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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

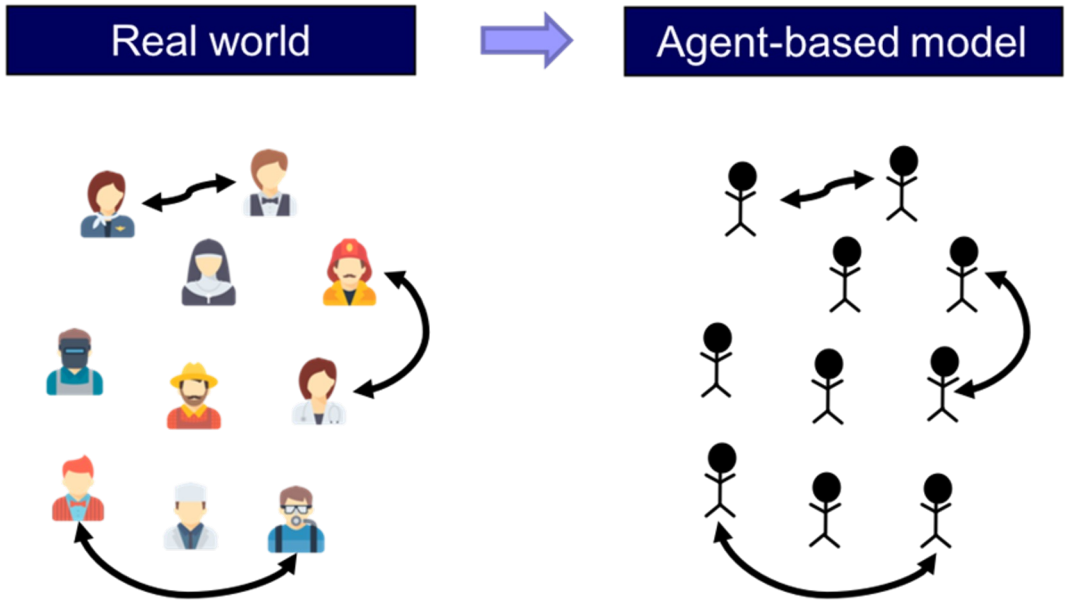
How can we increase resilience to multiple disasters that impact several interconnected countries in the Danube Region with strong macro-economic relationships?

https://danube-region.eu

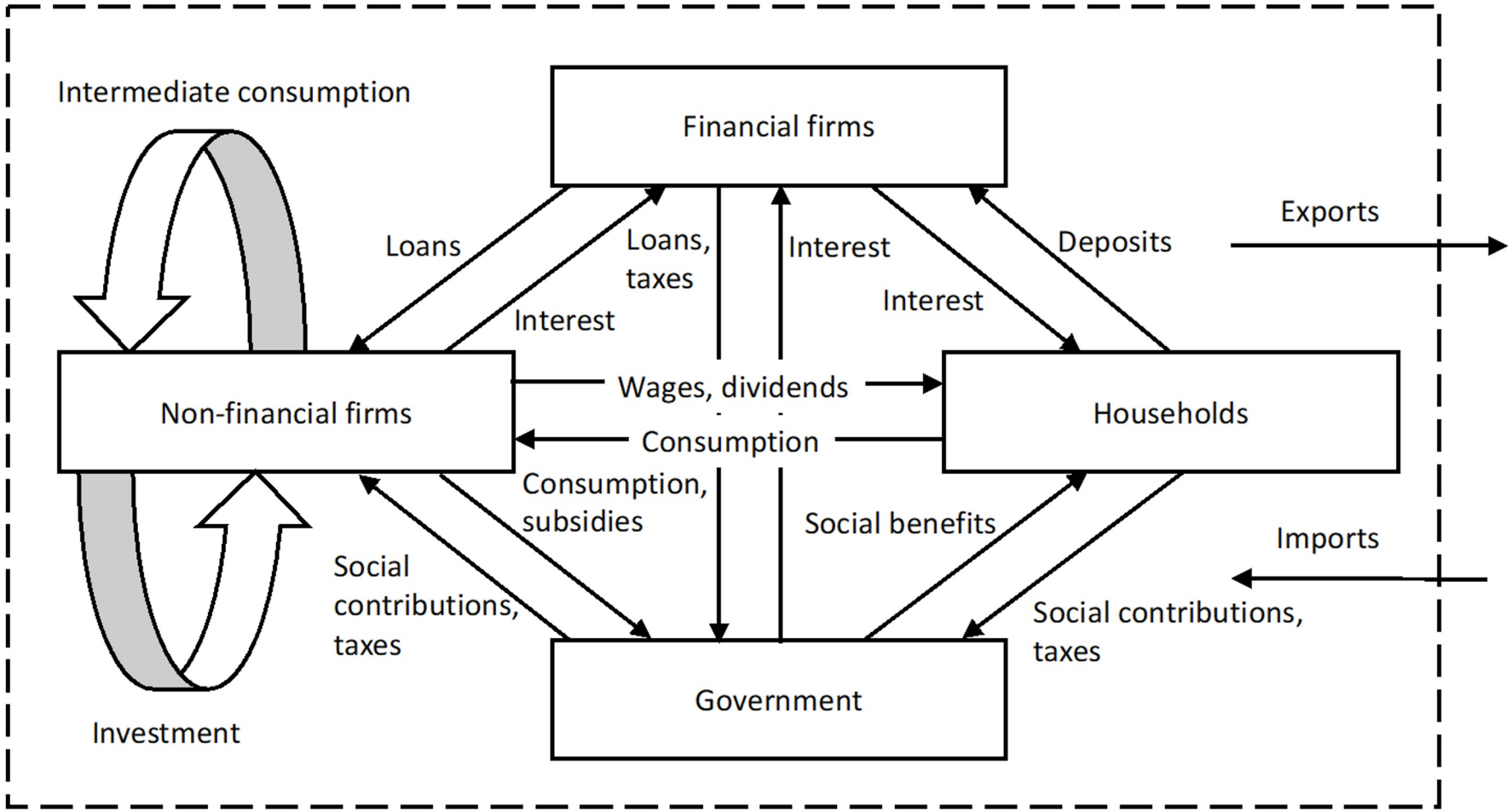
Method: Agent-based modeling (ABM) of economic systems

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**

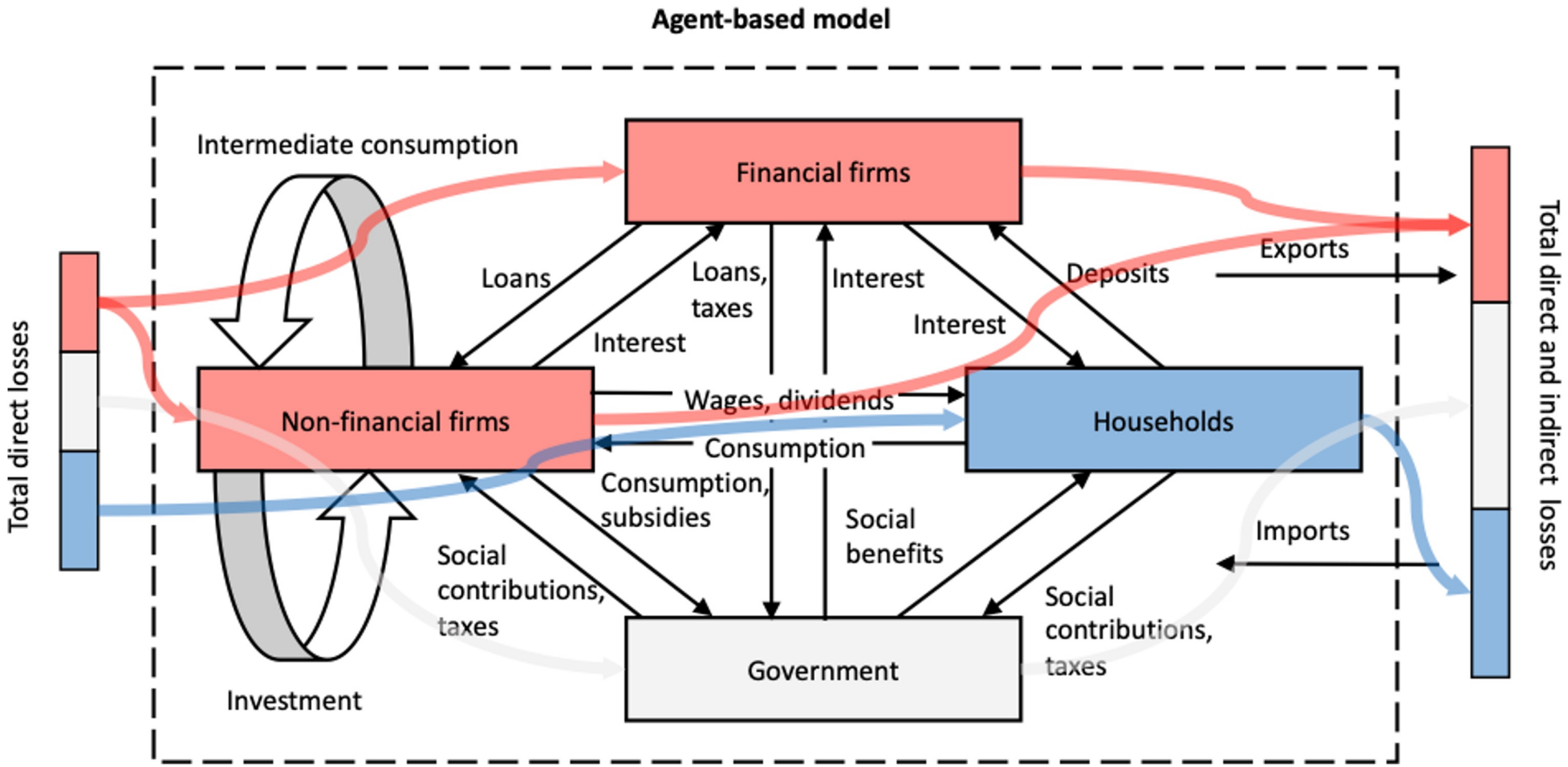


IIASA macroeconomic ABM



Major economic agents and their interactions (Poledna et al., 2023)

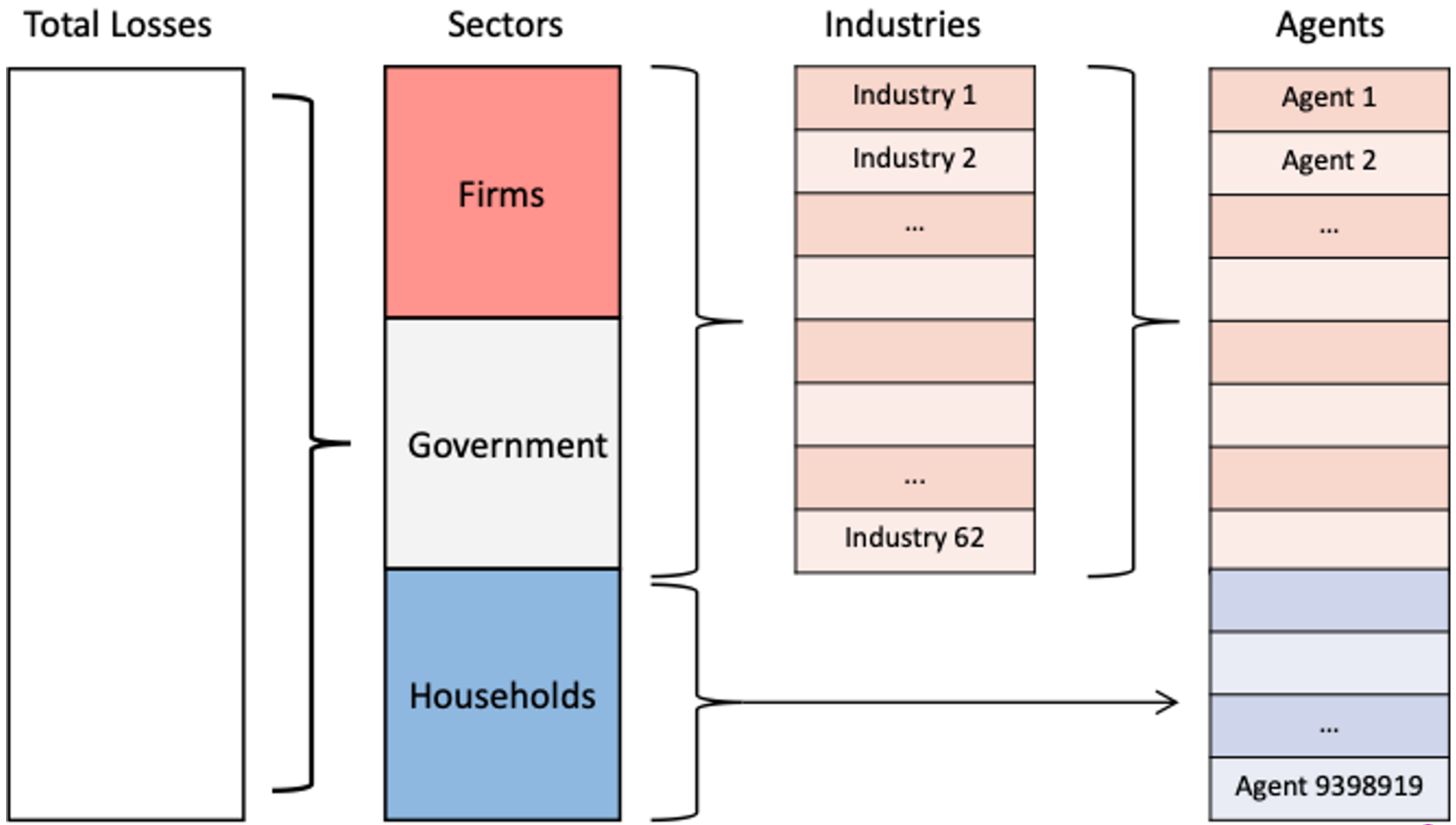
Modeling indirect losses with the ABM



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

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.

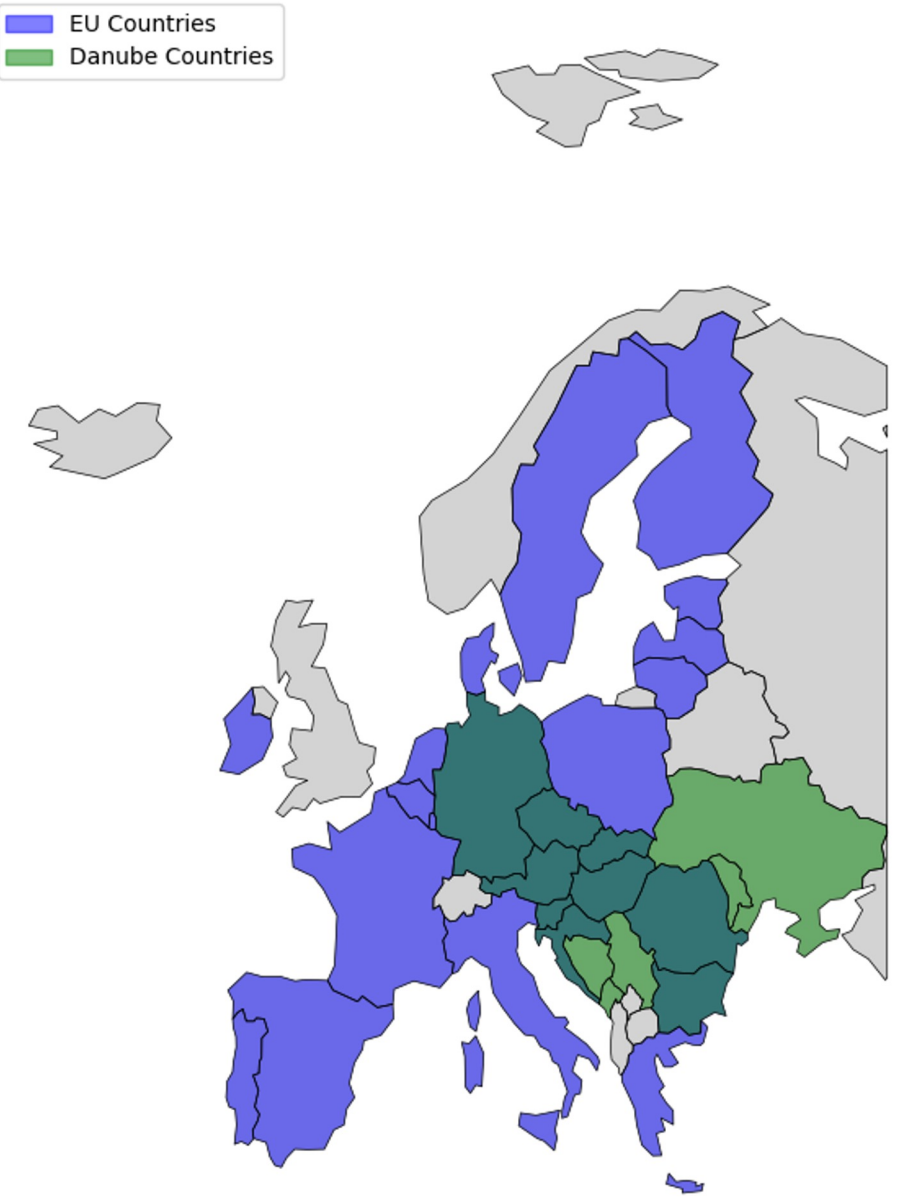
Modeling indirect losses with the ABM



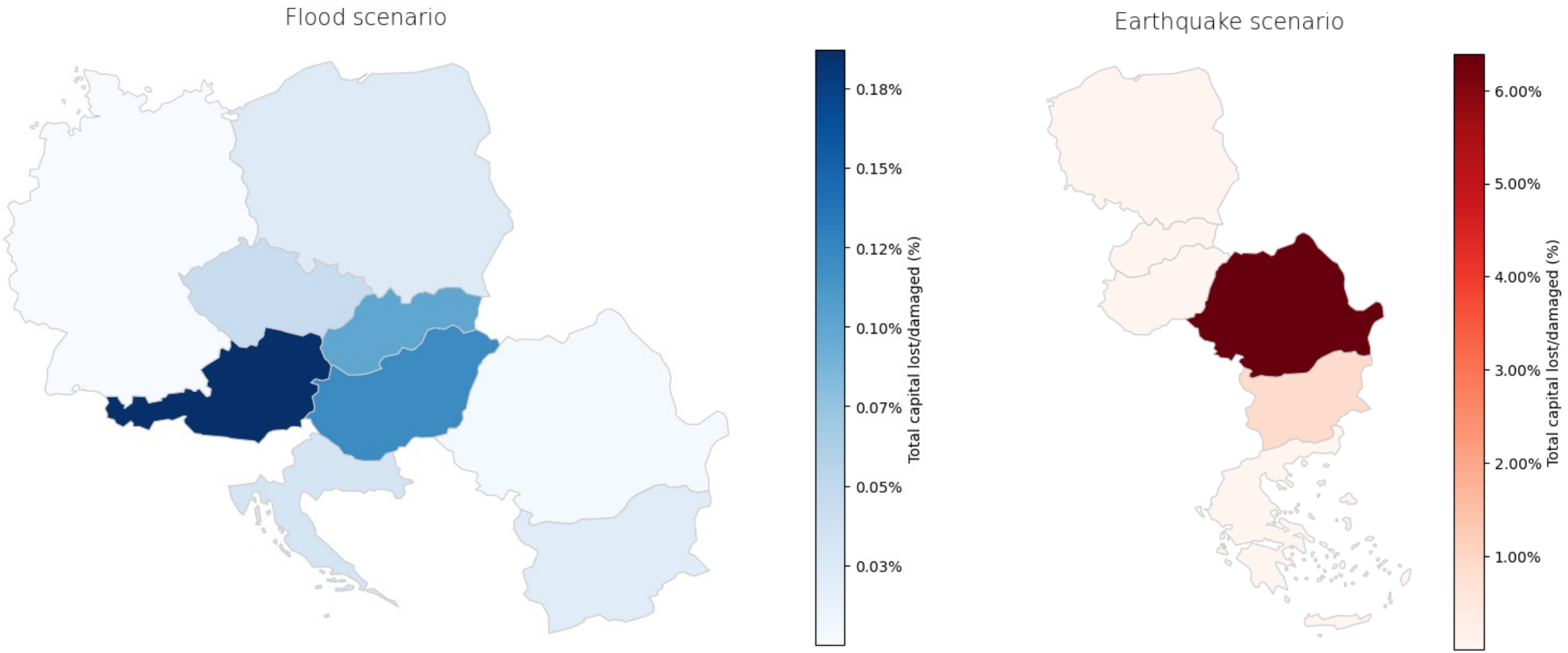
Coupling ABM with a damage scenario (Bachner et al. 2023)

ABM Overview

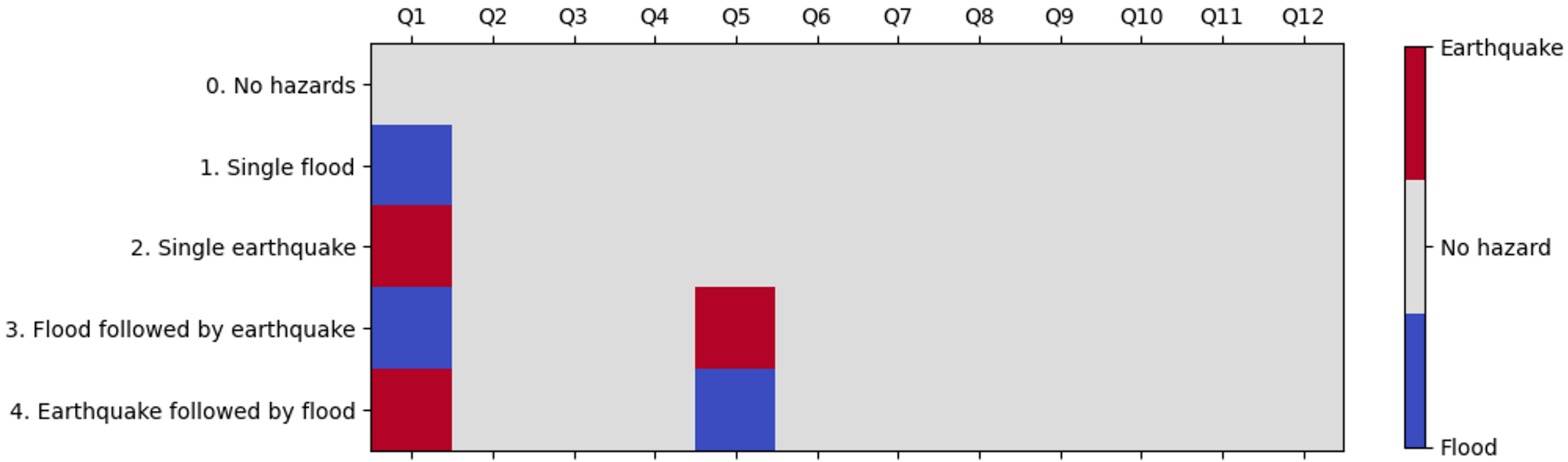
- 26 EU countries (except MT); 237 NUTS-2 regions
  - Including 9 Danube Region countries
- 64 industries (NACE)
  - Calibrated with FIGARO and Eurostat data
- Baseline calibration year: 2016
- 3–5 years time horizon
- Quarterly timestep



Damage scenarios: flood and earthquake

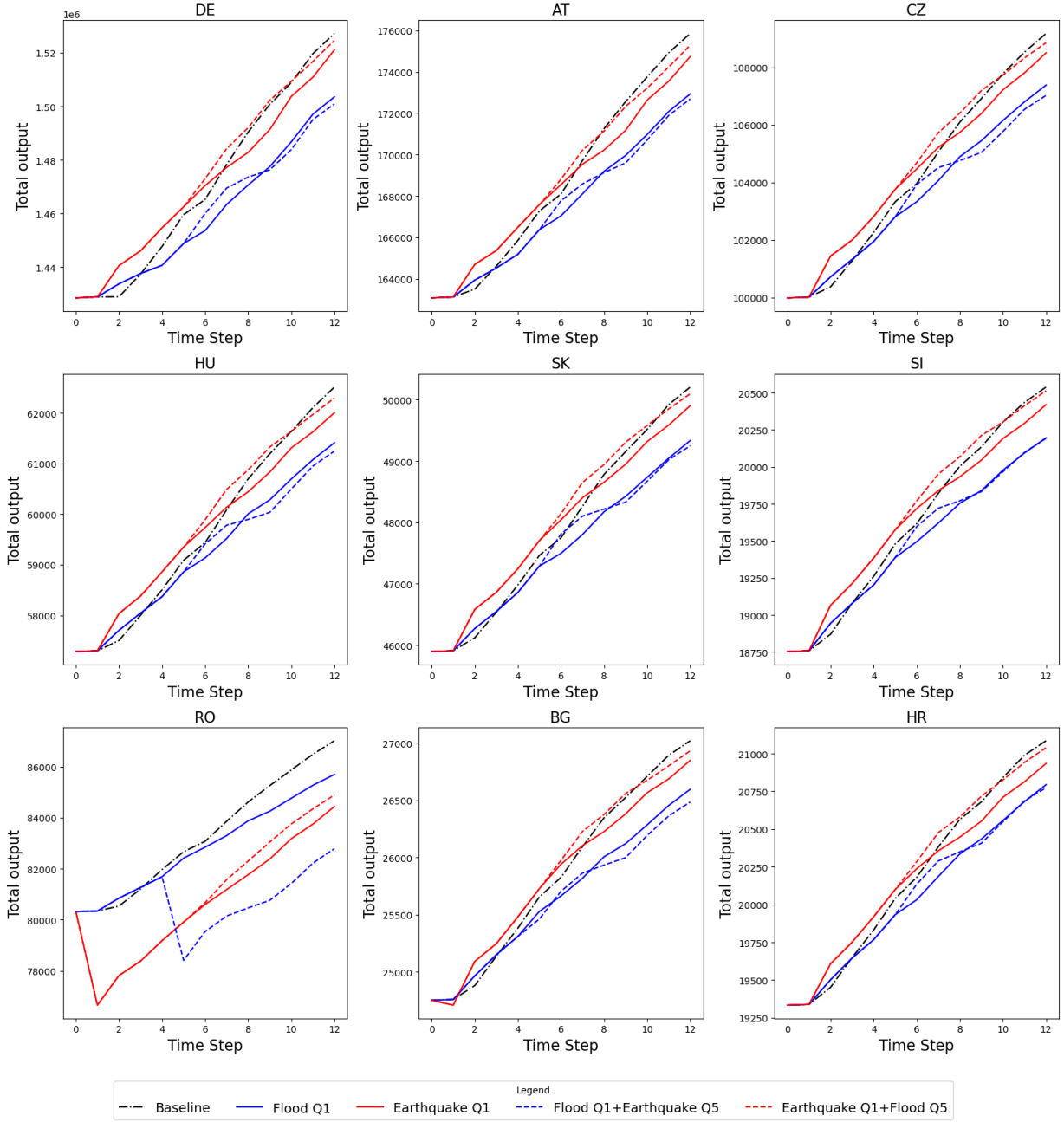


Modeling single and consecutive hazards



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



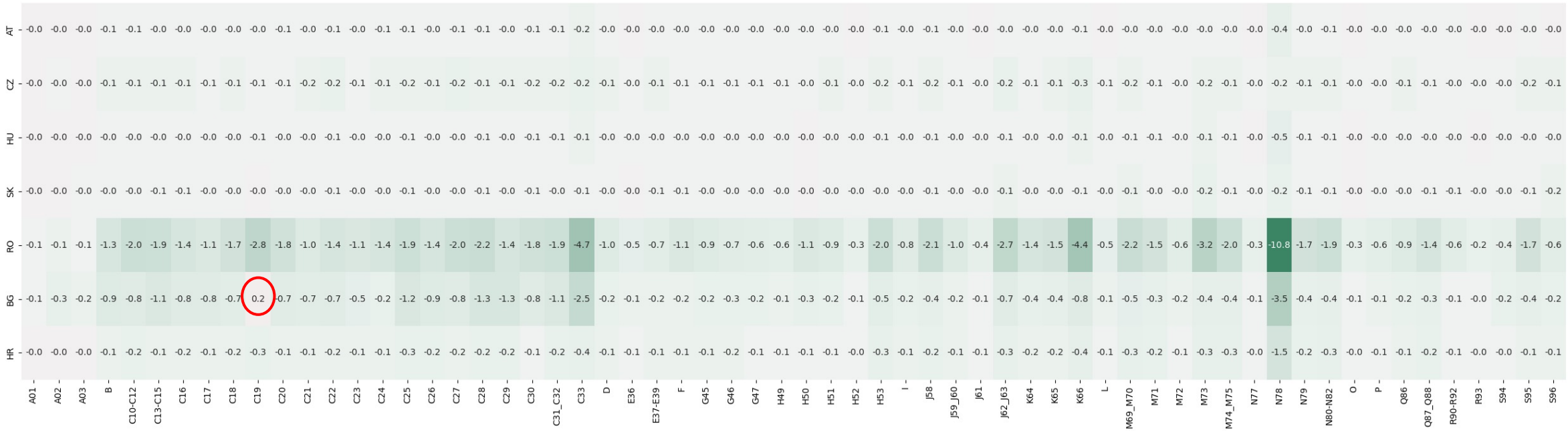
Measuring indirect risks by industry

$$IR_i = \frac{\Delta GVA_i}{KD_i},$$

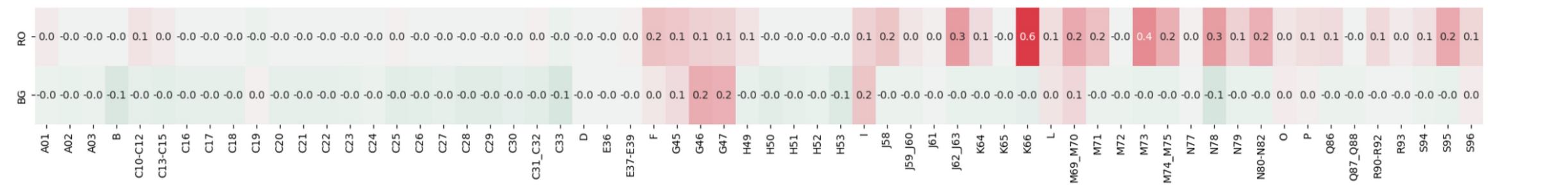
where ΔGVA_i is the change in GVA of sector i, and KD_i is the capital damage to sector i's capital stock

- 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

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Thank you for your time!

Questions?

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