

Cambridge Judge Business School

Rising temperatures, melting ratings

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Have we just realised that this is an important problem for the economy?

- The **climate-economy relationship** has been discussed for many centuries and goes back to at least Ibn Khaldun's 14th Century *Muqaddimah*, in which he attributed **poverty** to the **climate**.
- In fact Montesquieu came to the same conclusion in the *Spirit of Laws* (1750):

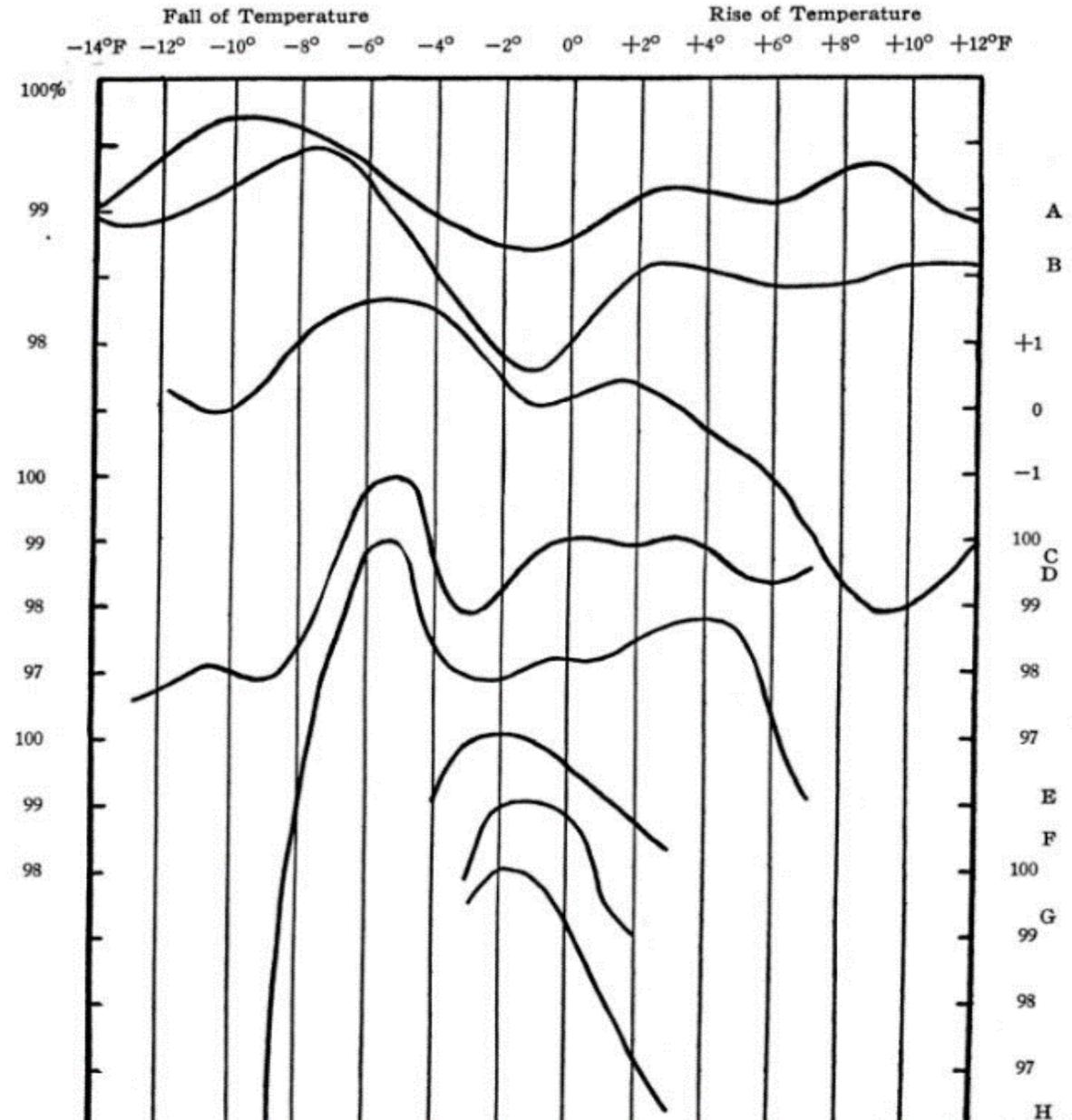


There are countries where the excess of heat enervates the body, and renders men so slothful and dispirited that nothing but the fear of chastisement can oblige them to perform any laborious duty...

- A few centuries later Huntington's (1915) *Civilization and Climate* aims to quantify the effects of climate on economic activity.

Human activity and changes of mean temperature from day to day

- A. 300 Men in Two Connecticut Factories, 1910-13.
- B. 256 Girls in Two Connecticut Factories, 1911-13.
- C. 460 Students in Mathematics and English at West Point and Annapolis, 1909-1913.
- D. 760 Cigar-makers at Tampa, Fla., in Winter (October-March), 1912 and 1913. Factory A.
- E. 400 Cigar-makers at Tampa in Winter, 1913. Factory B.
- F. 400 Cigar-makers at Tampa in Summer (April-September), 1913. Factory B.
- G. 380 Cigar-makers at Tampa in Summer, 1912. Factory A.
- H. 380 Cigar-makers at Tampa in Summer, 1913. Factory A.



CLIMATE

Warming Will Cost Rich and Poor Countries Alike

Limiting global temperature rise will substantially reduce the economic toll of climate change

By Andrea Thompson on November 1, 2019

The Washington Post

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Climate change will shrink 'virtually all' economies around the globe by 2100, study warns

CLIMATE · Published August 19

By Chris

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Climate Changed

Fighting Climate Change Will Help Economic Growth, Study Finds

By Catherine Bosley

August 19, 2019, 10:13 AM GMT+1



REUTERS

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SECOND

Japan's innovative technology for repurposing used EV batteries



BIG STORY 10 AUGUST 21, 2019 / 12:52 AM / 4 MONTHS AGO

Climate change will cripple economies regardless of countries' wealth: report

Kate Ryan

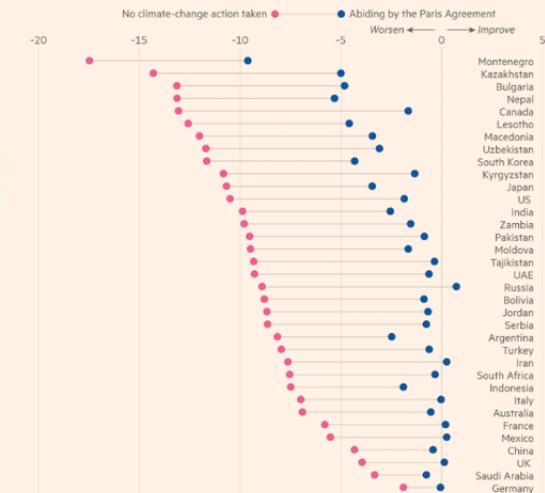
4 MIN READ

NEW YORK (Thomson Reuters Foundation) - Climate change will damage the economies of countries whether they are rich or poor, hot or cold by the year 2100, economists said in a new report, dispelling the notion that impoverished, warm countries will suffer the most on a warming planet.

Chart of the week

Impact of ignoring climate change

% change in GDP per capita by 2100



Source: Cambridge-Inet Institute © FT

Capital Weather Gang

Climate change could cost the U.S. up to 10.5 percent of its GDP by 2100, study finds

Extreme weather events will be a major source of future losses.



NEW YORK POST



LIVING

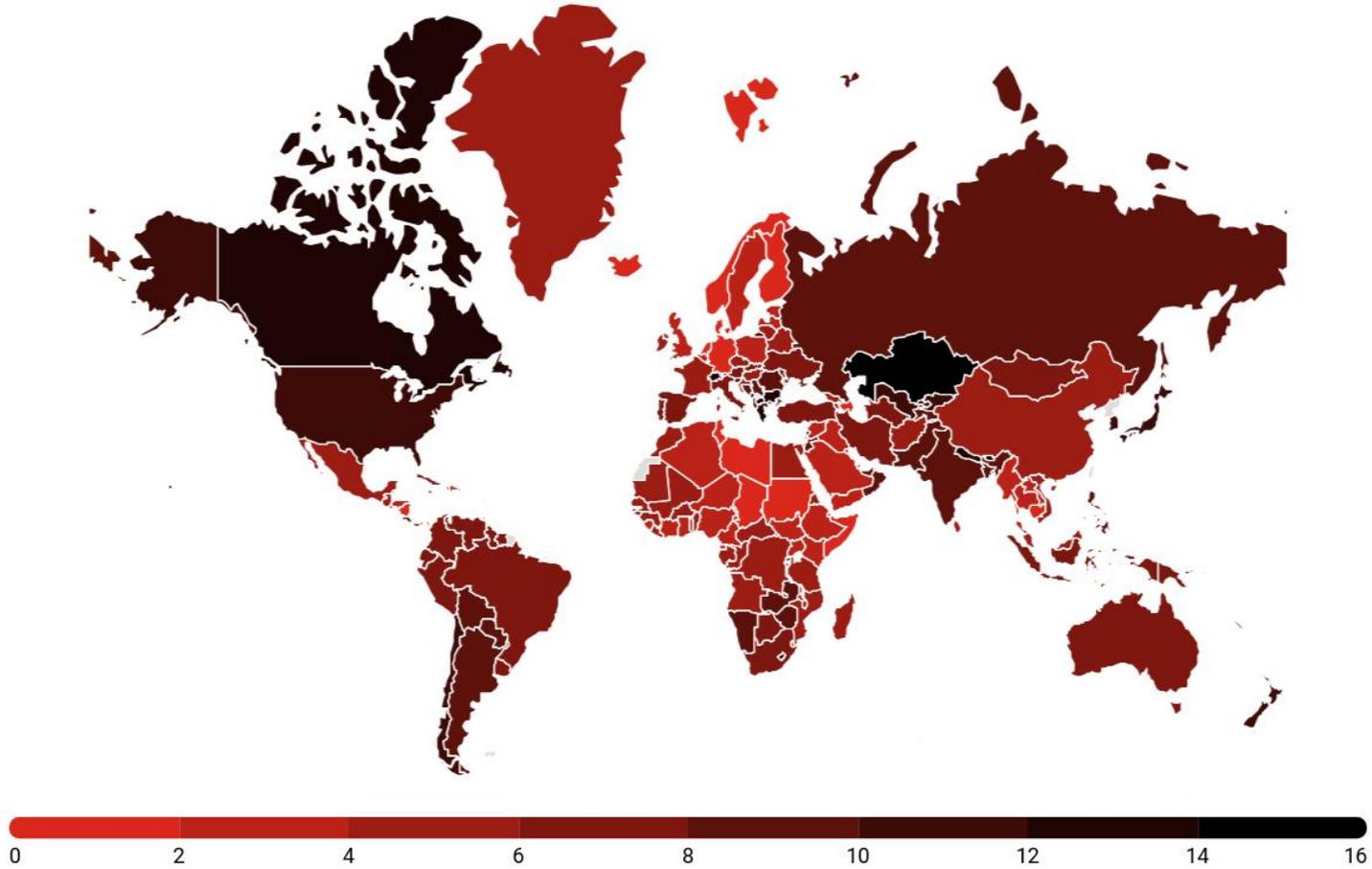
Climate change could cost the US 10.5% of its GDP by 2100, study warns

By Chris Ciacca, Fox News

August 20, 2019 | 11:01am | Updated



Percent Loss in GDP per capita by 2100 in the Absence of Climate Change Policies (RCP 8.5 Scenario)



Kahn, M.E., Mohaddes, K., Ng, R.N., Pesaran, M.H., Raissi, M., Yang, J.C., 2021. [Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis](#). *Energy Economics*

Making risk metrics useful

back

- Investigate the effect of environment on sovereign ratings over the past 20 years.
- CRA methodologies do not include environment as a ratings factor.
- But maybe environment has crept in as an “implicit factor” by influencing other credit-relevant variables.
- Caveat: future environmental change may differ from past trends, making any results difficult to interpret.

forward

- Extending the ratings methodology from a leading CRA to explicitly incorporate nature and climate-related risks under a range of future scenarios.
- This approach offers a ‘forward-look’, and is capable of providing insights into the future creditworthiness of nations.
- This approach will provide the foundations for an enhanced sovereign credit risk methodology.

Can we bridge this gap?

Climate
Science

Sovereign Credit Ratings

Train a ratings
model on
historical data

Adjust data for
environmental
change

Feed adjusted
data to the
trained model

Environmentally
Adjusted Credit
Ratings

Use a machine learning technique referred to as **random forest classification**.

1. Process macroeconomic & credit ratings data using a random forest model.
2. Adjust the input data for env change (climate or biodiversity).
3. Run the model on new data to predict ratings.

Overarching principle



Natural science

Remain as close as possible to natural science!



Economic principles

Use best available climate economics.



Real life ratings

Remain as close as possible to S&P's actual credit rating methodology.

Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness

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Abstract

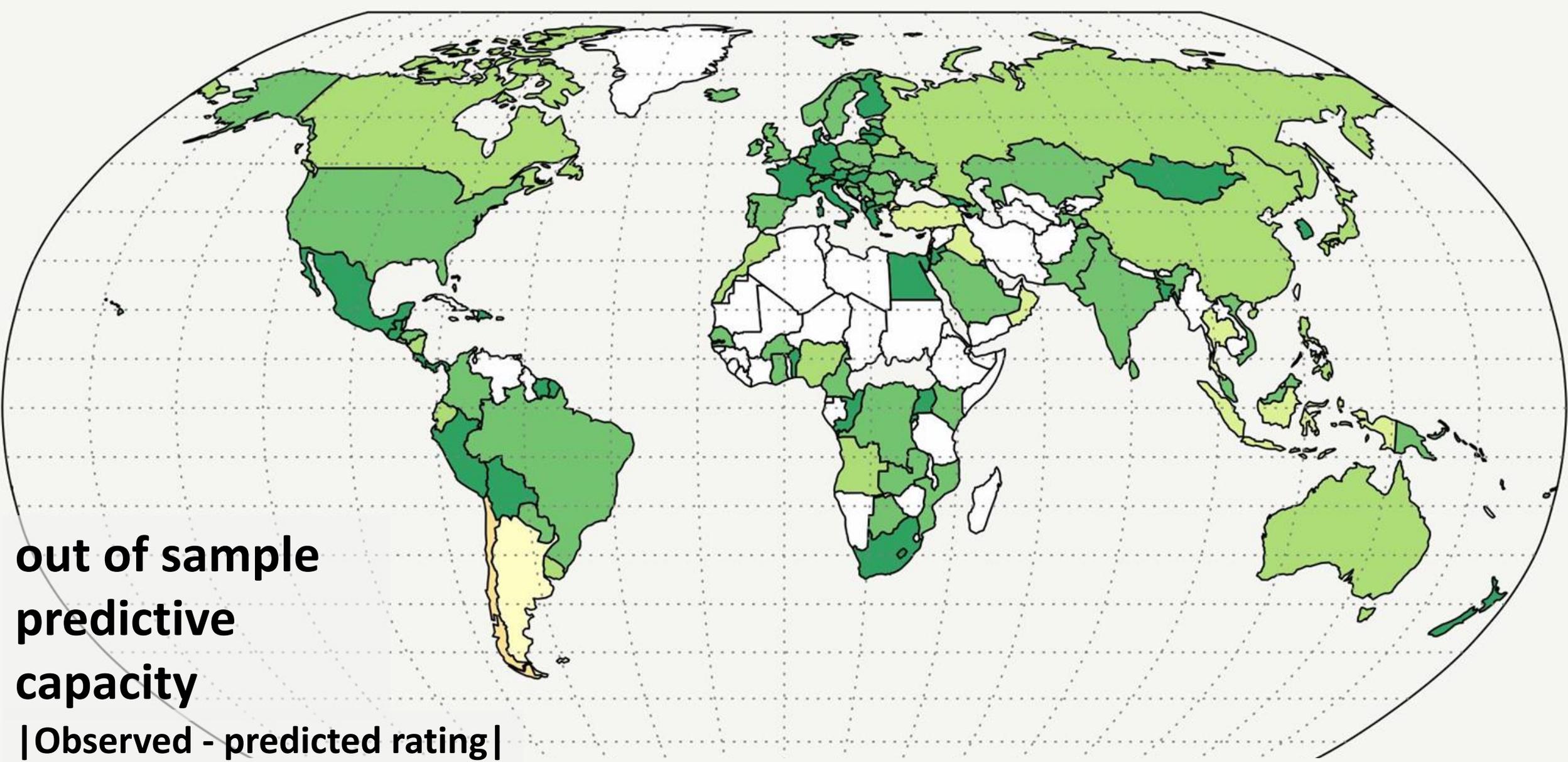
Enthusiasm for 'greening the financial system' is welcome, but a fundamental challenge remains: financial decision makers lack the necessary information. It is not enough to know that climate change is bad. Markets need credible, digestible information on how climate change translates into material risks. To bridge the gap between climate science and real-world financial indicators, we simulate the effect of climate change on sovereign credit ratings for 108 countries, creating the world's first climate-adjusted

What's in the model?

- GDP per capita
- GDP growth rate
- Net General Govt Debt/GDP
- Narrow Net External Debt/CARs
- Current Account Balance/GDP
- General Government Balance/GDP

Predict
Sovereign
Ratings

The first **climate smart**
sovereign credit ratings



**out of sample
predictive
capacity**
| Observed - predicted rating |

Model precision



Adjusting for nature loss

Macro indicators

- GDP per capita
- GDP growth rate

- Net General Govt Debt/GDP
- Narrow Net External Debt/CARs
- Current Account Balance/GDP
- General Government Balance/GDP

Environmental Changes

- 2C (Paris)
- 4.5C (doom)

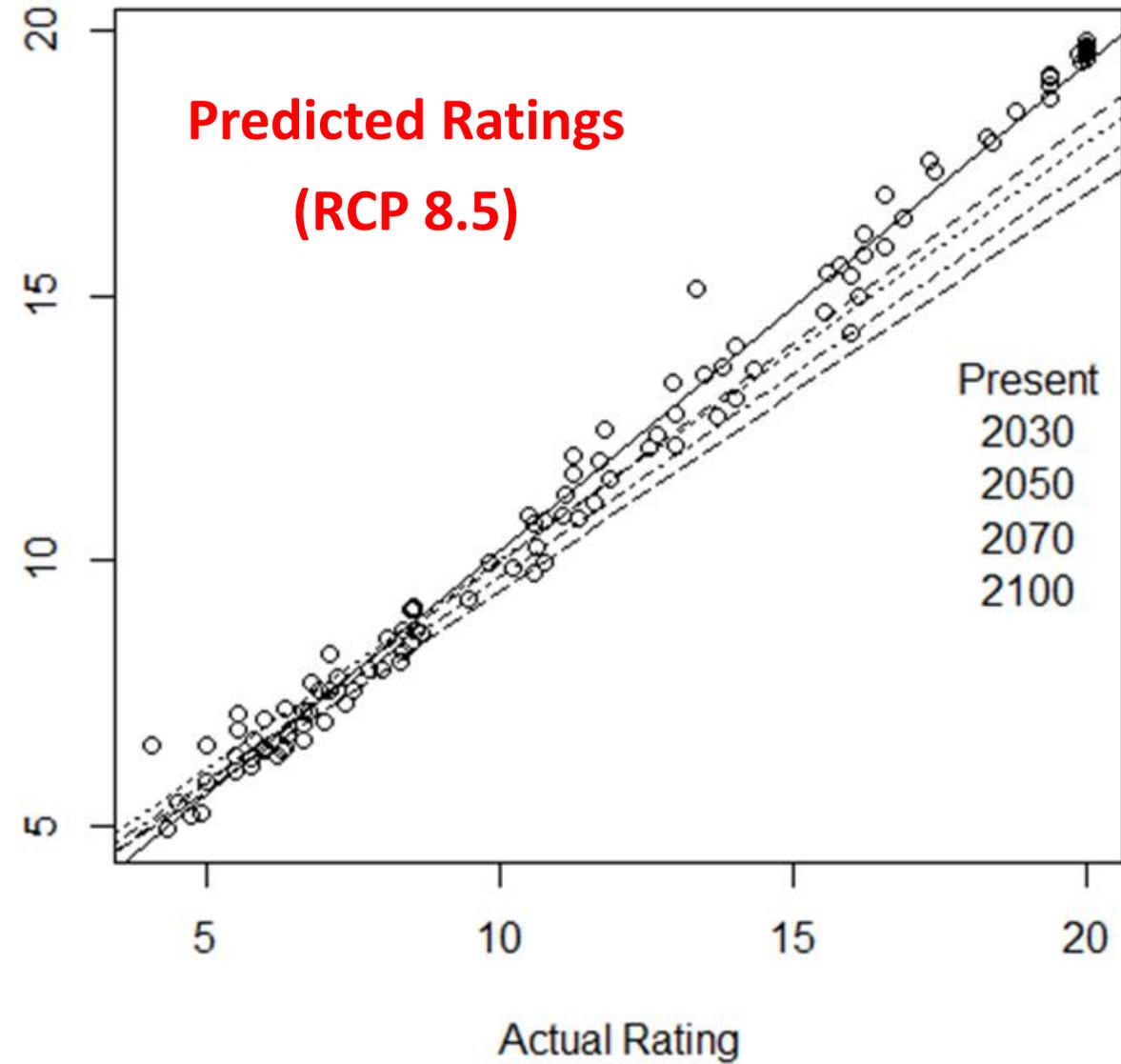
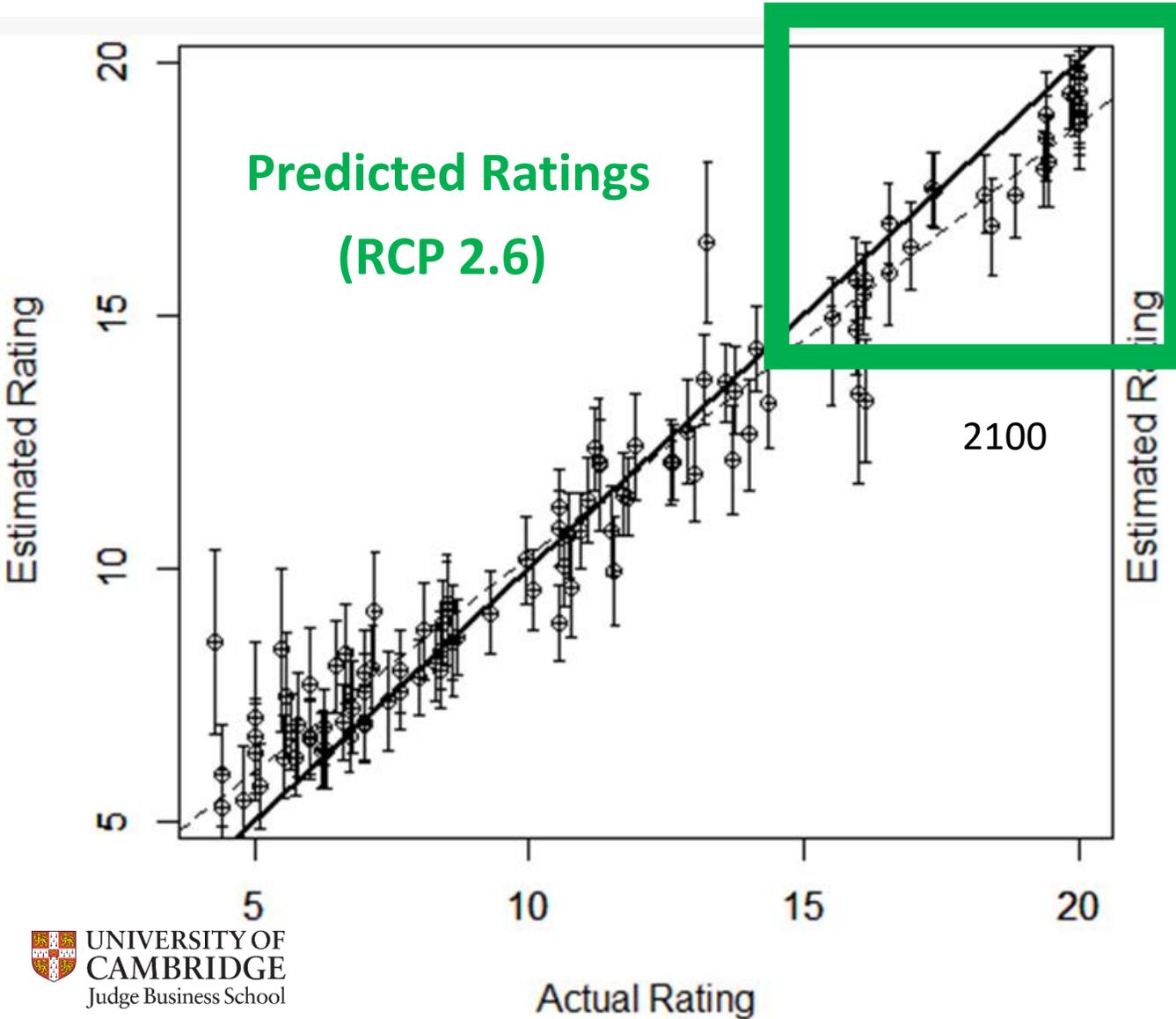
- 2C (Paris) + volatility
- 4.5C (doom) + volatility

- Business as usual
- Partial Nature Collapse (tipping points)

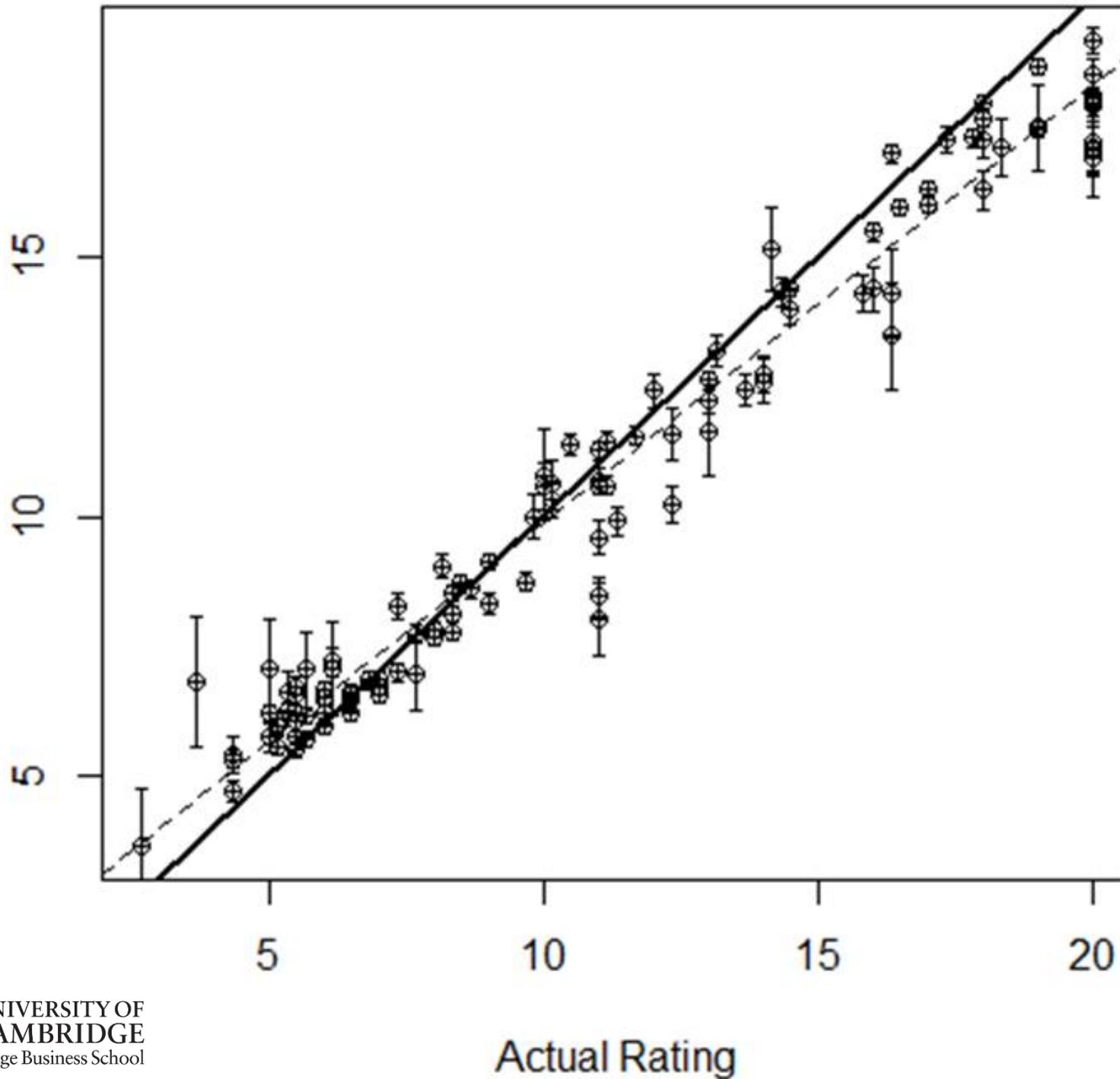
Scientific Evidence

- Ecosystem Models
- Climate Models
- Environmental Economic Models
- Climate (Kahn et al 2021)
- Biodiversity (Johnson et al 2021)
- S&P's own thinking

Predicted ratings: 2°C vs 4.5°C world (2100)

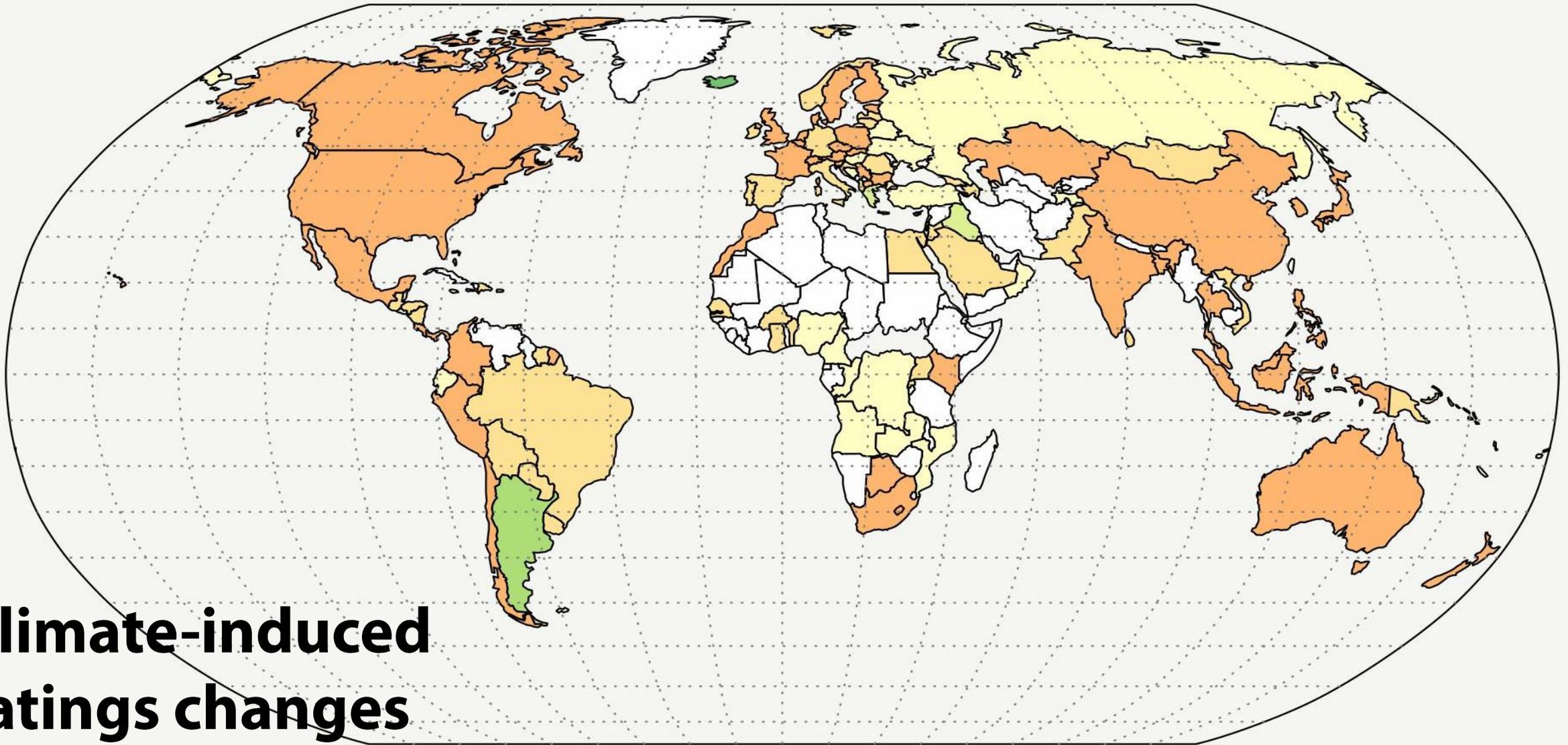


Estimated Rating



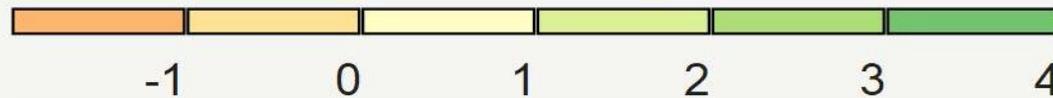
Predicted Ratings in 2030 (RCP 8.5)

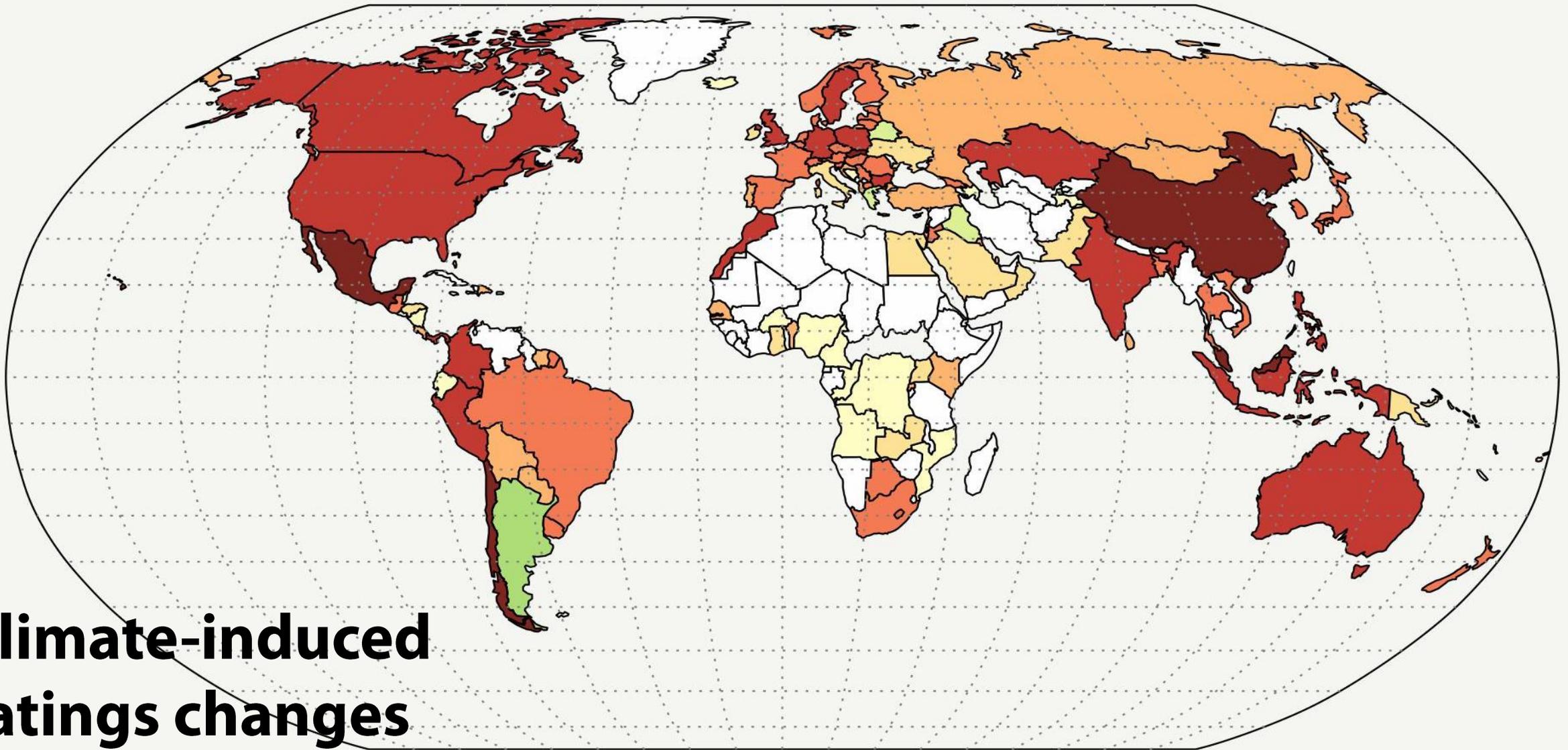
- 63 sovereigns face climate-induced downgrades
- Avg = 1.02 notches



Climate-induced ratings changes RCP 2.6 (2100)

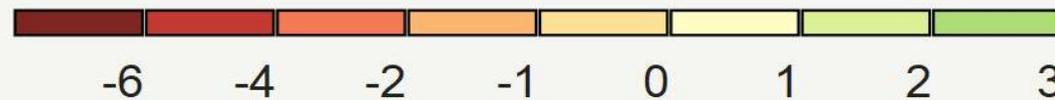
Notch change





Climate-induced ratings changes RCP 8.5 (2100)

Notch change



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[Climate Finance: It'll be cheaper in the long run if poorer countries receive it as a matter of urgency](#), Matthew Agarwala, Matt Burke, Patrycja Klusak, and Kamiar Mohaddes, in *The Conversation*.