Assessing transboundary and intersectoral spillovers of multiple natural hazards in the Danube Region using a large-scale macroeconomic agent-based model

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Research question

How can we increase resilience to multiple disasters that impact several interconnected countries in the Danube Region with strong macro-economic relationships?

https://danube-region.eu
Method: Agent-based modeling (ABM) of economic systems

Agent-based models (ABMs) are computer simulation models with the following features:

- They model individual agents and their individual decisions (decentralized decision-making)
- Can include thousands or even millions of agents
- Can capture bounded rationality (often in the form of some heuristics)
- Depict emergent patterns from micro-processes that aggregate to a macro level: the economy as a complex system subject to fundamental uncertainty
IIASA macroeconomic ABM

Major economic agents and their interactions (Poledna et al., 2023)
Modeling indirect losses with the ABM

Indirect risks arise not from the direct impact of a disaster but from the interconnectedness of system elements. They materialize through disruptions in transport, supply chains, or economic activities.
Modeling indirect losses with the ABM

Coupling ABM with a damage scenario (Bachner et al. 2023)
ABM Overview

- 26 EU countries (except MT); 237 NUTS-2 regions
  - Including 9 Danube Region countries
- 64 industries (NACE)
  - Calibrated with FIGARO and Eurostat data
- Baseline calibration year: 2016
- 3–5 years time horizon
- Quarterly timestep
Damage scenarios: flood and earthquake
Modeling single and consecutive hazards
Impact of shocks on total output

- Single hazards generally reduce the total output compared to the baseline
- Consecutive hazards have a more severe impact, leading to a lower total outputs, particularly, when the flood is followed by the earthquake
- The total output often recovers over time, but does not usually reach the baseline level (particularly in the “flood-first” scenarios)
- The recovery rate can vary significantly between countries and scenarios
Measuring indirect risks by industry

\[ IR_i = \frac{\Delta GVA_i}{KD_i}, \]

where \( \Delta GVA_i \) is the change in GVA of sector \( i \), and \( KD_i \) is the capital damage to sector \( i \)'s capital stock

- IR > 1 means that the lost GVA is larger than the direct capital damage ("high" indirect risk)
- IR = 1 its losses are the same
- 0 < IR < 1 sectoral GVA loss is smaller than the direct damage ("low" indirect risk)
- IR < 0 means that GVA can be increased, even though there is a direct damage to the sector (benefit of a hazard event) (Bachner et al., 2023)
Indirect risks by industry: flood and earthquake

Initially, virtually all industries (except for petroleum refinery in BG) benefit from the shock

Initially, the most severely affected is the financial sector in RO
Thank you for your time!

Questions?
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