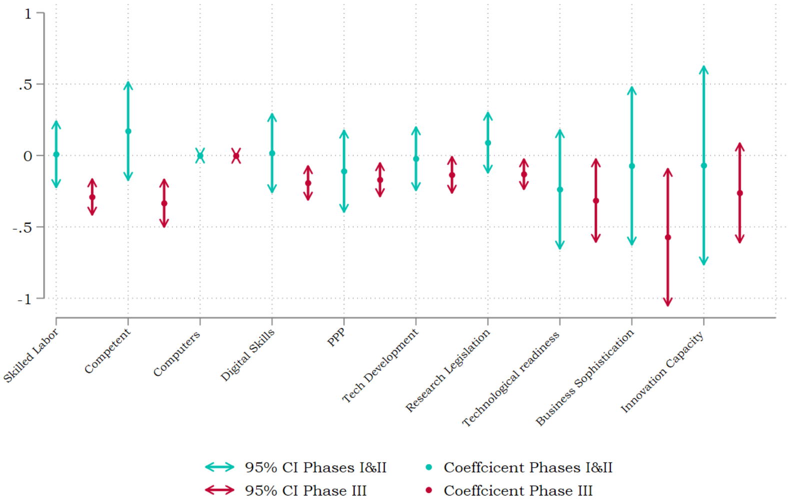
Key takeaways

- Negative significant relation, controlling for firm characteristics, macroeconomic variables, and sector effects
- 1 SD $\uparrow$ skilled labor indicator $\rightarrow\downarrow$ 15.6% emissions per installation
- Similar result for competent managers indicating the importance of labor market efficiency
- Technology infrastructure plays a significant role: 1 SD $\uparrow$ computers per capita $\rightarrow\downarrow$ 37.7% emissions per installation
- Highlighted importance of a supportive environment for technology development and research innovation
- Similar results for WEF indicators
- Overall, results underscore the mitigating effect that specific national characteristics, i.e. efficient labor market, technological infrastructure and supportive legal environment, can exert on firms' emissions

Regression analysis by phase period

- Phase I was a test phase for both firms and regulators and not conceived to result in major emission cuts.
- Phase II was characterized by a slow pace of adjustment following the 2008 financial crisis
- Phase III marked the implementation of the auctioning system
- We expect our results to be driven mainly by developments during Phase III
- In fact, the majority of national indicators turn out negative and significant only for the period 2013-2018
- Creating a more robust framework with an increased carbon price fostered stronger incentives for reducing emissions, which were further bolstered by a supportive institutional environment
- Promising for Phase IV and beyond

Coefficient plots from regression analysis by phase period



Conclusions

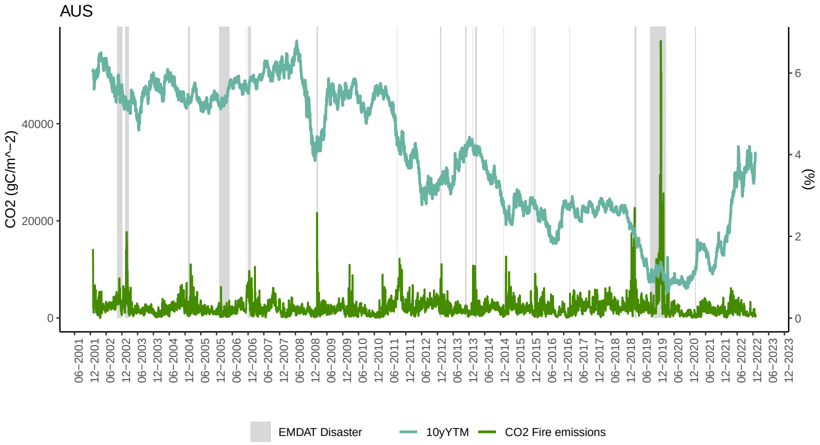
- Do structural and institutional factors contribute to the green transition of European economies?
- Yes!
- Despite the fact that emission abatement is achieved at the firm or plant level, structural and institutional factors at the country level are of material importance
- Strong institutions can act as enablers and accelerators fostering a conducive environment for firms and industries embarking on the green transition process
- All results underscore the importance of technological readiness, innovation capacity and skills in the emissions abatement effort
- Skills gap; investments in technological advancements and infrastructure; stakeholder collaboration; monitoring and evaluation of emission reduction measures

Second research question

- How does sovereign risk interact with climate vulnerability?
- Anyfantaki, Blix Glimaldi, Malovana, Madeira, Papadopoulos (2025) "Decoding climate-related risks in sovereign bond pricing: A global perspective"

Considering climate risk

- Investors in sovereign debt have traditionally incorporated environmental factors into their analysis
  - for example when countries are particularly vulnerable to extreme weather events, or dependent on soft commodities or tourism
- However, there is a need to take a more systematic approach to climate risk analysis
  1. increasing severity and frequency of weather events and disruptive effects on economies, including on supply chains
  2. expansion in regulation requiring to account for exposure to, and mitigation of, climate risks
- Is there a nexus between climate risk and sovereign risk?



AUS
CO2 (gC/m^−2)
(%)
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20000
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6
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12−2002
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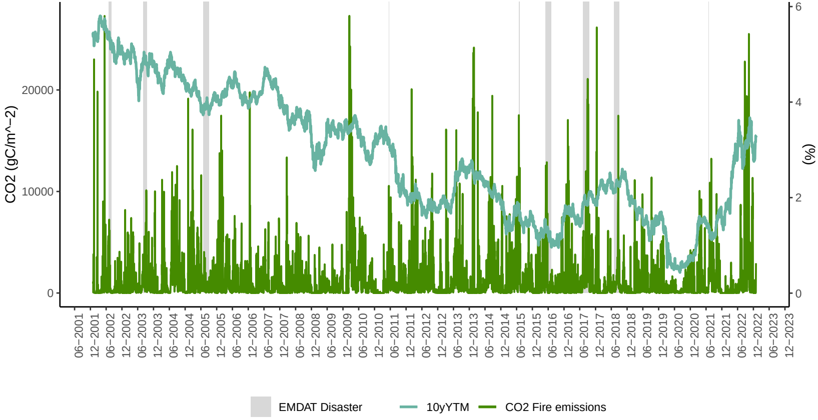
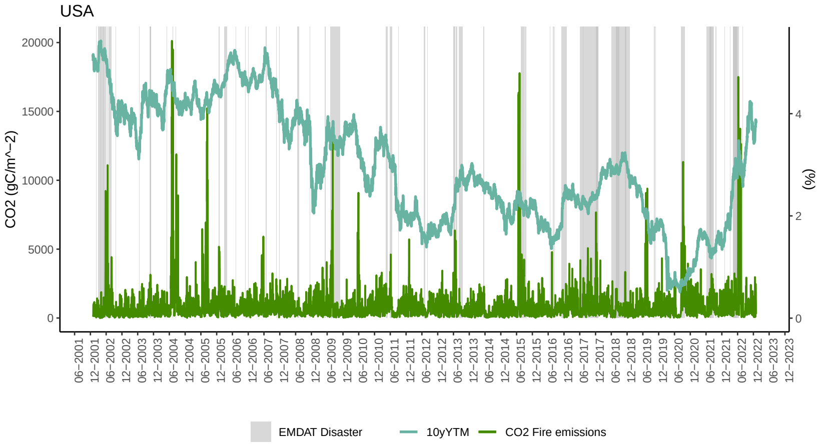
EMDAT Disaster
10yYTM
CO2 Fire emissions

CAN




USA
CO2 (gC/m^−2)
(%)
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12−2023
EMDAT Disaster
10yYTM
CO2 Fire emissions

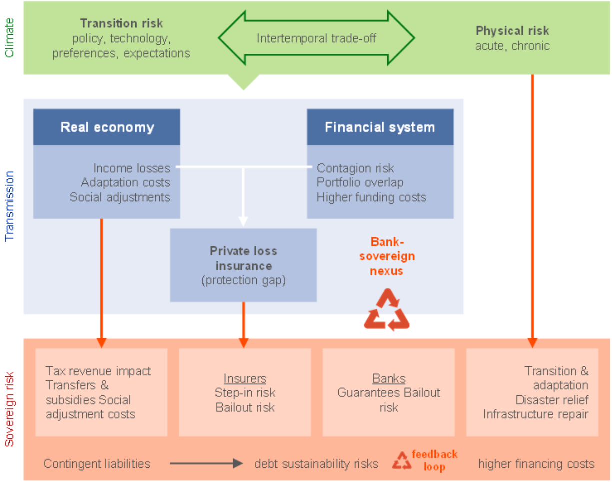
Transmission channels

- Climate change can affect public finances through multiple – and largely dependent on each other – transmission channels
- Directly, such as increased public spending to replace damaged assets and infrastructures, to support vulnerable households or firms
- Indirectly, via the materialisation of both explicit (e.g. relief or disaster-specific transfers to local governments, government guarantees for firms and public-private partnerships) and implicit contingent liabilities (e.g. public support to distressed financial institutions)
- Or through reduced tax revenue due to output losses following disruptions of economic activity in climate-sensitive sectors and regions

The nexus

Figure C.1

Sovereign climate-related risks and link to financial stability



Source: ECB.

Transition risk

- Higher mitigation and adaptation spending put pressure on public finance (but lead to milder impacts in terms of damages, growth and borrowing rates)
- Transition re-allocates resources from productive investments to adaptation investments or to new technologies, and has employment and social impacts
- Transition has direct (social transfers, insurance schemes), indirect (reduction in tax revenues), and discretionary fiscal impacts (investment to infrastructure, subsidies for clean energy)
- Repricing of sovereign wealth as assets become stranded
- Overall effects depend on the timing and design of policies

Physical risk - Chronic and Acute

- **Chronic hazards**: sea level rise, temperature rise and other medium and long term – and often irreversible – transformations of the environment
- **Acute risks** include extreme weather and climate-related events, which tend to cause immediate damage and lead to potential short- and medium-term consequences
- Damage and disruption to capital stock, disruption to trade flows...
- Changes in economic activity, migration within and between countries, increased government expenditure
- Ex-post disasters impact economic growth; persistent deviation of GDP from trend in medium term, despite reconstruction activities, especially in small developing countries
- Lower revenues & higher public expenditures
- Ex ante, climate-vulnerable countries incur a risk premium on their sovereign debt

Looking forward

- Physical and transition risks are not independent of each other but tend to interact
- More adverse effects for those in areas with high exposure to climate disasters and with lower capacity to prepare and cope with such events
- Sectors heavily reliant to natural resources and stable climate conditions are expected to experience greater impacts
- Increase in frequency and strength of many types of weather and climate-related extremes
- Damages are still most insurable, but insurance coverage is likely to become more costly and even unavailable
- Overall, 2024 was more costly in terms of disaster-related damage than the average year over the past two decades (EM-DAT)

Figure 8

Economic Losses (US$ billion) by Disaster Type: 2024 Compared to the 2004-2023 Annual Average

209.6 < **242**
2004 to 2023 in 2024

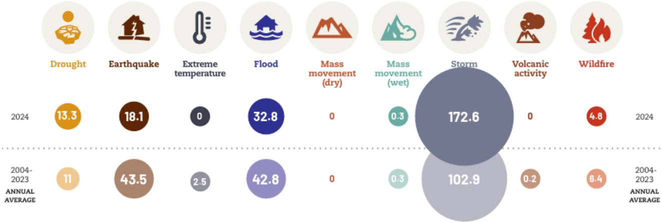
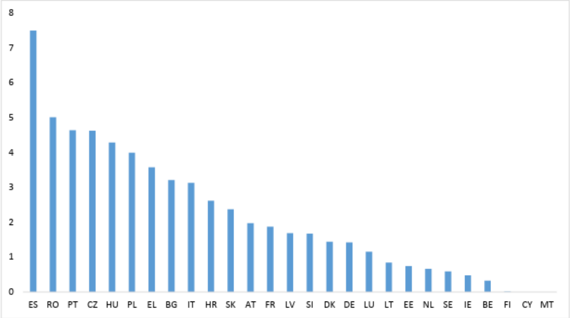


Table 3 Top 10 Economic Losses (US$) - 2024

USA	Hurricane Helene	56 billion
USA	Hurricane Milton	38 billion
Japan	Earthquake	15 billion
Spain	Flood	11 billion
USA	Hurricane Beryl	7.2 billion
Brazil	Flood	7 billion
USA	Storm (May)	6.6 billion
Brazil	Drought	6 billion
USA	Storm (March)	5.9 billion
USA	Drought	5.4 billion

Graph II.2.18: **Cumulated uninsured economic losses from extreme weather and climate-related events (% of country GDP), by country, 1980-2020**



(1): Information for CY and MT is missing.
Source: European Commission, based on The Emergency Events Database (EM-DAT; CRED, UCLouvain).

Sovereign bond market

- Sovereign bond market is one of the largest in the world
- Yet, has received less attention in the pricing-in of climate risk compared to other asset classes
- Most studies have focused on other financial markets
  - equities (Zhang, 2002; Bolton and Kacperczyk, 2023; Faccini et al., 2023)
  - corporate bonds (Huynh and Xia, 2021)
- Research on sovereign bond markets has primarily examined physical risks
- Most of research uses climate vulnerability and resilience indicators
- In advanced economies, climate-related fiscal risks have not been extensively explored

What we know

- Beirne, Renzhi and Volz (2020): sovereign bond yields increase with higher climate vulnerability, and to a lesser extent lower climate resilience (based on whether an economy has measures in place to address exposure to climate risks).
- Cevik and Jalles (2020): climate resilience (defined as capacity to address the consequences of climate change) helps lower the cost of borrowing, while climate vulnerability increases borrowing costs.
- Collender, Gan, Nikitopoulos, Richards and Ryan (2022): higher carbon dioxide emissions are associated with higher sovereign yields and also sovereign spreads against US
- Boehm (2022): countries that are warm and have a lower quality of institutions have worse sovereign debt performance
- Bingler (2022): for longer-dated government bonds issued by higher-rated countries, lower yields are associated with higher climate transition performance, lower transition risk exposure and higher transition opportunity. For lower-rated countries, lower preparedness to physical climate impacts is associated with higher yields

What we do

- We contribute with new findings through an in-depth empirical analysis using an augmented dataset of countries and climate-change indicators
- We consider both long- and medium-term perspectives
- We begin with panel country-fixed-effects regressions
  1. We distinguish between transition & physical risks – chronic vs acute
  2. AE vs EMDEs
- We use local projections to uncover the medium-term impact of physical risk
  1. Look at both the frequency and the severity of climate-related natural disasters
  2. Impact of different types of natural disasters

Data & Sample

- Several sources to construct a panel dataset with annual observations
- 52 countries; 2000-2023

Country group	No.	Countries
AE	26 (28)	Australia, (Austria), Belgium, Canada, Cyprus, Denmark, (Estonia) Finland, France, Germany, Greece, Iceland, Ireland, Italy Japan, Latvia, Lithuania, Netherlands, New Zealand, Norway, Portugal Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States
EMDE	26 (32)	(Albania), Argentina, (Bahamas), Botswana, Brazil, Chile China, Colombia, Costa Rica, Croatia, Czech Republic, Dominican Republic, El Salvador (Georgia), Guatemala, Hungary, Israel, Jamaica, Malaysia, Mauritius (Mongolia), Panama, Philippines, Poland, Romania, South Africa, South Korea Thailand, (Trinidad and Tobago), Turkey, Ukraine, (Uruguay)

- Dependent variable is countries' 10-year government bond yield (Bloomberg)

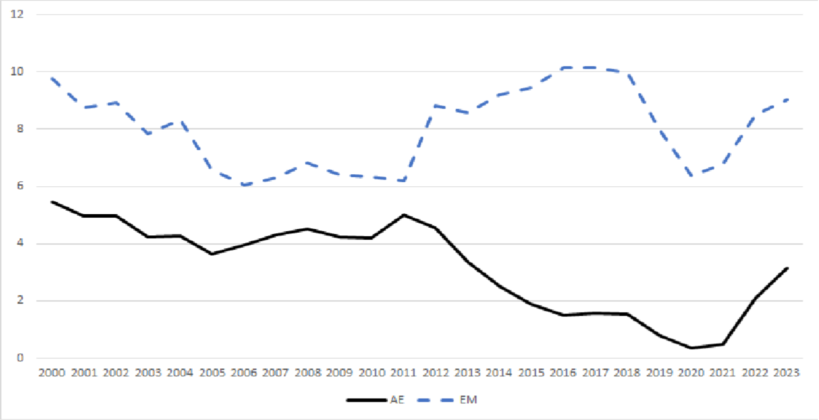


Figure 1: Average 10 year sovereign bond yields for AEs and EMDEs

Data - Climate risk

- **Transition risk** is measured by CO_2 emissions per capita (World Bank)
- **Chronic physical risk** is proxied by growth in annual temperature relative to the mean temperature between 1951 and 1980 (World Bank)
- **Acute physical risk** is measured by losses due to natural disasters, either annual economic costs or total number of people affected (EM-DAT)
- EM-DAT defines disasters as *situations or events which overwhelm local capacity, necessitating a request for external assistance at the national or international level*.
- Disasters are *unforeseen and often sudden events that cause significant damage, destruction, and human suffering*
- Classified into two groups of hazards: natural and technological
- Natural is further classified into: biological; **climatological**; geophysical; **hydrological**; **meteorological** and; extra-terrestrial
- 7,700 climate-related natural disasters since 2000

Figure 2: Distribution of climate-related natural disaster events

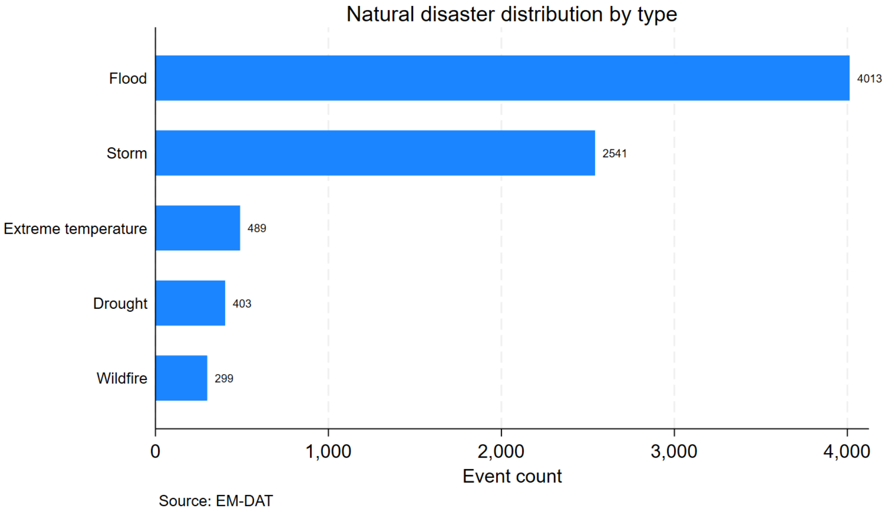


Figure 3: Human and economic impact by type of climate-related natural disaster events

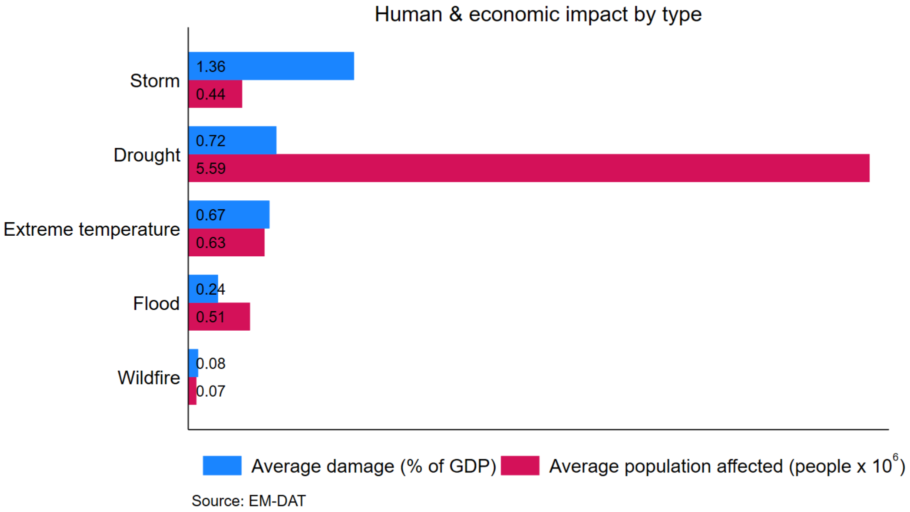


Figure 4: Average duration of climate-related natural disaster events by type

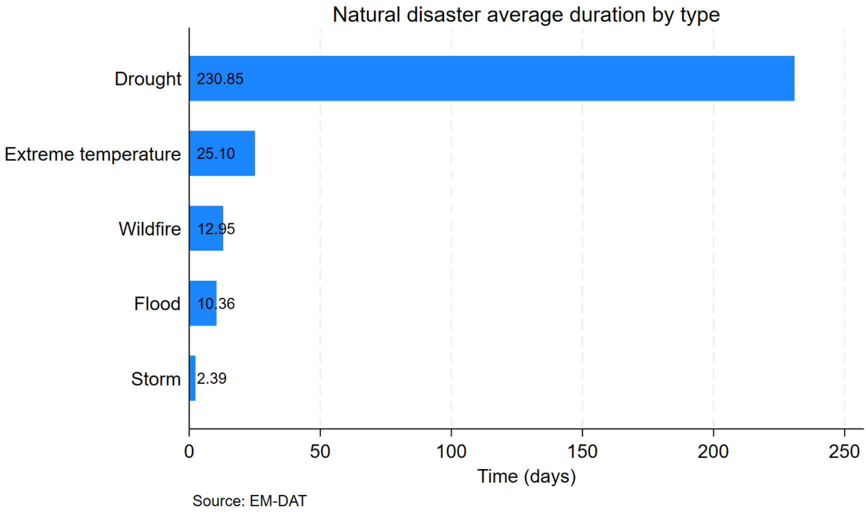


Table 2: **Climate-related natural disasters: Frequency and severity**
Statistics calculated for the country sample from 2000 until 2023. Damages are reported in billion USD, adjusted for inflation and as a share of real GDP

	All	Drought	Extreme temperature	Flood	Storm	Wildfire
AE						
Frequency	1436	19	141	440	751	128
Duration (avg., in days)	7.57	245.50	27.46	5.52	3.06	15.85
Deaths (avg.)	149	144	1035	8.48	15.30	13.28
Affected (avg.)	127727.50	26000	10706	48298	238287	12620
Damages (avg., in bn USD)	2.56	5.66	1.83	1.43	3.24	1.35
Damages (avg., % of GDP)	0.06	0.20	0.14	0.06	0.05	0.07
EMDE						
Frequency	1746	50	88	975	669	42
Duration (avg., in days)	7.95	255.29	22.72	9.27	2.44	5.38
Deaths (avg.)	47.76	61.00	122.94	34.81	55.86	12.51
Affected (avg.)	1268499	8693631	2838348	1120503	868496	260959
Damages (avg., in bn USD)	0.80	1.59	3.30	0.97	0.48	0.31
Damages (avg., % of GDP)	0.13	0.23	0.23	0.12	0.13	0.12

Key takeaways

- Across all countries the most common type of climate-related natural disaster is flood and then storm
- Although storms are the most costly natural disasters in economic terms, droughts have a far greater human toll
- While droughts occur far less frequently, they last longer exhibiting a mean duration of about 230 days
- On the contrary, the most frequent natural disasters – storms and floods – last on average only ten to two days respectively
- Extreme temperature, storms and wildfires are more frequent and with longer duration in AEs than EMDEs. However, although the economic impact is high the total people affected in AEs is far less than in EMDEs
- This is true for every type of natural disaster indicating the high stress on EMDEs
- Severity and frequency play a role; disaster type

Panel regressions

Our baseline specification is the following:

$$Y_{i,t} = \alpha_i + \beta_t + \gamma Climate\_risk_{i,t-1} + \delta' X_{i,t-1} + \epsilon_{i,t}. \quad (2)$$

- $Y_{i,t}$ is (log) 10-year sovereign bond yield
- $Climate\_risk_{i,t-1}$ is (log) CO_2 emissions per capita or yearly changes in temperature (chronic risk) or number of natural disasters or total economic costs/total uninsured costs (%GDP) or total number of people affected (% population) associated with climate-induced natural disasters (acute risk)
- $X_{i,t-1}$ is government debt as a share of GDP, CPI inflation, GDP growth, (log) exchange rate, government efficiency and political stability indicator
- α_i are country FEs and β_t are time FEs
- $\epsilon_{i,t}$ standard errors clustered at the country level

Baseline model with climate risk

	(1)	(2)	(3)	(4)	(5)	(6)
CO_2	0.969***					
	(0.141)					
Temperature		-0.026				
		(0.026)				
NaturalDisasters			0.014			
			(0.012)			
TotalCosts/GDP				-0.008		
				(0.033)		
TotalUninsured/GDP					-0.038	
					(0.037)	
TotalAffected/Population						-0.006
						(0.006)
Observations	747	766	584	554	554	554
R-squared	0.902	0.874	0.875	0.872	0.872	0.872
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Time	Yes	Yes	Yes	Yes	Yes	Yes

Key takeaways

- Transition risks are priced in sovereign yields $\rightarrow$ Progress in climate transition performance is associated with lower 10-year maturity bond yields
- Increased chronic physical risks are not associated with higher sovereign yields
- Variables for acute risk are not statistically significant
- Same results if we include all types of climate risks in a model

Distinction between AE vs. EMDE

	(1) AE	(2) EMDE	(3) AE	(4) EMDE	(5) AE	(6) EMDE	(7) AE	(8) EMDE
CO_2	0.109	0.928***						
	(0.250)	(0.177)						
Temperature			-0.014	-0.031				
			(0.074)	(0.051)				
NaturalDisasters					0.031*	0.015**		
					(0.017)	(0.007)		
TotalAffected/Population							0.007**	-0.002
							(0.003)	(0.005)
Observations	542	294	622	309	445	284	337	277
R-squared	0.914	0.896	0.912	0.858	0.915	0.865	0.896	0.857
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Key takeaways

- The effect of the transition risk is notably more pronounced for developing economies $\rightarrow$ The large imposition of green financial policies by AEs offsets the transition risk premium
- Developing countries with higher carbon emissions and a less sustainable growth trajectory will find it harder to smoothly transition to a decarbonized economy
- The effect on yields from acute physical climate risks is partly priced with a difference between the significance of frequency or severity for advanced and developing economies

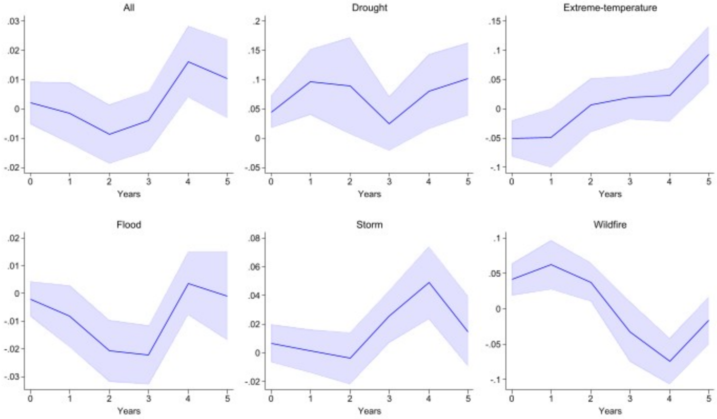
Local projections - Medium term effects

Impulse responses are derived from separate regressions for each forecast horizon $t + h$, conditional on a given set of variables at time t:

$$Y_{i,t+h} = \beta^h ND_{i,t} + \sum_{j=1}^{3} \gamma_j^h Y_{i,t-j} + \sum_{j=1}^{3} \delta_j^h X_{i,t-j} + \alpha_i^h + \alpha_t^h + \epsilon_{i,t+h} \tag{3}$$

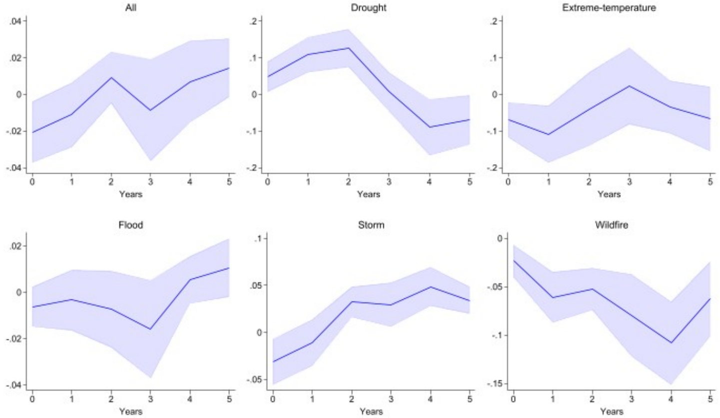
- $Y_{i,t+h}$ is 10-year sovereign yields
- $ND_{i,t}$ is the climate shock: **frequency** of climate-related natural disasters or **total damages** as a percentage of GDP
- $X_{i,t}$ is the vector of control variables and CO_2 emissions per capita
- α_i^h are country FEs and α_t^h are time FEs
- We include three lags of the dependent variable to augment local projections

Figure 5: Impact of climate shocks on sovereign yields: Disaster frequency



Note: The figure shows impulse response functions constructed from regression results of the lag-augmented local projection model in equation (3). Solid lines display the coefficients of (non-cumulative) responses of the sovereign yields over the five years following a climate shock as measured by the occurrence of natural disasters. Shaded areas refer to 68% confidence intervals. The first panel is for all climate related natural disasters, i.e. drought, extreme-temperature, flood, storm and wildfire.

Figure 6: Impact of climate shocks on sovereign yields: Disaster severity



Note: The figure shows impulse response functions constructed from regression results of the lag-augmented local projection model in equation (3). Solid lines display the coefficients of (non-cumulative) responses of the sovereign yields over the five years following a climate shock as measured by the total damages of natural disasters (% GDP). Shaded areas refer to 68% confidence intervals. The first panel is for all climate related natural disasters, i.e. drought, extreme-temperature, flood, storm and wildfire.

Key takeaways

- Heterogeneity in the response of 10-year sovereign yields to climate shocks related to the frequency and severity of each type of natural disaster
- The yields experience the largest increases in response to climate shocks related to droughts
- These are the natural disasters with the longest mean duration and the highest human toll
- Although shocks related to storms, the most common type of natural disasters, also have positive effects on yields, their impact is significant only for the third year after the incidence of the event

Nonlinear effects

- We explore whether initial macro-fiscal conditions at the time of the shock influence the impact of climate shocks as measured by total damages (% GDP) on sovereign yields $\rightarrow$ **state-dependent impulse response functions**
- Model similar to STAR model (Granger and Terasvirta 1993); allows the effect of climate shocks to change smoothly between states

$$Y_{i,t+h} = \beta_L^h F(z_{i,t}) ND_{i,t} + \beta_H^h (1 - F(z_{i,t})) ND_{i,t} \quad (4)$$

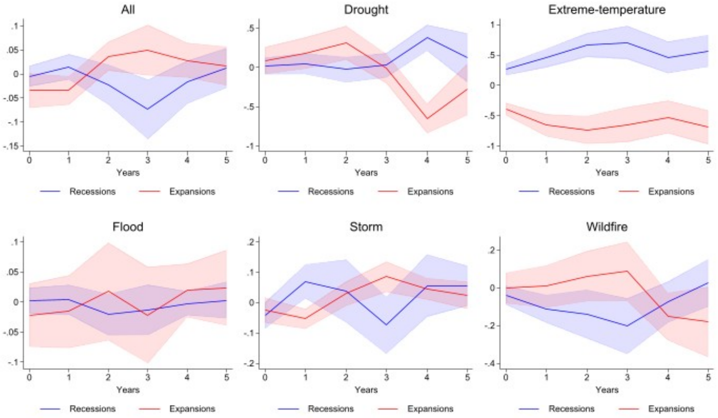
$$+ \sum_{j=1}^{3} \gamma_j^h Y_{i,t-j} + \sum_{j=1}^{3} \delta_j^h X_{i,t-j} + \alpha_i^h + \alpha_t^h + \epsilon_{i,t+h} \quad (5)$$

$$F(z_{i,t}) = \frac{exp(-\gamma z_{i,t})}{1 + exp(-\gamma z_{i,t})}$$

where $z_{i,t}$ is either the real GDP growth or the public debt-to-GDP, standardized to have mean and standard deviation one

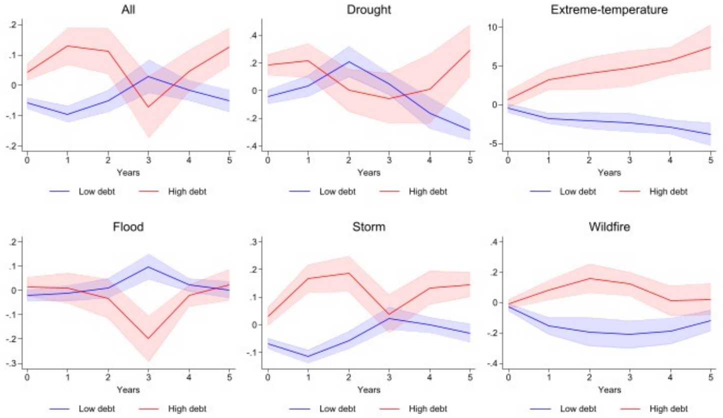
- The weights assigned to each regime vary between 0 and 1 according to the weighting function $F(z_{i,t})$, so that this can be interpreted as the probability of being in a given space state
- β_L^h and β_H^h capture the impact of climate shocks for recessions (low debt) and expansions (high debt). Following Cevik et al. 2023, we choose $\gamma = 1.5$.

Figure 7: Disasters and the role of business cycle



Note: The figure shows impulse response functions constructed from regression results of the lag-augmented local projection model in equation (4). Solid lines display the coefficients of (non-cumulative) responses of the sovereign yields over the five years following a climate shock as measured total damages (% GDP). The first panel is for all climate related natural disasters, i.e. drought, extreme-temperature, flood, storm and wildfire. Shaded areas refer to 68% confidence intervals.

Figure 8: Disasters and the role of fiscal space



Note: The figure shows impulse response functions constructed from regression results of the lag-augmented local projection model in equation (4). Solid lines display the coefficients of (non-cumulative) responses of the sovereign yields over the five years following a climate shock as measured total damages (% GDP). The first panel is for all climate related natural disasters, i.e. drought, extreme-temperature, flood, storm and wildfire. Shaded areas refer to 68% confidence intervals.

Conclusions

- Transition risk is associated with higher sovereign yields $\rightarrow$ achieving progress in climate transition performance can offset the transition risk premium
- Natural disasters increase sovereign yields in the medium term. The impact is faster and steeper for more severe (e.g. droughts) and more frequent (e.g. storms) events.
- Climate-related shocks have a smaller impact on low-debt countries likely reflecting their more robust fiscal response capabilities, where governments can afford to increase spending to aid recovery efforts

Policy implications

- Overall, our paper highlights the role of climate change as a significant risk factor, especially for high-debt, fiscally vulnerable countries
- Policymakers need to better understand how transition efforts affect the cost of borrowing and to intensify their efforts for an international policy agenda aiming to address both climate and sovereign debt challenges
- At the same time, the frequency and intensity of extreme weather events and natural catastrophes are increasing, a trend that may continue or even accelerate in coming decades
- High debt countries may be less well placed to deal with the challenges of severe weather events as well as the costs of the green transition