Economic assessment of climate-related extreme event risk

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Outline

1. **Introduction to climate-related risks**
2. Computational modeling approaches for simulating direct and indirect economic impacts of climate-related risk
3. Climate extreme risk in fiscal and budgetary planning
The Global Risks Landscape 2019

World Economic Forum (2021)
Climate-related and geophysical disasters 1998-2017

→ Climate-related: 91% of 7,255 recorded events (1998-2017)

CRED & UNISDR (2018)
Economic losses (US$) due to natural disasters 1998-2017

- 46% US$ 1,330 billion
- 23% US$ 661 billion
- 23% US$ 656 billion
- 4% US$ 124 billion
- 2% US$ 68 billion
- 2% US$ 61 billion

77% climate-related

CRED & UNISDR (2018)
Disaster losses per income group, 1998-2017

CRED & UNISDR (2018)

0.5 \%GDP^*

* IMF threshold for a major economic disaster
A changing world – widespread observed changes in extreme weather impacts

“Some of the changes in extreme weather and climate events observed since about 1950 have been linked to human influence” (IPCC, 2013)
Attributing extreme weather to climate change

Source: https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world
A risk perspective on climate change
Outline

1. Introduction to climate-related risks
2. Computational modeling approaches for simulating direct and indirect economic impacts of climate-related risk
3. Climate extreme risk in fiscal and budgetary planning
Direct vs. indirect economic impacts from climate-related risk

- Direct impacts: damage to assets (e.g., property) caused directly by a climate-related disaster (Botzen et al., 2020)
  - losses occurring at the time of the disaster or shortly thereafter
  - Examples: destruction of residences, businesses, productive capital, infrastructure, crops, livestock, and (monetized) physical and mental health impacts

- Indirect macroeconomic impacts (“higher-order effects”): changes in economic activity that follow the disaster and induced by direct impacts (Botzen et al., 2020)
  - Interruptions of economic activities
  - Positive spillover effects due to the substitution of production and the demand for reconstruction
  - Capture short- and long-term economic losses in economic production and consumption and any related economic recovery paths (Kousky, 2014)
Computational models for simulating direct and indirect economic impacts of climate-related risks

• Why computational simulation models?
  • Low probability of disaster occurring in a particular area → few historical observations for estimating future losses
  • Lack of detailed recording of disaster losses

• Catastrophe models estimate potential direct economic impacts from specific disasters by simulating hypothetical physical characteristics of natural hazards, such as flood events, at a particular location based on GISs

• Direct disaster impacts feed into macroeconomic models that simulate indirect economic effects
Macroeconomic Input-Output (I-O) models

- Macroeconomic models are used to estimate indirect effects resulting from climate-related risks

- **Input-Output (I-O) models**
  - Based on matrices that capture the trade flows of the production inputs and outputs of different sectors in an economy (*Social Accounting Matrices*)
  - Examine how natural disasters affect these trade flows up and downstream in the supply chain and the related **short-run** production outputs
  - Findings: although direct economic impacts can be important for certain sectors, the broader macroeconomic system has an inherent flexibility that moderates the aggregate impacts
Short-term direct and indirect economic flood impacts in Germany

Random Forest (machine learning) model: Probabilistic, object-based direct damage estimation, considering uncertainties (hazard, exposure, vulnerability)

Supply side IO model: assessment of indirect economic effects, considering uncertainties. Applied to 19 economic sectors in eight federal states of Germany.
Macroeconomic Computable General Equilibrium (CGE) models

More flexible model framework than I-O models:
- include demand and supply equilibrium in various markets
- nonlinear (e.g., they account for economies of scale and nonlinear impact functions).

Simulate impacts of disasters on economic activity by estimating how disruptions to the supply of goods and services affect GDP
- through relative price and quantity changes and
- considering input and import substitution possibilities for the demand of intermediate and final consumption goods.

Because of this price flexibility CGE models are better able to represent the long-run economic consequences of climate-related disasters than I-O models
→ Lower ratio of indirect/direct impacts than in I-O models
Integrated Assessment Models (IAMs) of climate change

- IAMs estimate the impacts of climate change in GDP terms and the social cost of carbon, and derive economically optimal GHG reduction pathways.
- Based on simplified version of neoclassical economic growth theory (exogenous economic growth).
- Most IAMs focus on aggregate economic impacts of climate change, only some consider disasters.
- IAMs are being criticized for simplified ad-hoc damage functions, which do not capture extreme event risks.
Mainstreaming of Climate Extreme Risk into Fiscal and Budgetary Planning

• Concerns over contingent climate-related public costs have received little attention so far but

• Research shows that future climate-related fiscal liabilities will not be negligible

• Triannual longer term budget forecast for Austria qualitatively highlights importance of climate risk (BMF, 2016)

• Aim

• Design and test a mainstreaming methodology to integrate climate risk into longer-term fiscal planning and governance
Methodology – Mainstreaming framework

Source: Mochizuki et al. (2018)
Results: Stochastic debt trajectories

Flood risk

Stochastic debt trajectories for Austria under SSP2 scenario up to 2030, flood risk only. Showing 5th to 95th percentiles. Source: Mochizuki et al. (2018)
Conclusions

- Ex-post and particularly ex-ante economic assessment of climate-related risk important for risk management practice and budgetary planning
- Substantial progress has been made in recent decades in the development of approaches for assessing climate-related risks ex-ante
  - Catastrophe models
  - Macroeconomic IO and CGE models
- Macroeconomic models often based on simplifying assumptions and average conditions (‘expected losses’)
- Novel methods emerging for probabilistic macroeconomic assessment and risk-based fiscal planning