

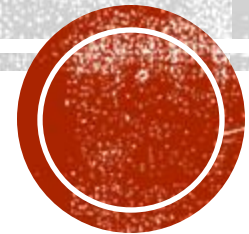
CLIMATE RISKS, POLICY FINANCING, AND DEBT SUSTAINABILITY

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National Academy of Sciences, Letters, and Arts

Bruegel



Environmental Policy Options
Durham, July 2023.

CLIMATE RISKS AND POLICY FINANCING

A decade of not building for the future

Eurozone net public investment, per cent of GDP



Four-quarter moving average

Source: Eurostat

© FT

→ International Energy Agency:

- \$3tn in additional annual clean energy investments globally
- 3% of the world's GDP
- 6:1 crowd-in ratio, government spending increases 0.5% GDP

→ How big is this?

- Doubling of many countries' recent net public investment rates
- US Inflation Reduction 0.15% of GDP

← We have been lagging



21ST CENTURY CHALLENGES TO FISCAL POLICY AND DEBT

More resources go to things that are state responsibilities
(Brad De Long, IMF 2015)

Structural changes in advanced economies

- health because of ageing (and pandemics)
- education because of the knowledge economy
- climate change

- Add defense spending, post-2020
- Economic resilience, at the cost of redundancy or inefficiency

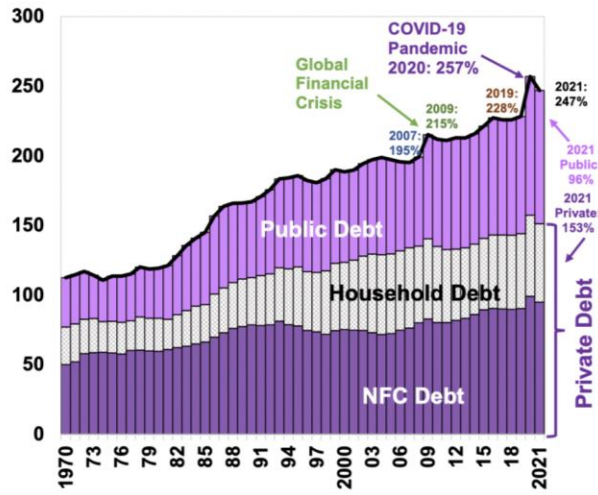
“The thesis that the State footprint in the economy will be permanently greater has held up well.”

- Martin Sandbu, *Financial Times*, June 15



2022 Global Debt Monitor

Figure 1. Global Public and Private Debt, 1970–2021 (Percent of GDP, weighted averages)



Source: IMF Global Debt Database, 2022

JOURNAL ARTICLE

State Contingent Debt as Insurance for Euro Area Sovereigns [Get access >](#)

Maria Demertzis, Stavros A Zenios

Journal of Financial Regulation, Volume 5, Issue 1, March 2019, Pages 64–90,

<https://doi.org/10.1093/jfr/fjz003>

Published: 14 May 2019 [Article history ▾](#)

Climate Capital World Bank [+ Add to myFT](#)

World Bank to 'stretch every dollar' with new lending measures

Initiatives will involve taking more risk in pivot towards climate change and pandemics



Ajay Banga, World Bank president, unveiled a series of new measures to help boost lending to the world's poorest countries © AFP via Getty Images

21ST CENTURY DEBT CHALLENGES





OUTLINE

Climate risk exposure of European sovereigns

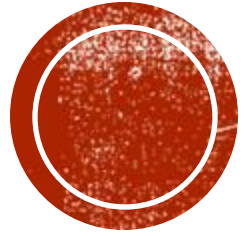
- **Transmission to fiscal risks**

Pricing of climate risk in sovereign debt markets

Climate risks and sovereign debt sustainability

- **Problem of deep uncertainty**
- **DSA with climate risks**

Conclusion



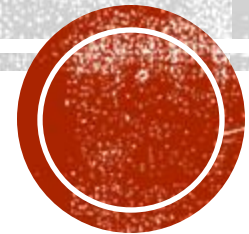
CLIMATE RISK EXPOSURE OF EUROPEAN SOVEREIGNS



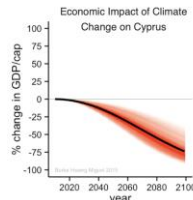
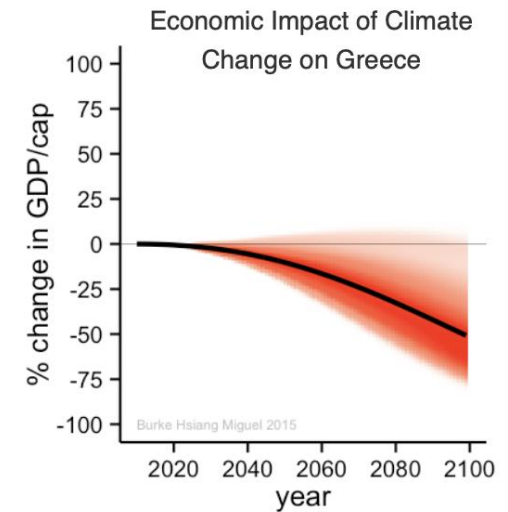
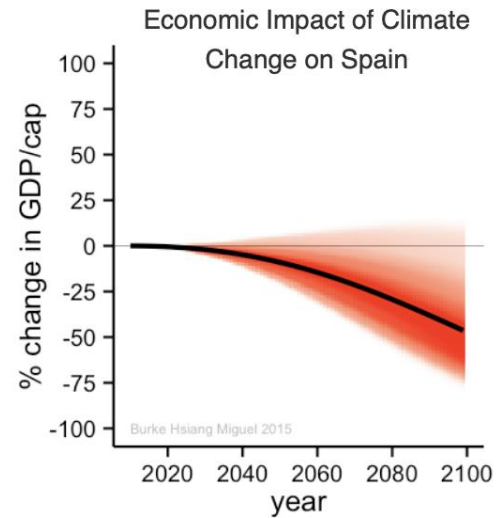
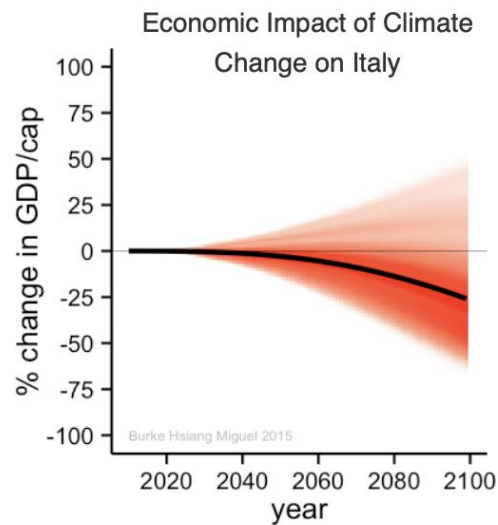
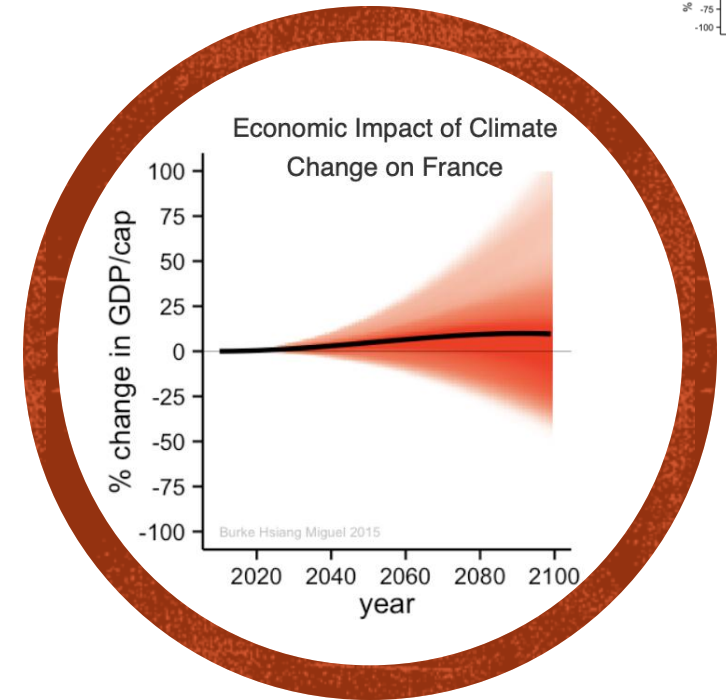
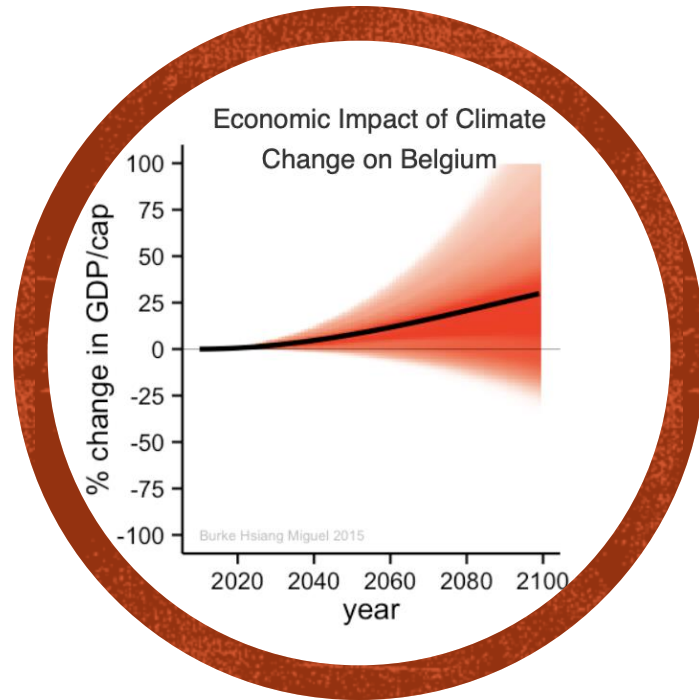
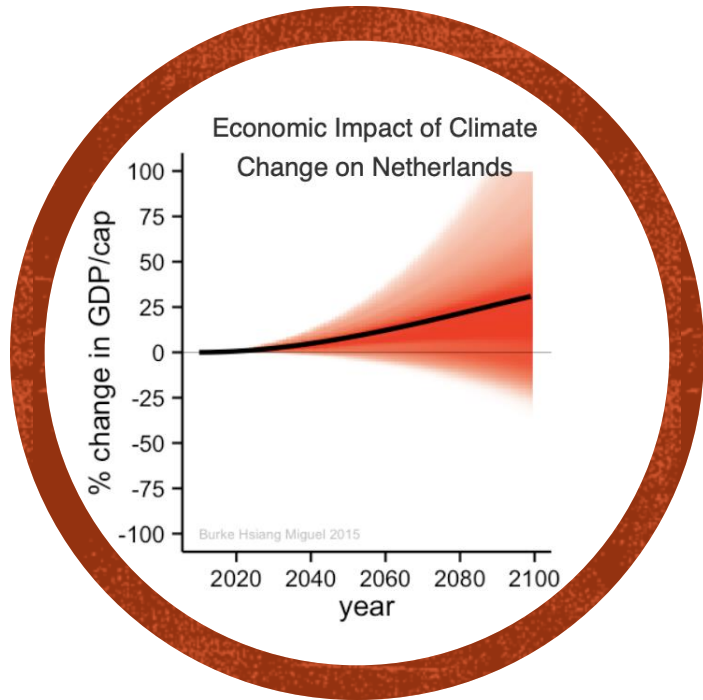
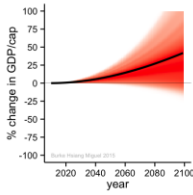
GDP/PER CAPITA UNDER REPRESENTATIVE CONCENTRATION PATHWAY RCP8.6

Burke, Hsiang, and Miguel, *Nature*, 2015.

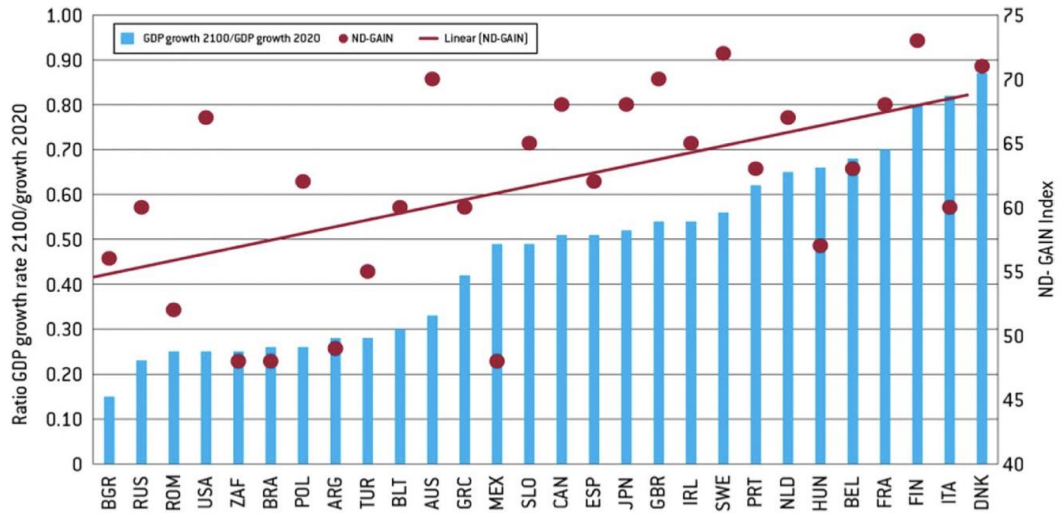
<https://web.stanford.edu/~mburke/climate/map.php>



Divergent climate risks: A new North-South climate divide

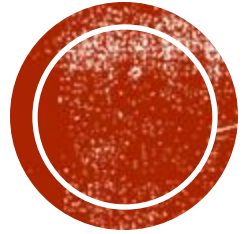


CLIMATE DIVIDE OF EUROPEAN SOVEREIGNS



■ Source: Author based on RICE under SSP2, BAU

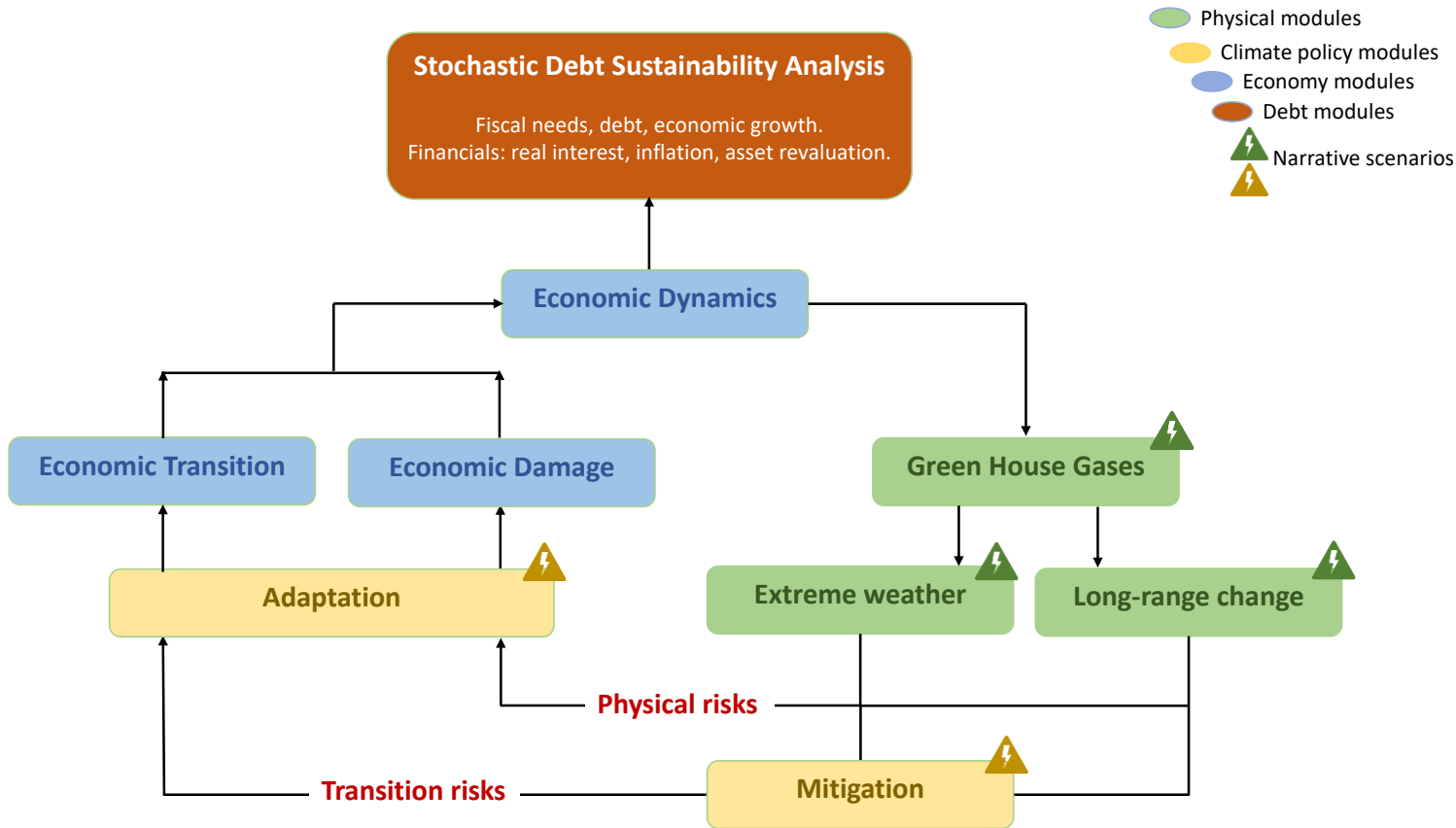




MY GENERAL POINT:

A POTENTIAL CLIMATE-DEBT LOOP

TRANSMISSION TO FISCAL RISKS



- **Deep uncertainty**
 - Risk
 - Ambiguity
 - Misspecification
- **Fat-tails**
- **Acute and chronic effects**
- **The Tragedy of the Horizon**



INTEGRATED ASSESSMENT MODELS FOR DEBT SUSTAINABILITY ANALYSIS

- - Sustainable planet or sustainable debt?
- - Front-load or back-load climate debt?



DICE-2016R2 and RICE-2010



International Institute for
Applied Systems Analysis

IIASA www.iiasa.ac.at

Burke et al., *Nature*, 2015

Hsiang et al., *Science*, 2017

Kahn et al., *IMF Working Paper*, 2019

IAM FOR DSA

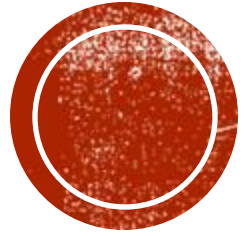
- **Risk: Forward-looking scenarios**

- GDP growth
- Fiscal: mitigation, adaptation
- Financial: r^* , inflation \rightarrow ECB
- Asset revaluation
- Contingent liabilities (bailouts, large-scale damages)

- **Ambiguity: Narrative scenarios**

- **Mis-specification: Ensemble of climate IAM**



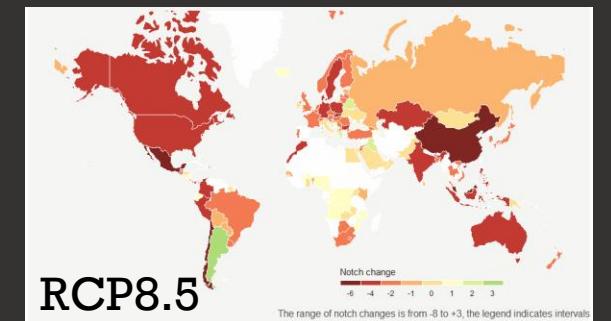
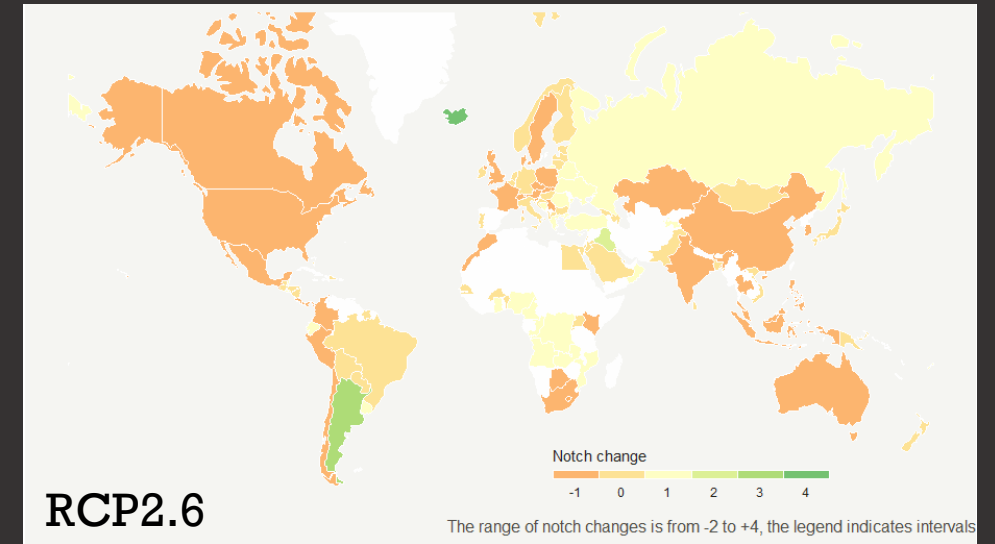


PRICING CLIMATE RISK IN SOVEREIGN DEBT MARKETS



CREDIT RATINGS

- Downgrades are at the top of ratings scale
- RCP2.6 → 55 down ratings by 0.66 notches
- RCP8.5 → 80 down ratings by 2.48 notches
- Temperature increase and variability
- Downgrades start from 2030
- Increase of borrowing costs:
 - France 1,35-2 bn per year
 - Germany 0.23-0.35 bn per year



THE CLIMATE- DEBT LOOP CLIMATE-DEBT VICIOUS LOOP

- **Adverse effects:**
 - GDP growth
 - Damages (chronic and acute)
 - Transition risks
 - Stranded assets
 - Bail-outs
- **Mitigation and adaptation policy costs**
- **Each effect may seem small and inconsequential**
- **Aggregate effects significant**
- **Aggregate effects has adverse effects on ratings**



CAN WE MODEL CLIMATE RISKS TO SOVEREIGN DEBT?

“even if the true scientists should all recognize the limitations of what they can do, so long as the public expects more there will always be some who will pretend, and perhaps honestly believe, that they can do more to meet popular demands than is really in their power.”

-Friedrich von Hayek, Nobel Prize Lecture

“The ability to incorporate [climate] risks into economic evaluations is being undermined by difficulties in bridging the climate science, economics, and modeling cultures.”

- “The missing risks of climate change”, *Nature* (2022)
Rising et al.





**CLIMATE RISK FRAMEWORK
FOR DEBT SUSTAINABILITY**

$$D_t = (1 + i_{t-1})D_{t-1} - B_{t-1} \text{ (stock)}$$

$$F_t = i_{t-1}D_{t-1} + A_t - B_{t-1} \text{ (flow)}$$

Y_t (debt-to-GDP)

$\Rightarrow D_t/Y_t$ and F_t/Y_t

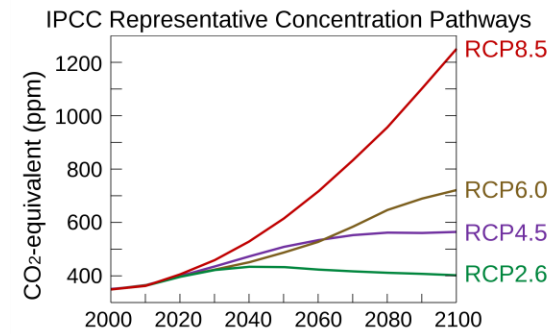
Reds ← Economic scenarios and climate scenarios

A_t, B_t can be contingent liabilities

Narrative scenarios + Calibrated scenario trees



Socio-economic challenges
for mitigation



NARRATIVE SCENARIOS

- SSP- Shared Socio-economic Pathways
- RCP- Representative Concentration Paths

(*Climatic Change*, special issue 2014)



	SSP1	SSP4	SSP2	SSP3	SSP5
RCP8.5					
RCP6.0					
RCP4.5				4	4
RCP2.6	6	6	6		3
RCP1.9	6	3	6		2

SCENARIO MATRIX ARCHITECTURE

CLIMATIC CHANGE, 2014)

- Number of IAM that converge (Rogelj, Emmerling et al., *Nature*, 2018)
- 1.5C, 2C, 2.8C, 3.2, 4.2C



DSA WITH CLIMATE RISK

Climatic Change (2022) 172: 30
<https://doi.org/10.1007/s10584-022-03373-4>

ESSAY



The risks from climate change to sovereign debt

Stavros A. Zenios^{1,2,3}

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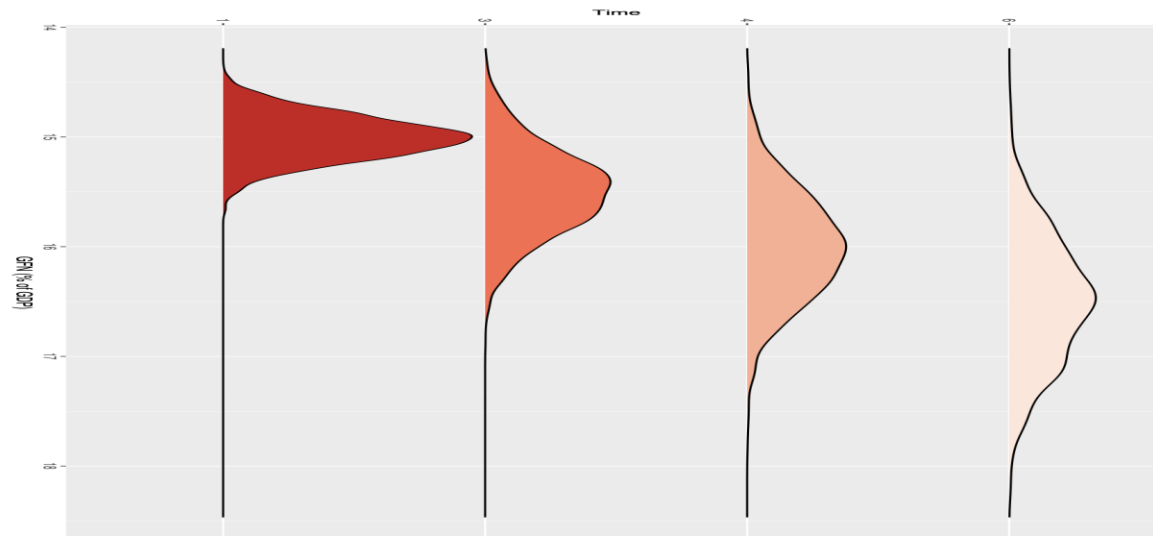
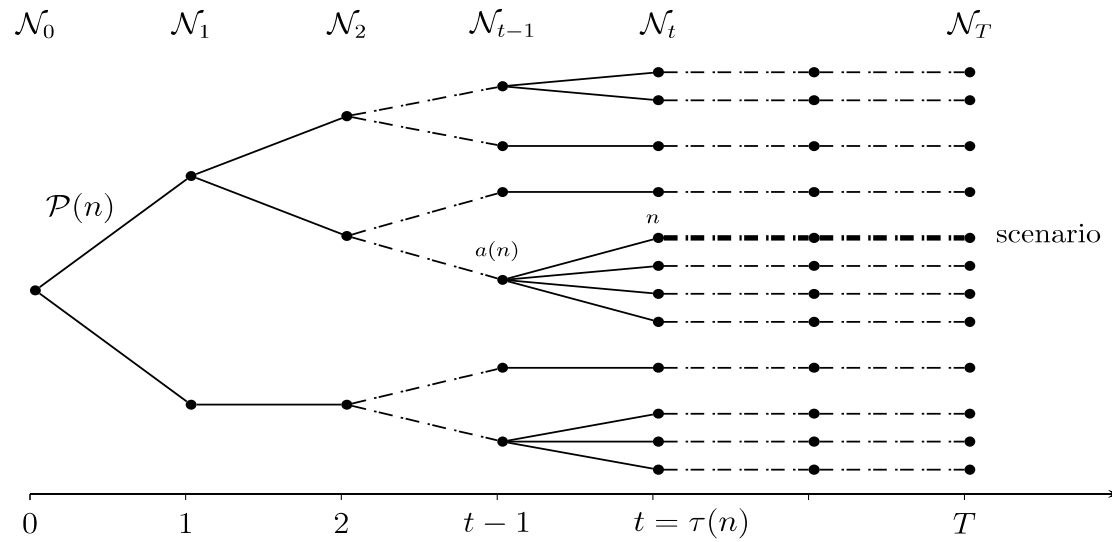
Risk Management for Sustainable Sovereign Debt Financing

Stavros A. Zenios, Andrea Consiglio, Marialena Athanasopoulou, Edmund Moshhammer, Angel Gavilan, Aitor Erce



Q1. Optimize debt financing

● Discrete state-space, discrete time-space scenario tree



/ 41

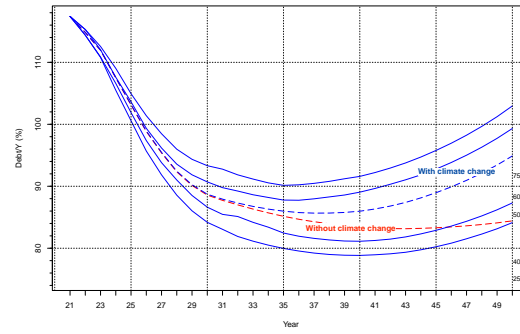


Q1+Q2. Optimize debt financing with sustainability controls

$$\begin{aligned} & \text{Minimize}_x && \sum_{n \in \mathcal{N}} p^n NIP_t^n \\ & \text{s.t.} && \\ & && \Psi(gfn) \leq \omega \\ & && \frac{\partial d^n}{\partial t} \leq \delta \end{aligned}$$

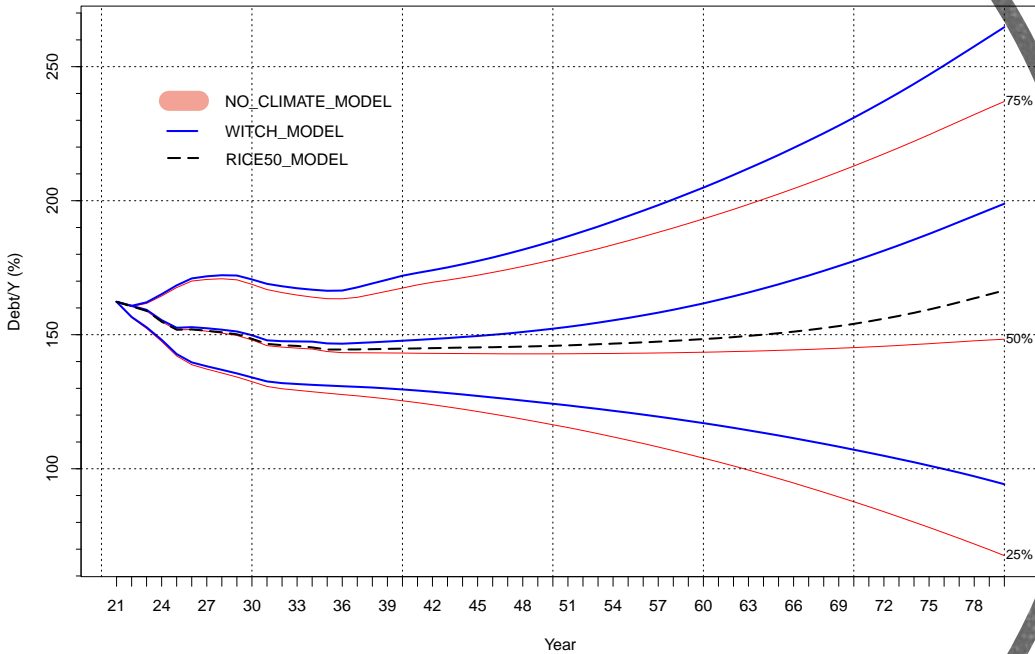
Ψ is a tail risk function



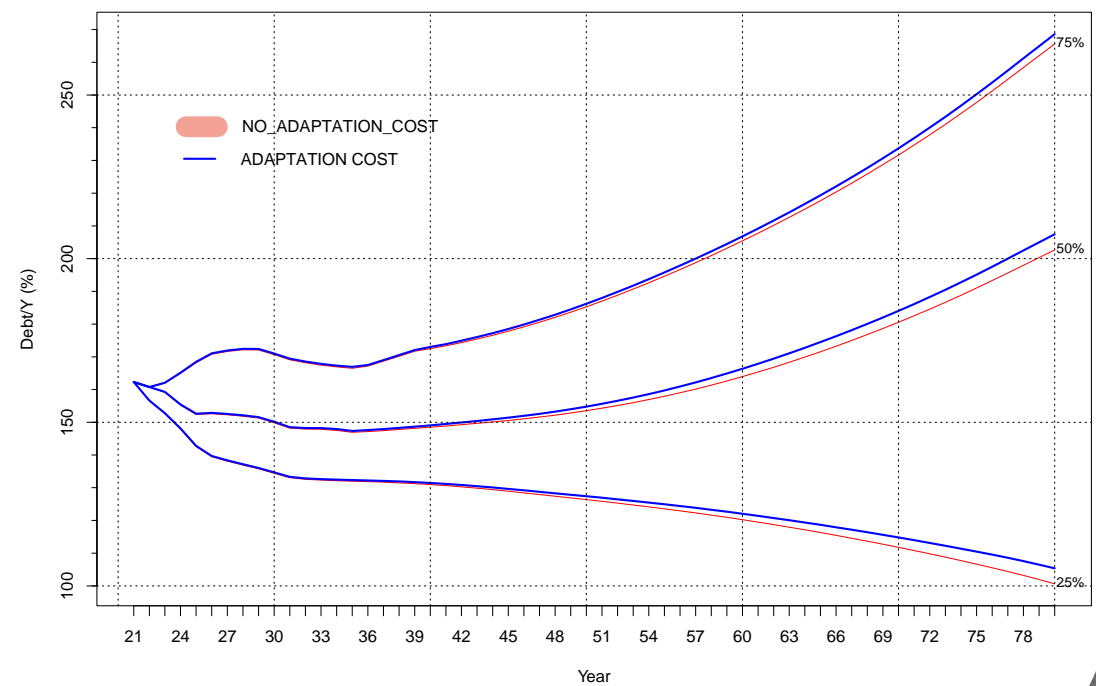


ITALY AND CYPRUS POST COVID-19 WITH CLIMATE RISK: GDP EFFECT

- Pink – risk
- Blue- ambiguity
- Black- misspecification

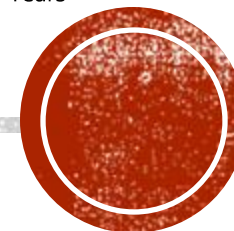
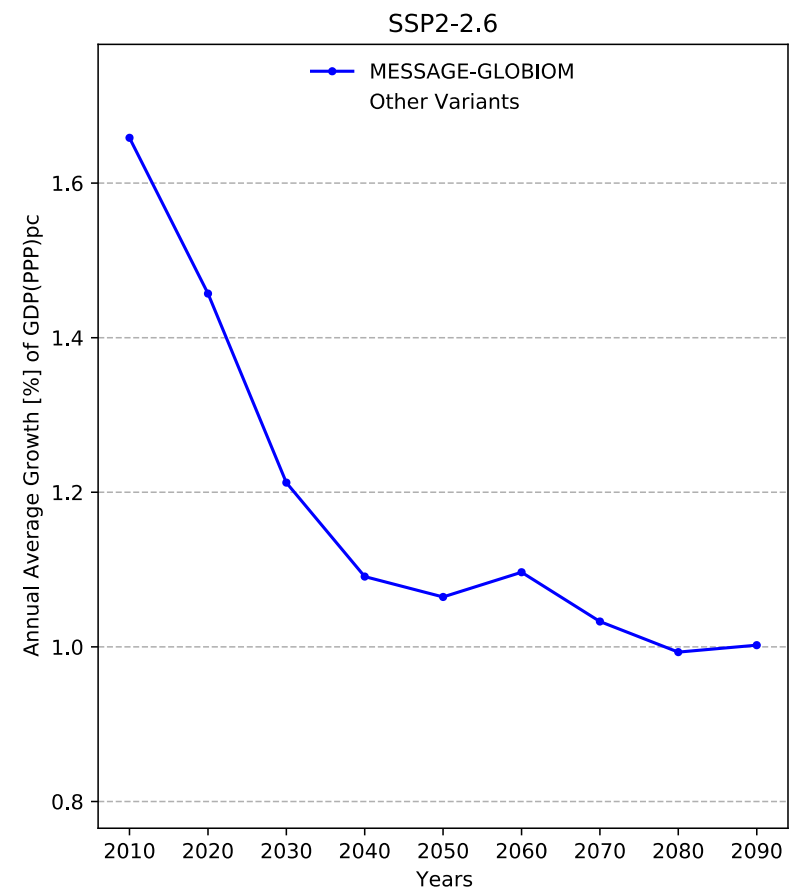


ITALY POST COVID-19 WITH CLIMATE RISK: ADAPTATION EFFECT



MIS-SPECIFICATION

Ensemble of integrated assessment models



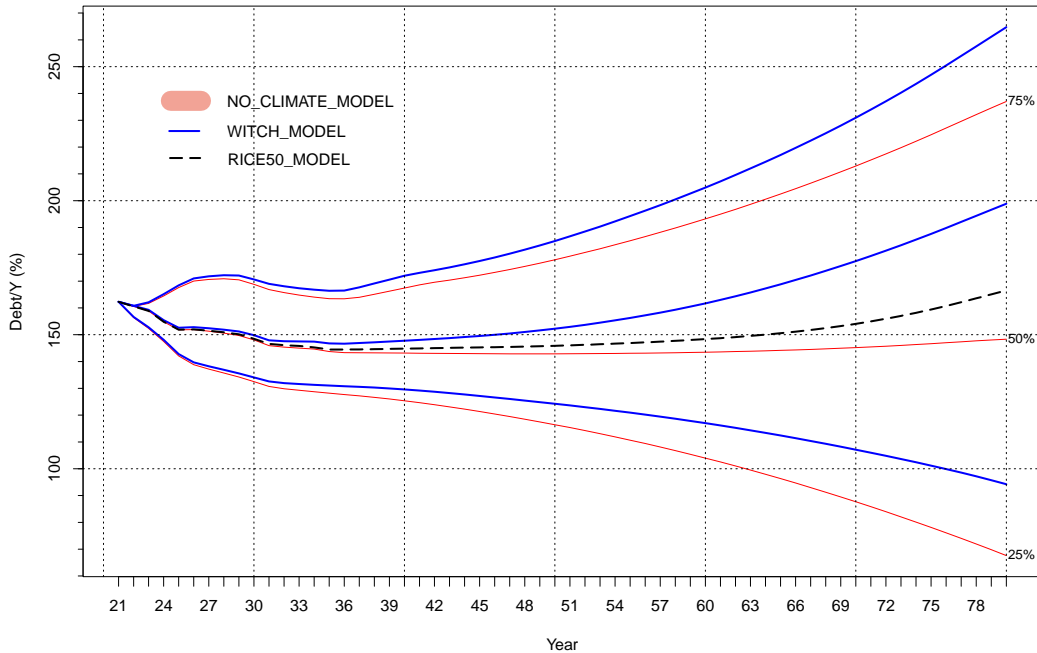
CONCLUSION

- *Climate risks and sovereign debt a first-order problem*

- ***Building blocks to answer two questions***

- Sustainable planet or sustainable debt?

- Front-load or back-load climate debt?



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