



EUROPEAN CENTRAL BANK

EUROSYSTEM

Credit Worthy: Do Climate Change Risks Matter For Sovereign Credit Ratings?

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Motivation

Climate change is an important source of risk for sovereigns

- Climate change can affect the economy and the ability of sovereigns to service their debt [Mallucci, 2020; Klusak et al. 2021; Zenios, 2022]
- Credit ratings are key indicators to measure creditworthiness of a country. Credit rating agencies claim to be paying attention to climate-related risks
- Policy relevant question for investors, governments, regulators and central banks

Research Questions

- Is there evidence that credit rating agencies systematically incorporate physical and transition climate risk in their sovereign credit rating assessments?
- Do credit ratings agencies attribute more weight to climate-related risks in their sovereign rating assessments following the Paris Agreement?

Base Model for Ratings (Cantor & Packer 1996)

- **Predictors:** GDP per capita, GDP growth, Inflation, Debt to GDP ratio, Current Account Balance to GDP ratio, External Debt to Export Ratio, Previous Default, Developed or Emerging economy (dummy)
- **Sample period:** 1999 – 2021
- **Dependent Variable:** Foreign Currency Ratings – average of S&P, Moody's, DBRS and Fitch.
- **Number of Countries:** 124

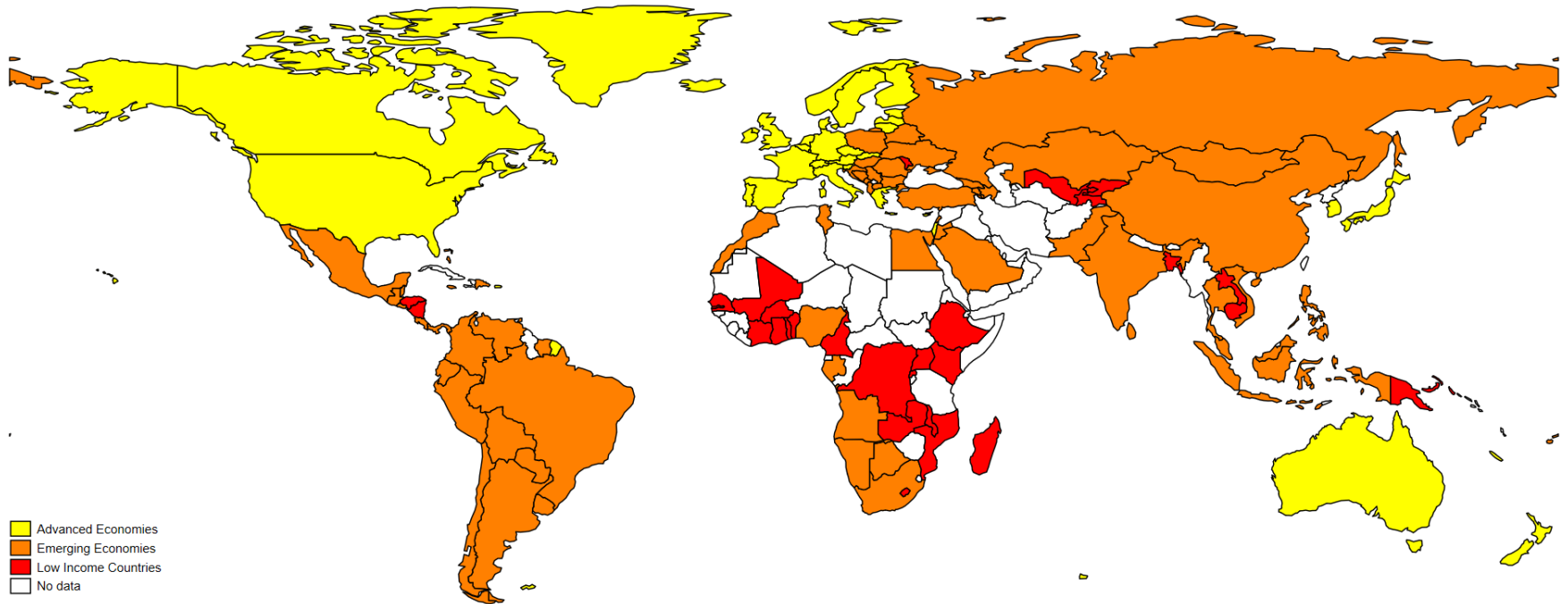
Table 12

Results for panel regression computed on 124 countries over the time window 1999-2021. the model is inspired to Cantor & Packer (1996).

	Rating (1)
Log GDP t-1	2.014*** (0.371)
GDP Growth t-1	0.0345** (0.0157)
Inflation t-1	-0.0185*** (0.00594)
Debt to GDP ratio t-1	-0.0336*** (0.00887)
Current Account Balance to GDP ratio t-1	-0.0114 (0.0101)
External Debt to Export ratio t-1	-0.00197** (0.000773)
Default	-0.799* (0.428)
Economy	5.854*** (1.223)
Constant	-4.328 (2.898)
Observations	2,013
R-squared	0.956
Country FE	YES
Year FE	YES
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Coverage

33 Advanced, 62 Emerging Economies and 29 Low Income Countries



Climate Risk Measures

- **Temperature Anomalies**
- **Change in Number of Disasters**
- **Number of Disasters per Sq. Km**
- **Readiness**
- **Vulnerability**

Physical Risk



- **CO2 Emissions / GDP** (levels and rate of change)
- **Primary Energy Consumption / GDP**
(levels and rate of change)
- **CO2 Reduction Target**

Transition Risk



Physical risk is reflected in credit ratings (over the entire sample – panel)

Table 2

Panel regressions for 124 countries from 1999 to 2021. Cantor & Packer (1996) augmented with physical risk variables.

	Rating				
	(2)	(3)	(4)	(5)	(6)
Temperature Anomalies t-1	→ -0.148* (0.0765)				
Percentage Change in Disasters t-1	→ -0.000441* (0.000261)				
Number of Disasters per Sq. Km t-1			-237.7 (207.5)		
Vulnerability				3.807 (10.20)	
Readiness				→ 8.981*** (2.057)	
Observations	2,000	2,013	2,013	1,882	1,888
R-squared	0.956	0.956	0.956	0.957	0.960
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Robust standard errors in parentheses					
*** p<0.01, ** p<0.05, * p<0.1					

Higher temperature anomalies and a higher frequency of disasters are associated with lower ratings

Countries with higher readiness have higher ratings

Transition risk is not reflected in credit ratings over the entire sample (panel)

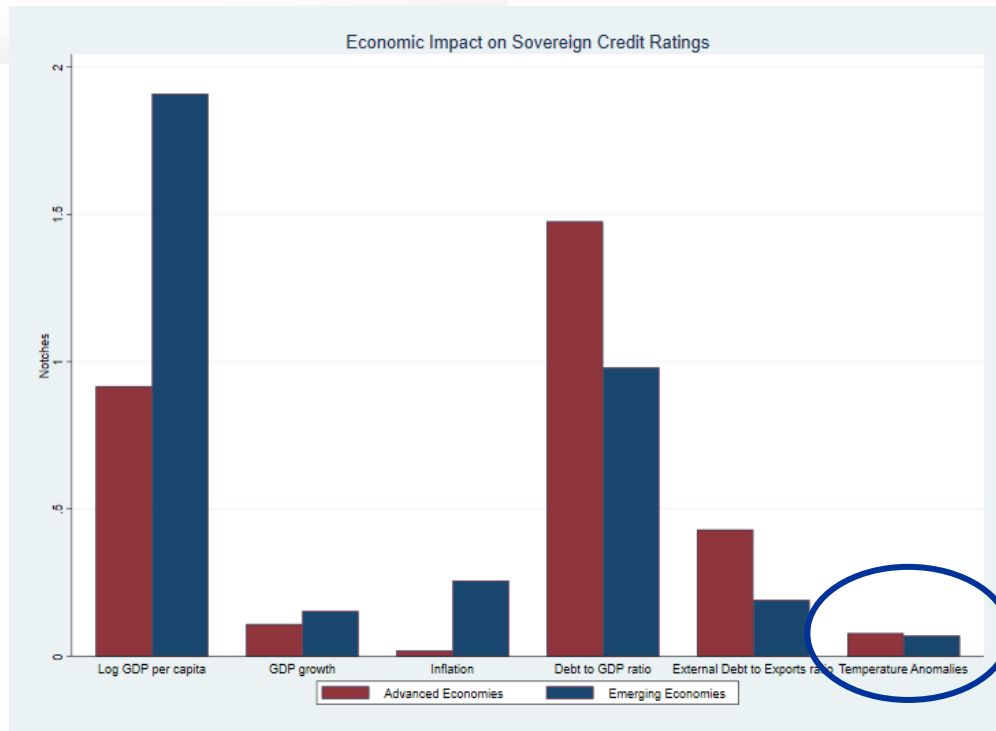
Table 3

Panel regressions for 124 countries from 1999 to 2021. Cantor & Packer (1996) augmented with transition risk variables.

	Rating				
	(7)	(8)	(9)	(10)	(11)
Emission Intensity t-1	-0.744 (0.544)				
Primary Energy Consumption to GDP ratio t-1		0.0198 (0.238)			
CO2 ReductionTarget			0.334 (0.587)		
Emission Intensity Growth t-1				0.000836 (0.00343)	
Primary Energy Consumption to GDP ratio Growth t-1					0.000300 (0.00399)
Observations	2,013	1,969	2,013	2,013	1,969
R-squared	0.956	0.957	0.956	0.956	0.957
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Robust standard errors in parentheses					
*** p<0.01, ** p<0.05, * p<0.1					

Coefficients of the estimation are not significant for a variety of measures of transition risk

Economic Impact of Macroeconomic vs Climate Factors



Absolute value of the effect of one (1% Winsorized) standard deviation shock of macroeconomic and climatic variables on sovereign credit ratings for advanced (red) and emerging (blue) economies.

A natural experiment around the Paris agreement

Is there evidence that credit ratings agencies reviewed their frameworks following the Paris agreement?

- Difference-in-difference approach
- Paris agreement in 2015 as an exogenous event that might have shifted credit ratings agencies' assessments of sovereign ratings
- The exposure scores from Ferrazzi et al. (2021), from the EIB, are used to identify treatment and control groups
 - Scores for **Physical Risk exposure** consider Acute Risk, Chronic Risk and Adaptation Capacity
 - Scores for **Transition Risk exposure** consider Fossil Fuel Rents, GHG emissions, Energy Consumption, Renewables Production, Climate ambition

General Model

$$\begin{aligned} Rating_{i,t} = & \alpha + \beta ClimateVariable_{i,t-k} + \gamma PostPA + \delta Treatment_i + \omega Treatment_i * PostPA + \\ & \nu Treatment_i * ClimateVariable_{i,t-k} + \eta PostPA * ClimateVariable_{i,t-k} + \\ & \lambda Treatment_i * PostPA * ClimateVariable_{i,t-k} + \nu X_{i,t-1} + \phi_i + \theta_i \end{aligned}$$

Where:

- X_{it-1} includes the control variables specified by (Cantor & Packer, 1996)
- $ClimateVariable$ is a variable related to physical or transition risk taken with lag 0 or 1 depending on their characteristics
- $Treatment$ is a dummy variable identifying countries exposed to physical and transition risk
- ϕ_i and θ_i are country and year fixed effects

Partial evidence that credit ratings agencies attribute lower ratings to the countries that are more exposed to physical risk relative to the control group after the Paris agreement

Table 4

Difference in Difference for temperature anomalies, number of natural disasters per squared kilometer and readiness. Partial evidence that physical risk is integrated in sovereign credit risk assessment models.

	Rating		
	(12)	(13)	(14)
Exposed to Physical Risk x Post Paris Agreement	-0.202 (0.600)	-0.635*** (0.247)	0.180 (1.069)
Temperature Anomalies t-1 x Exposed to PR x Post PA	-0.364 (0.399)		
Number of Natural Disasters per Sq. Km t-1 x Exposed to PR x Post PA		-212.5 (433.9)	
Readiness x Exposed to PR x Post PA			-1.336 (2.174)
Observations	2,000	2,013	1,888
R-squared	0.957	0.957	0.961
Country FE	YES	YES	YES
Year FE	YES	YES	YES
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Little evidence that credit ratings agencies have started to treat transition risk differently in their rating assessment after the Paris agreement

Table 5


Difference in Difference for Emission intensity, Primary energy consumption to GDP ratio (levels and percentage growth) and CO2 reduction under target achievement scenario. No evidence that transition risk is integrated in sovereign credit risk assessment models.

	Rating				
	(15)	(16)	(17)	(18)	(19)
Exposed to Transition Risk x Post Paris Agreement	0.0445 (0.408)	0.291 (0.585)	-0.149 (0.238)	-0.0942 (0.229)	-0.191 (0.243)
Emission Intensity t-1 x Exposed to TR x Post PA	-2.459 (1.930)				
Primary Energy Consumption to GDP ratio t-1 x Exposed to TR x Post PA		-0.726 (0.523)			
Emission Intensity Growth t-1 x Exposed to TR x Post PA			-0.0234* (0.0125)		
Primary Energy Consumption to GDP ratio Growth t-1 x Exposed to TR x Post PA				-0.00548 (0.0164)	
CO2 Reduction Target x Exposed to TR					1.203 (1.023)
Observations	2,013	1,969	2,013	1,969	2,013
R-squared	0.957	0.957	0.956	0.957	0.956
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1					

Climate risk and fiscal capacity

The impact of climate risk should be more substantial for countries with high levels of sovereign debt because they have more limited fiscal space to absorb future shocks

- **High Debt:** identify high indebted countries using the value of the sovereign debt before the Paris agreement
- **Evidence:**
 - Highly indebted countries have lower ratings after the Paris Agreement
 - Countries that are exposed to physical and transition risks have lower ratings after the Paris agreement

Post PA x High Debt	
Full Sample	 -0.659*** (0.216)
Physical Risk Exposed	-0.669** (0.302)
Transition Risk Exposed	-0.815** (0.357)
Physical Risk Not Exposed	-0.406 (0.283)
Transition Risk Not Exposed	-0.604** (0.275)

Climate risk and reliance on fossil fuel revenues

The impact of climate risk should be more substantial for countries that rely on fossil fuel revenues

- **Fossil Fuel exports and Fossil Fuel Rents** (top 20 and overall value)
- **Evidence:**
 - Countries that are exposed to physical and transition risks and are also relying on fossil fuel revenues have lower ratings after the Paris agreement

Table 7

Results for difference-in-difference specification for physical (first column) and transition (second column) risk exposure, augmented with information of fossil fuel reliance. Coefficients for triple interactions among exposure dummies, post PA dummy and indicators of fossil fuel reliance. In order, fossil fuel reliance is measured each year as: top 20 fossil fuels exporter, share of fossil fuels export in a given year, top 20 in terms of fossil fuels rents including and excluding gas, fossil fuels rents including and excluding gas as a % of GDP.

	Physical Risk	Transition Risk
Exposed x Post PA x Top 20 FF exporter	-1.946***	-1.225*
Exposed x PostPA x FF exports (% of total Export)	-0.0265**	-0.0120
Exposed x PostPA x Top 20 FF renter (Oil, Coal, Gas)	-1.903***	-1.689***
Exposed x PostPA x Top 20 FF renter (Oil, Coal)	-1.383	-1.924***
Exposed x PostPA x Top 20 FF rents (% of GDP, Oil, Coal, Gas)	-0.158*	-0.0954**
Exposed x PostPA x Top 20 FF rents (% of GDP, Oil, Coal)	-0.157*	-0.0962**

Climate risk and commodity export revenues

Impact of climate risk may be different for countries with revenues from the exports of commodities that are linked to the green transition

- **Commodity exporters:** focus on the top 7 transition-critical materials identified by Miller et al. (2023) and consider the exports of:
Copper, Graphite, Nickel, Manganese, Lithium, Cobalt and Rare Earths
- **Evidence:** critical materials exporters receive higher ratings after the Paris Agreement
- Countries exposed to physical and transition risk

	Exporter of at least one material x Post PA	Top 50% critical material net exports x Post PA
Full sample	→ 0.573**	→ 0.572**
Physical Risk Exposed	0.288	0.834*
Physical Risk Not Exposed	0.413	0.23
Transition Risk Exposed	0.645*	0.705**
Transition Risk Not Exposed	0.378	0.357

Summary of results and policy implications

- **Physical risk** is reflected in sovereign credit ratings, but we find no evidence that **transition risk** is included in credit ratings at least in a systematic way
- The **natural experiment around the Paris agreement** provides little evidence that countries that are relatively more exposed to physical and transition risk have received lower ratings after 2015
- However, when countries have specific exposures linked to climate risks credit ratings take into account the combination of both risks. This is the case for **high sovereign debt, reliance on fossil fuel revenues and reliance on exports of commodities linked to the green transition**
- Our findings can inform the debate on the **reliance on credit ratings** for
 - financial stability purposes (regulation, evaluation of future losses etc...)
 - monetary policy implementation (collateral framework, greening of public sector bond holdings; see Schnabel, 2023)

Additional Slides

Physical and Transition Risk



Physical Risk: Economic costs of extreme weather events (**acute** physical risks); longer-term gradual shifts of the climate (**chronic** physical risks) and indirect effects of climate change such as loss of ecosystem services



Transition Risk: The risks related to the process of transition towards a low-carbon economy

(BIS, 2021)

Data Sources



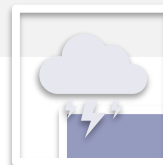
Macroeconomic Data

- WEO, IMF (2021)
- IFS, IMF (2021)
- IDS, World Bank (2021)
- QEDS, World Bank (2020)
- BoPS, World Bank, (2020)
- BoC-BoE Sovereign Default Database (2021)



Transition Risk Data

- Our World in Data (2021)
- Climate Change Dashboard, IMF
- NDC Database, IGES
- European Investment Bank*



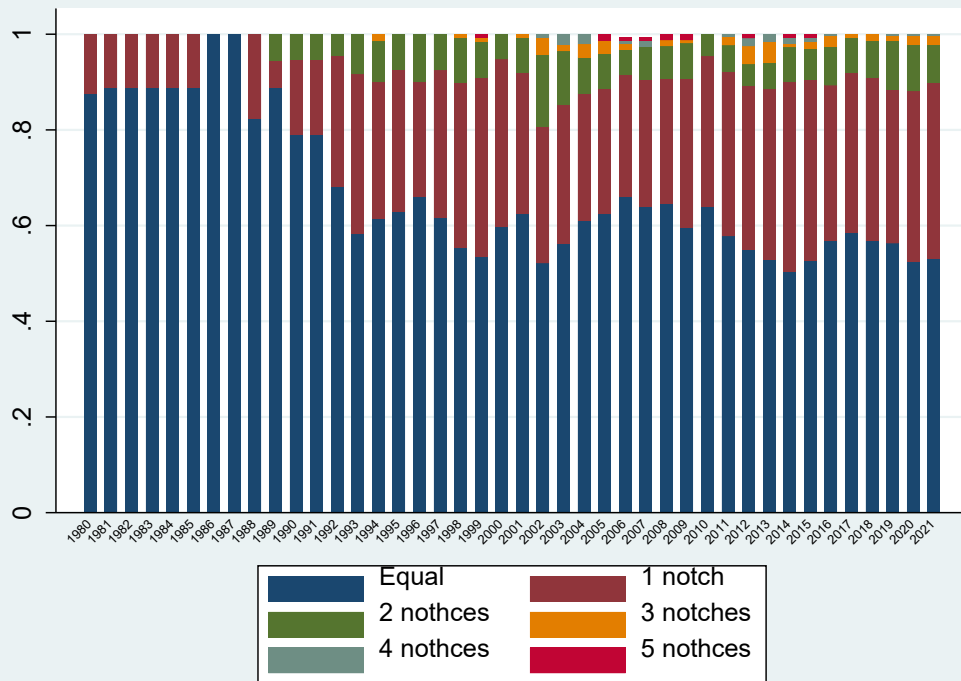
Physical Risk Data

- EM-DAT (2022)
- FAOSTAT (2021)
- ND-GAIN
- European Investment Bank*

*The authors thank the European Investment Bank for sharing their confidential scores on physical and transition risk exposure.

Ratings Data

- **Credit Rating Agencies:** S&P, Moody's, Fitch and DBRS
- **Average across CRAs**
- **Conversion Scale:** from 1 to 21 in ascending order
- **Data Source:** CSDB (ECB) and Bloomberg



Diff-in-diff: Robustness

Results are robust to different specifications

- **Break Year:** we run our model using a different break year for the Paris Agreement (2016)
- **Treatment and Control:** we identify the treatment groups as the countries in the top 25% in terms of exposure to physical and transition risk
- **Shorter Time Window:** we estimate the models on data from 2005 to 2021

References

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- Ferrazzi, M., F. Kalantzis, S. Zwart, 2021, “Assessing climate change risks at the country level: The EIB scoring model,” EIB Working Papers, No. 2021/03, ISBN 978-92-861-5034-0, European Investment Bank (EIB), Luxembourg, <https://doi.org/10.2867/854649>
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- Zenios, S. A., 2022, “The risks from climate change to sovereign debt,” *Climatic Change*, 172(3-4), 30.24