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Economic assessment of climate-related extreme event risk

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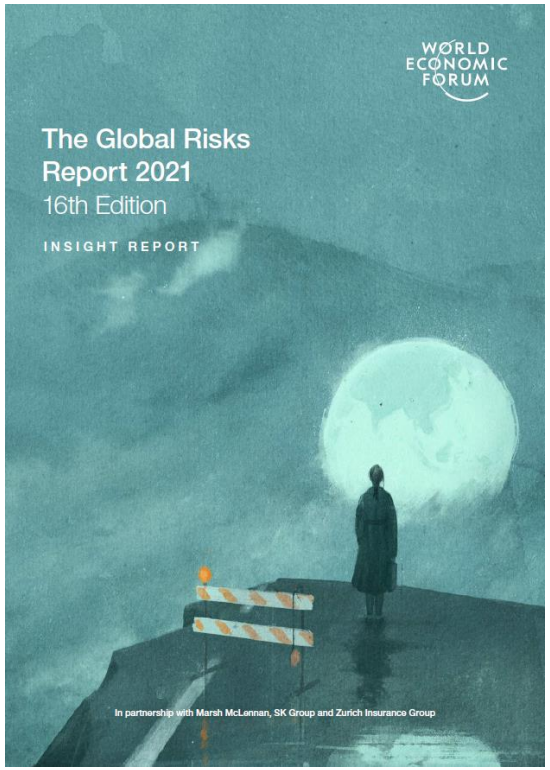
JVI Climate Webinar #5: Modelling Climate Change

06/29/2021, Vienna

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

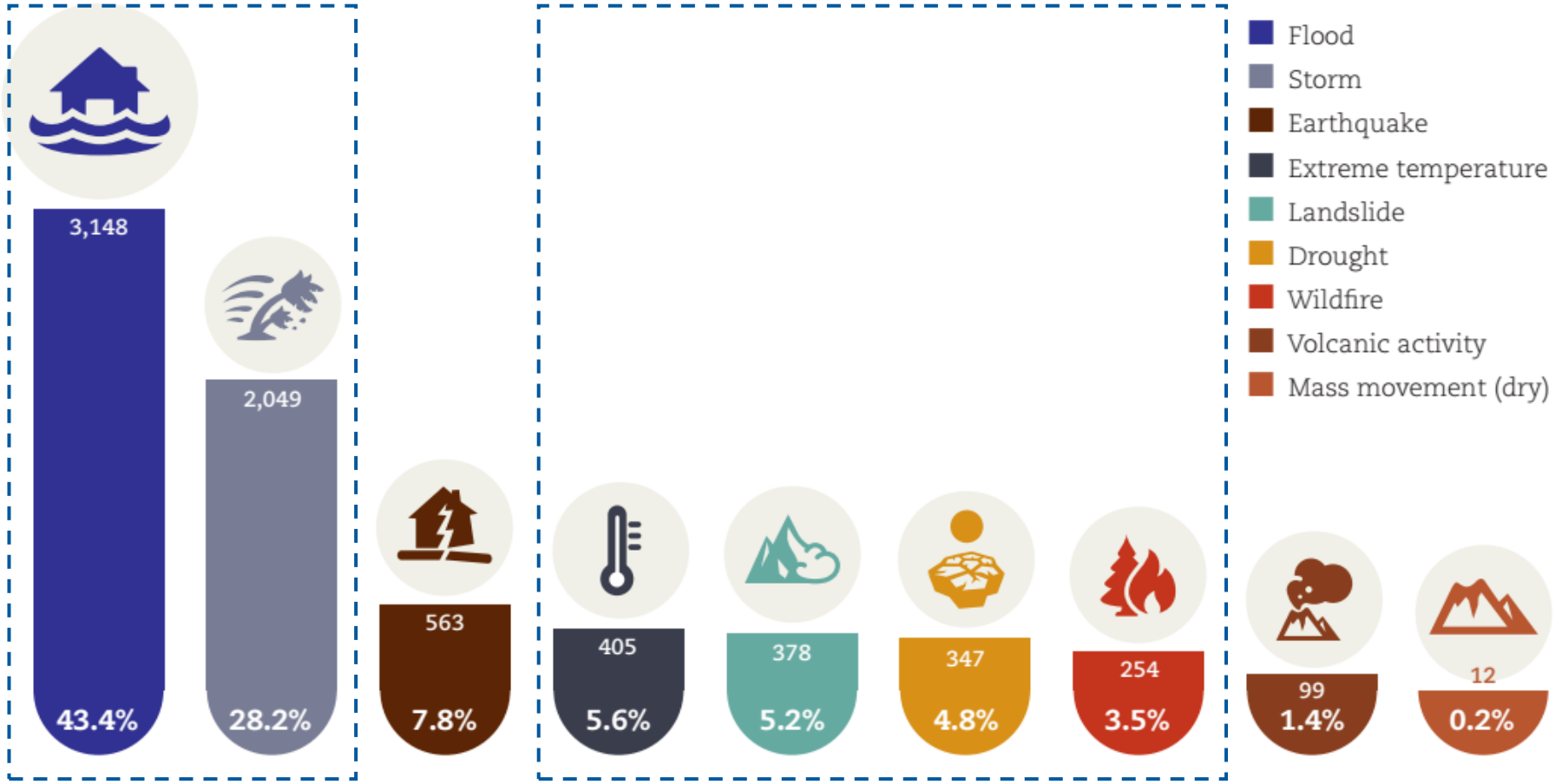
The Global Risks Landscape 2019



World Economic Forum (2021)

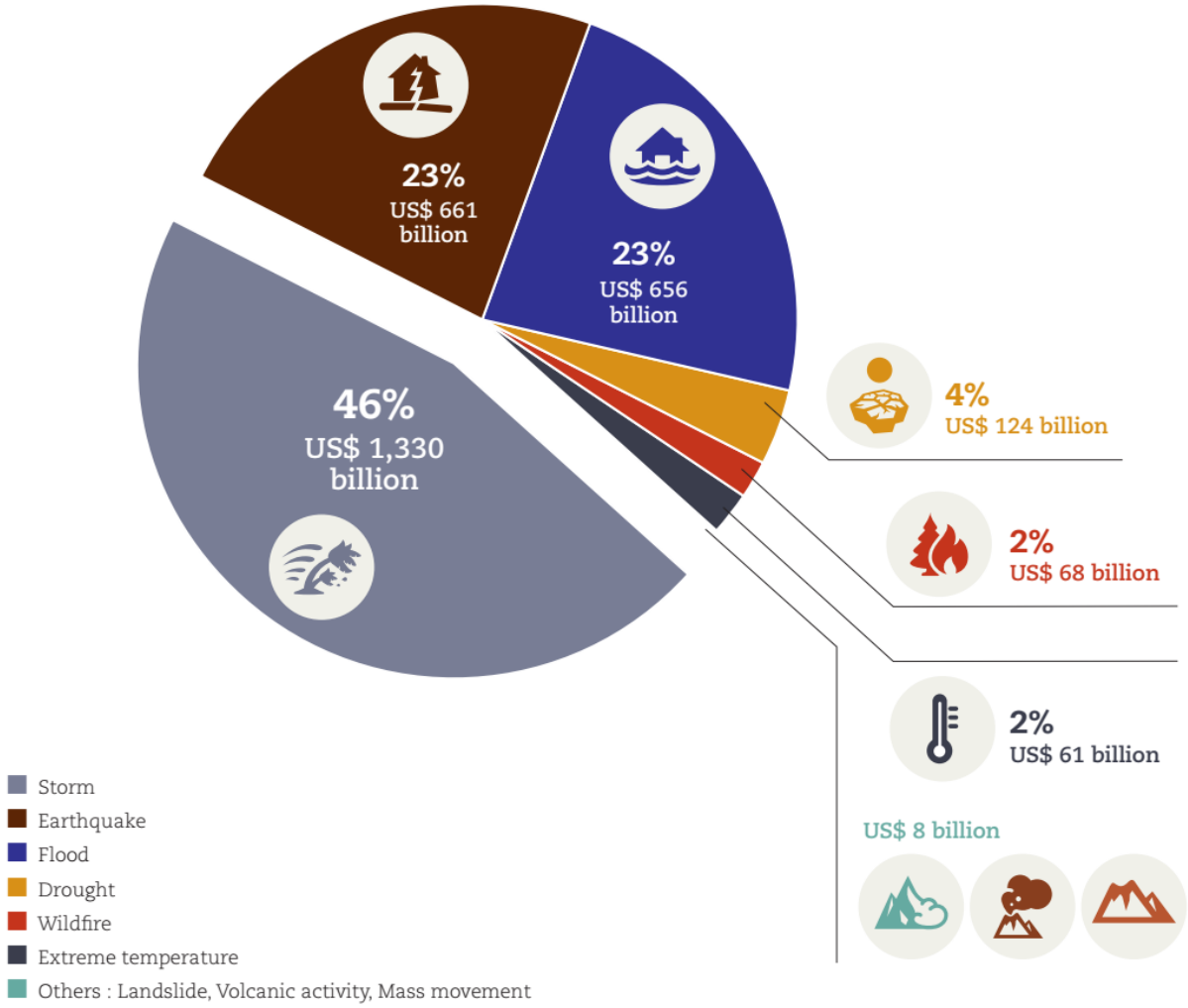
Climate-related and geophysical disasters 1998-2017

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



CRED & UNISDR (2018)

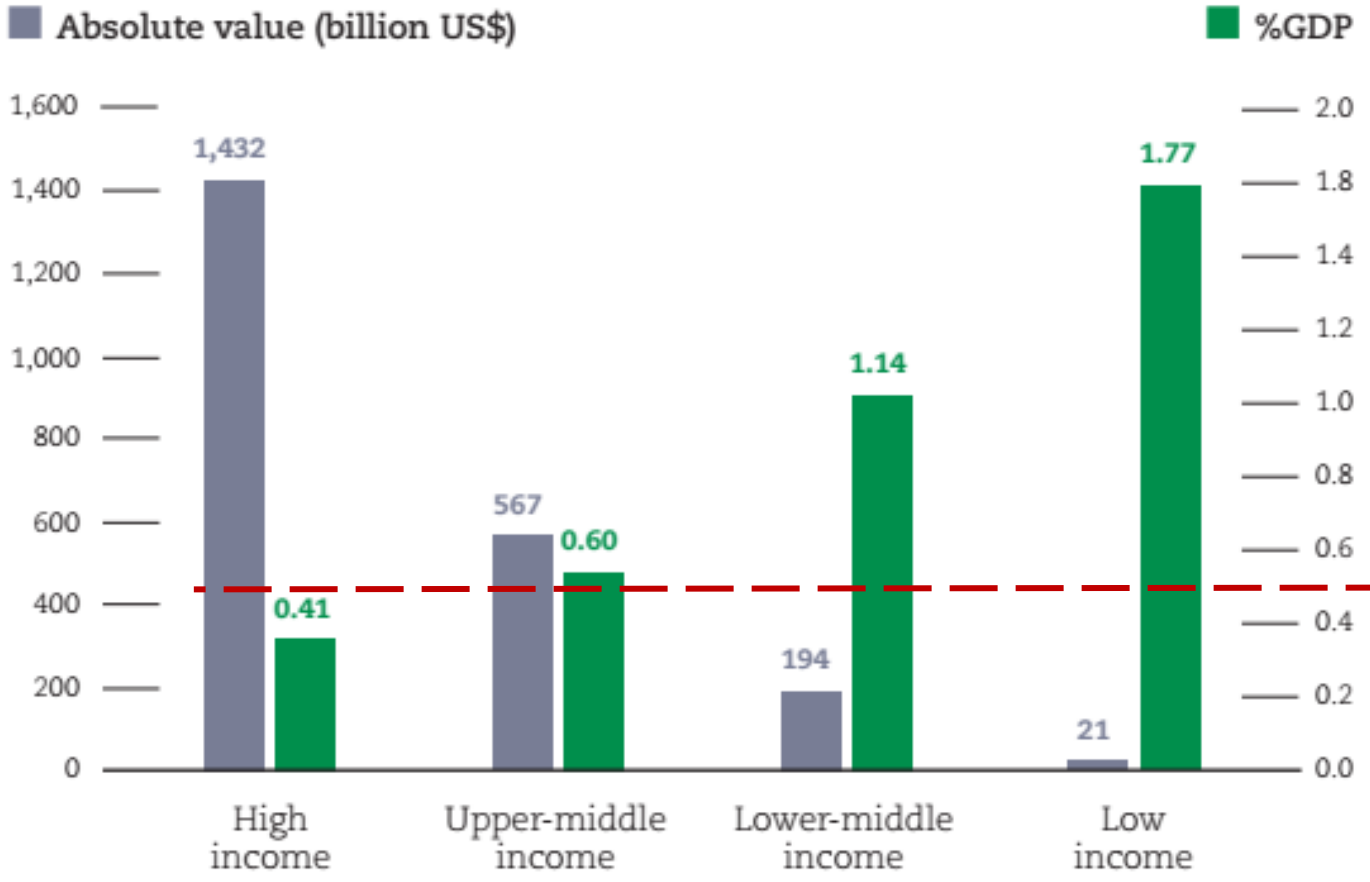
Economic losses (US$) due to natural disasters 1998-2017



→ **77% climate-related**

CRED & UNISDR (2018)

Disaster losses per income group, 1998-2017



0.5 %GDP*

* IMF threshold for a major economic disaster

CRED & UNISDR (2018)

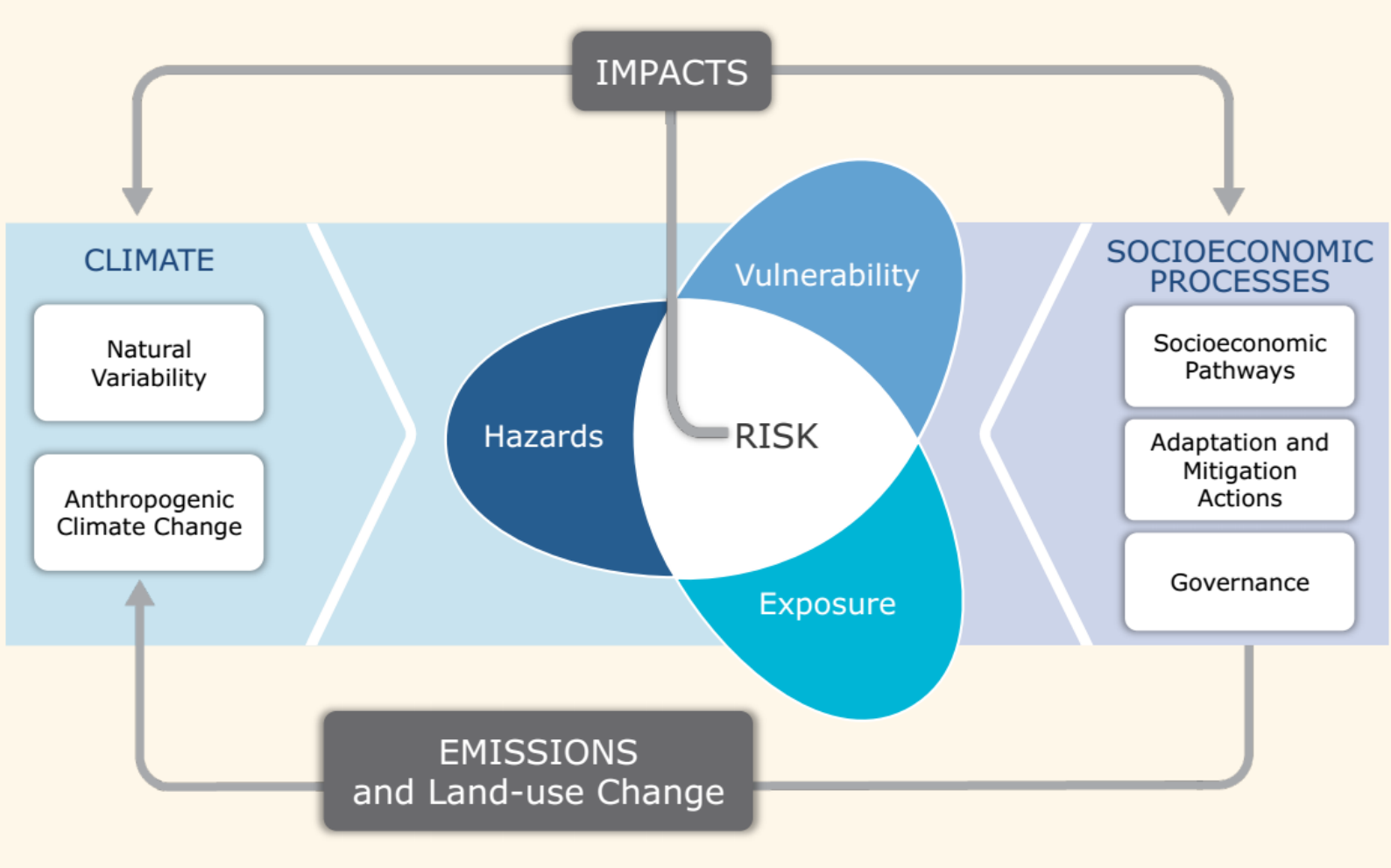
A changing world – widespread observed changes in extreme weather impacts

"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



IPCC (2014)

Outline

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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

PLOS ONE

RESEARCH ARTICLE

Integrated assessment of short-term direct and indirect economic flood impacts including uncertainty quantification

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OPEN ACCESS

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Data Availability Statement: All official statistic data sets are available from the GENESIS online data base from the German Federal Statistical Office (accession number(s) 52111-0003, 81000-0117.) The water mask was provided by JBA Risk management (www.jbarisk.com) under data licence restrictions. JBA owns these data, and other interested researchers can access these data in the same manner as the authors by purchasing the data from JBA. The authors had no special privileges to these data. All OpenStreetMap data sets are available from the OpenStreetMap online

Abstract

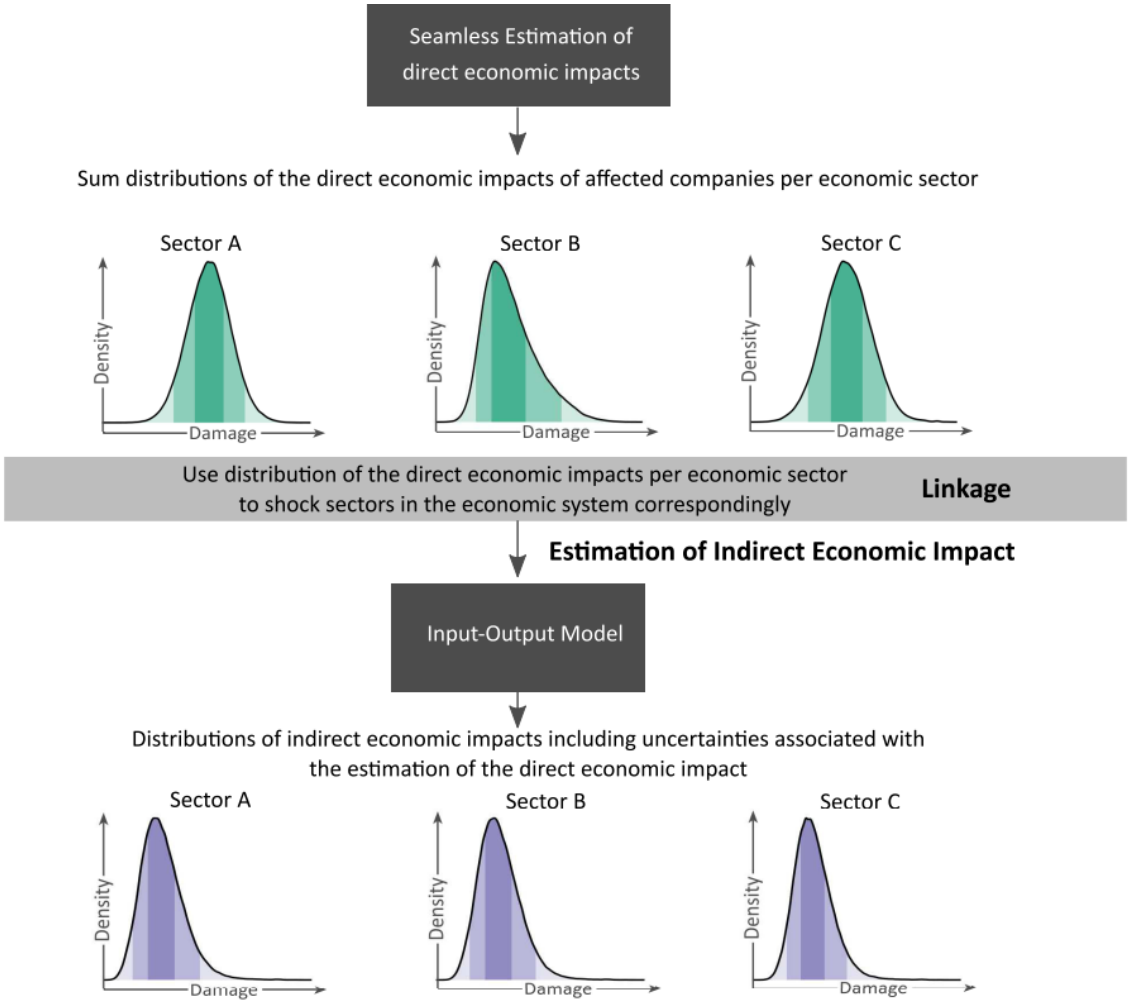
Understanding and quantifying total economic impacts of flood events is essential for flood risk management and adaptation planning. Yet, detailed estimations of joint direct and indirect flood-induced economic impacts are rare. In this study an innovative modeling procedure for the joint assessment of short-term direct and indirect economic flood impacts is introduced. The procedure is applied to 19 economic sectors in eight federal states of Germany after the flood events in 2013. The assessment of the direct economic impacts is object-based and considers uncertainties associated with the hazard, the exposed objects and their vulnerability. The direct economic impacts are then coupled to a supply-side Input-Output-Model to estimate the indirect economic impacts. The procedure provides distributions of direct and indirect economic impacts which capture the associated uncertainties. The distributions of the direct economic impacts in the federal states are plausible when compared to reported values. The ratio between indirect and direct economic impacts shows that the sectors Manufacturing, Financial and Insurance activities suffered the most from indirect economic impacts. These ratios also indicate that indirect economic impacts can be almost as high as direct economic impacts. They differ strongly between the economic sectors indicating that the application of a single factor as a proxy for the indirect impacts of all economic sectors is not appropriate.

Introduction

Flood events can have multiple impacts on economic sectors at all scales of an affected region. Those are not limited to direct impacts on companies, which commonly occur inside the flooded areas, but also include indirect impacts across economic sectors, which typically occur outside the flooded regions [1, 2], by e.g. affecting other companies due to disruptions in the

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.



Source: Sieg et al. (2019a)

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

Regional Environmental Change
https://doi.org/10.1007/s10113-018-1300-3

ORIGINAL ARTICLE

Mainstreaming of climate extreme risk into fiscal and budgetary planning: application of stochastic debt and disaster fund analysis in Austria

Junko Mochizuki[1] · Thomas Schinko[1] · Stefan Hochrainer-Stigler[1]

Received: 4 July 2016 / Accepted: 5 February 2018

Abstract
While ageing-related costs are perceived as the major drivers of fiscal pressure in the EU, concerns over climate-related public expenditures have received comparatively little attention in securing the EU's long-term fiscal sustainability. Using the Shared Socioeconomic Pathways (SSPs) scenarios as bridging concept for linking the assessment of public cost of demography- and climate-related expenditures, this study proposes a climate risk mainstreaming methodology. We apply a stochastic debt model and assess the potential flood risk in Austria to the public debt and the national disaster fund. Our results indicate that public debt under no fiscal consolidation is estimated to increase from the current level of 84.5% relative to GDP in 2015 to 92.1% in 2030, with macroeconomic variability adding further risk to the country's baseline public debt trajectory. The study finds that the estimated public contingent liability due to expected flood risk is small relative to the size of economy. The existing earmarked disaster risk reduction (DRR) funding will likely reduce the risk of frequent-and-low impact floods, yet the current budgetary arrangement may be insufficient to deal with rising risk of extreme floods in the future. This prompts the need for further discussions regarding potential reforms of the disaster fund. As many EU member states are in the early stages of designing climate change policy strategies, the proposed method can support the mainstreaming of climate-related concerns into longer-term fiscal and budgetary planning.

Keywords Stochastic debt assessment · Climate extremes · Flood risk · Public contingent liability

Introduction

Longer-term fiscal discipline is increasingly seen as an integral part of sound macroeconomic planning. According to the latest survey conducted by the International Monetary Fund, 89 countries around the globe have now adopted some forms of fiscal rules—such as debt, budget balance, expenditure and revenue rules—to ensure fiscal sustainability (IMF 2015). Within the European monetary union, the Stability and Growth Pact (SGP) serves as the cornerstone of such fiscal governance. Under this pact, member states must adhere to their deficit criterion (an annual government deficit of less than 3% of GDP) and debt criterion (a government debt-to-GDP ratio of less than 60%) (EC 2015a). Temporary deviations from these criteria are allowed in the case of extraordinary circumstances, as seen during the recent economic crisis. In the foreseeable future, however, fiscal consolidation will likely be required for many EU states, which must plan for long-term adjustment of their revenue and spending structures.

Under the existing EU fiscal governance, demographic concerns—such as population ageing, future unemployment and education and health care needs—are considered as major drivers of longer-term fiscal pressure (EC 2015a). The Medium-Term Budgetary Objective (MTO) therefore mandates that contingent liabilities resulting from the future costs

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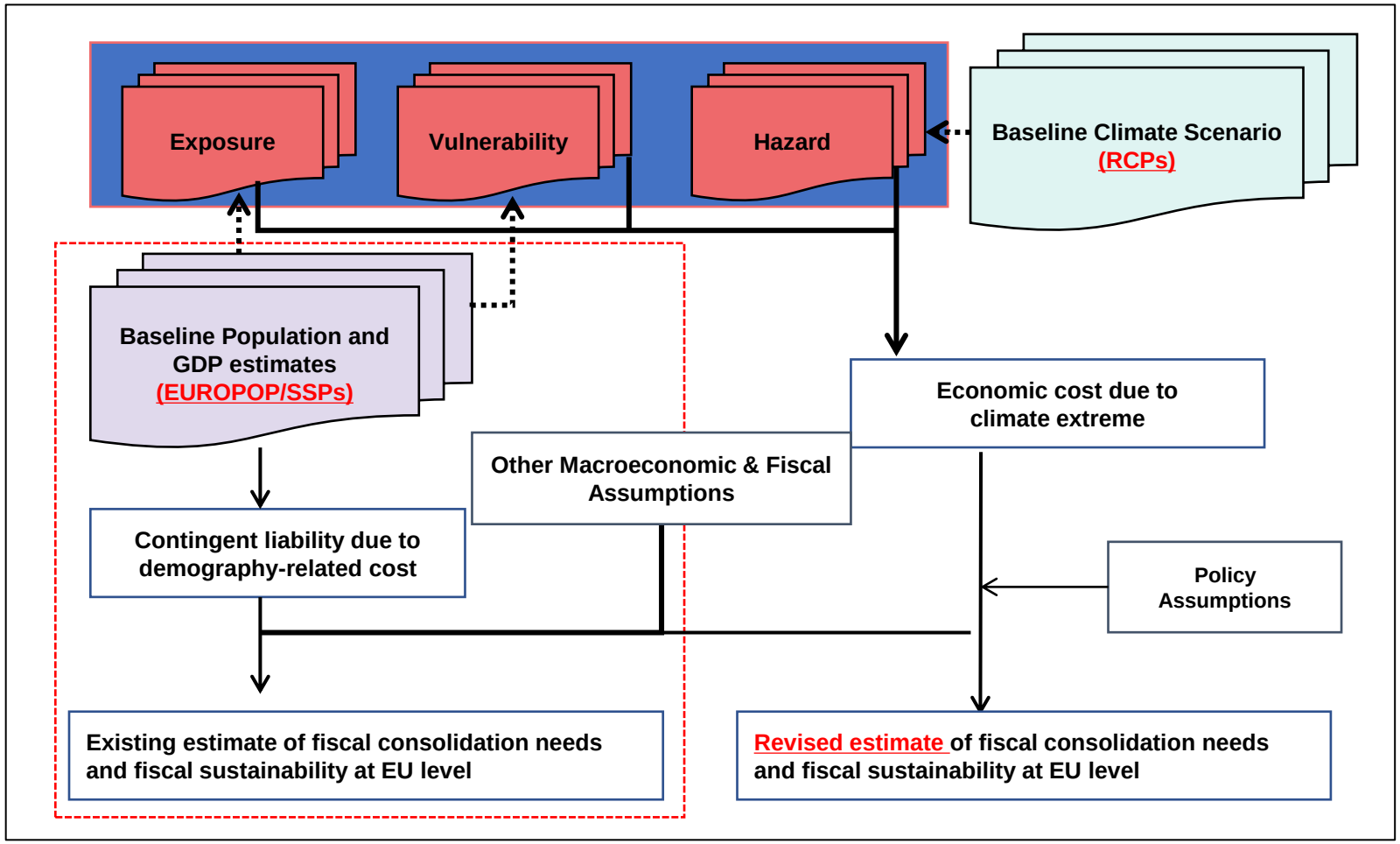
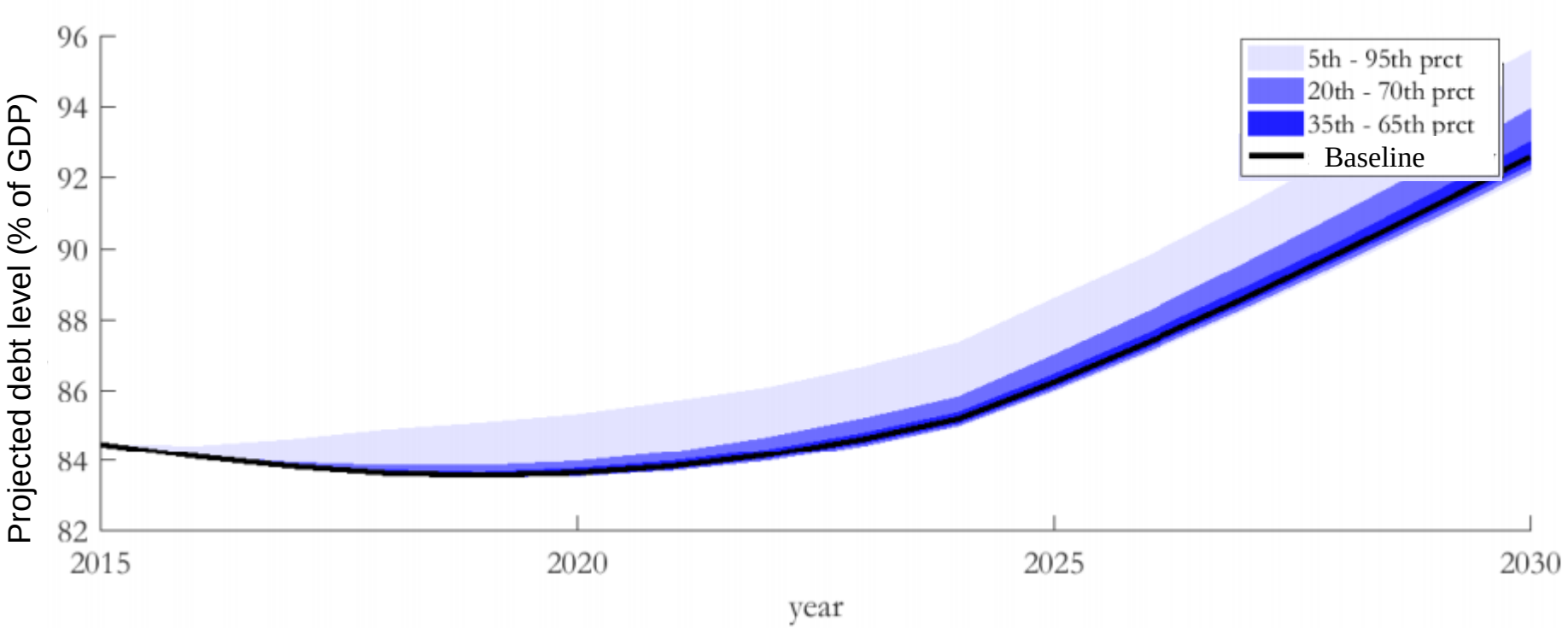
Methodology – Mainstreaming framework



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 percenties. 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