The macroeconomic implications of extreme weather events

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Background: extreme weather events

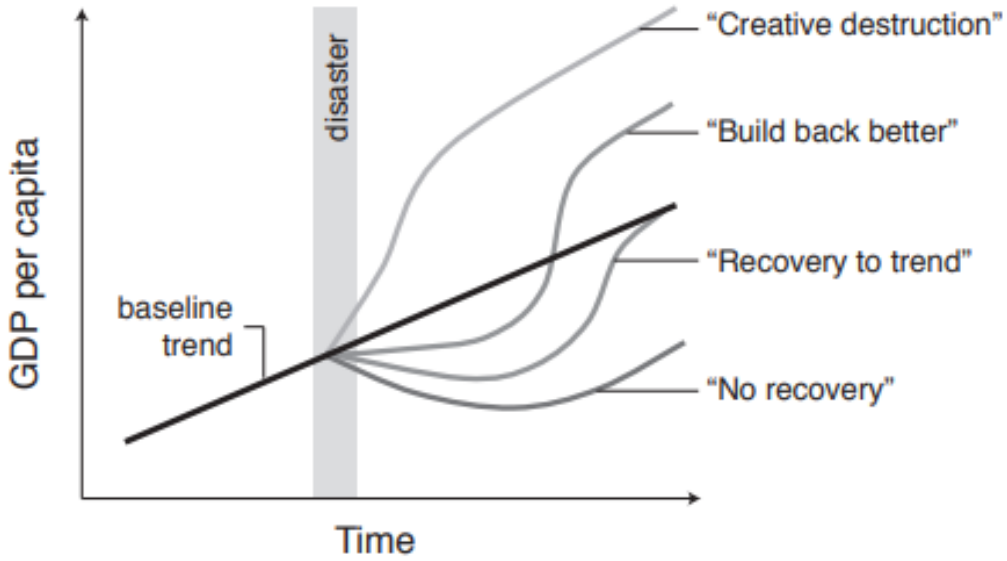
- Extreme weather events are expected to increase in frequency and severity (IPCC, 2021).
- Severe/tail events likely have different economic impacts from other changing weather patterns.

Different channels

Supply: destruction of productive capital, disruption to supply chains, impacts on labour supply (-), relocation of resources to more productive sectors (+)

Demand: wealth, confidence effects (-), government spending, international aid transfers (+)

Spillovers: supply chain disruption, loss of external demand (-), reallocation of resources and/or demand from affected region (+)



Extreme weather events: What do we know? What are we missing?

Cross-country panel studies with national-level data : mixed evidence for advanced economies using national-level data.

- For developing countries: significant negative impacts on GDP with large range of estimates:

  -6% (Felbermayr & Grosch, 2014) to -0.6% (Raddatz, 2009).

- Advanced economies: impacts mostly insignificant (e.g. Loayza et al., 2012; Raddatz, 2009, Panwar & Sen 2019), some negative (Hsiang & Jina 2014), some positive (Skidmore & Toya, 2002)

Individual country studies with subnational data: stronger findings but external validity?

- Localized effects of weather events => study impacts at fine degree of geographical aggregation.
- Statistically significant negative impacts on economic activity (e.g. Strobl, 2011, for the USA, Mohan et al, 2018 for Japan).

⇒ **Combine both approaches: cross country sample using subnational economic data.**

Overview of the paper

How do extreme weather events affect macroeconomic activity in OECD countries?

Direct effects
(At the location of disaster)

Indirect effects
(Spillovers from disasters in neighbours)

Analysis at the **regional level (TL3)**

What can we say about *transmission mechanisms* and impacted *sectors*?

What is the role of fiscal, economic, and demographic conditions in reducing costs?

Are impacts important at the macroeconomic level?

Dataset of disaster-region pairs across OECD countries

Natural disasters

- EM-DAT: most comprehensive database of natural disasters
- Most reliable from 2000 onwards

Macro data

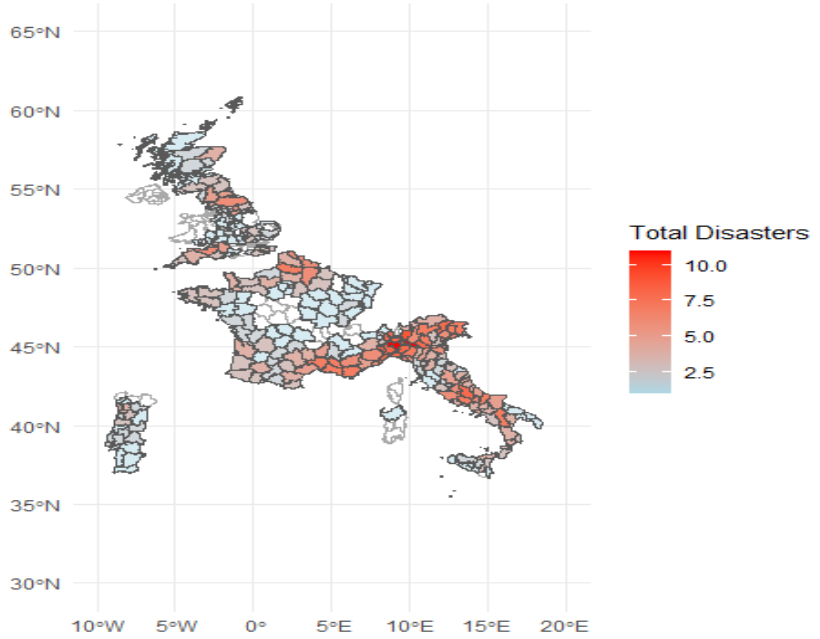
- OECD cities and regions database of economic variables at TL3 (municipal) level

Spatial matching

- Match EM-DAT disaster location polygons to TL3 regions using shapefiles from OECD and Rosvold & Buhuag (*Nature*, 2021), available up to 2018.

- Distance between regions

Over 640 severe region disaster pairs across 33 OECD countries between 2000-18

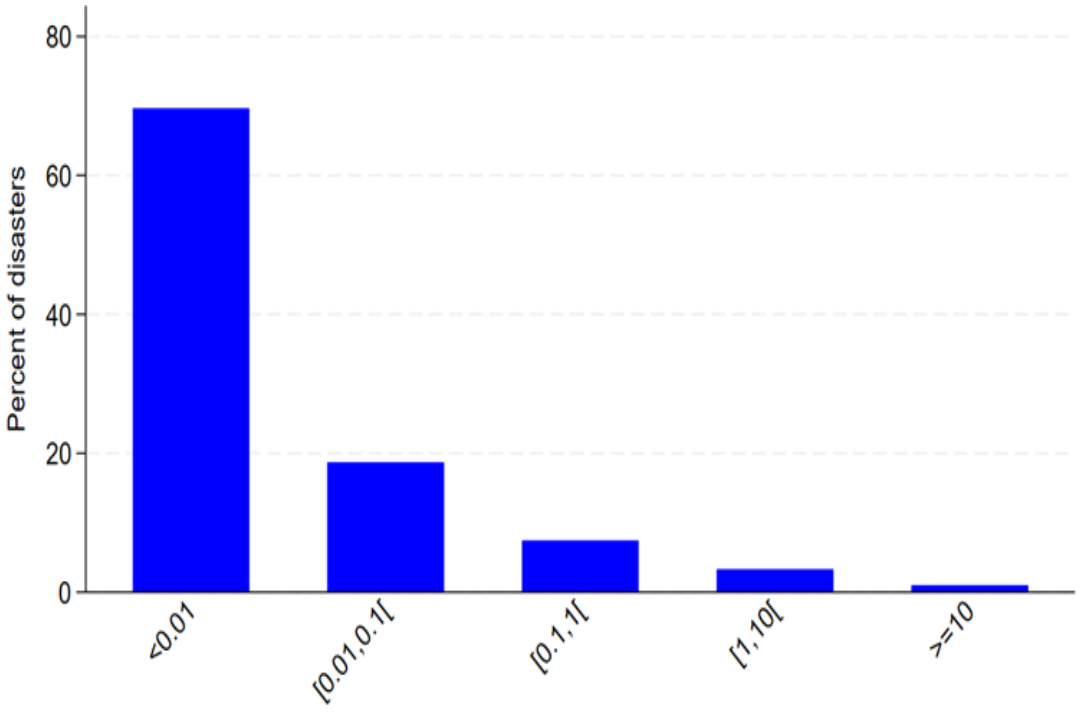


Dataset of disaster-region pairs across OECD countries

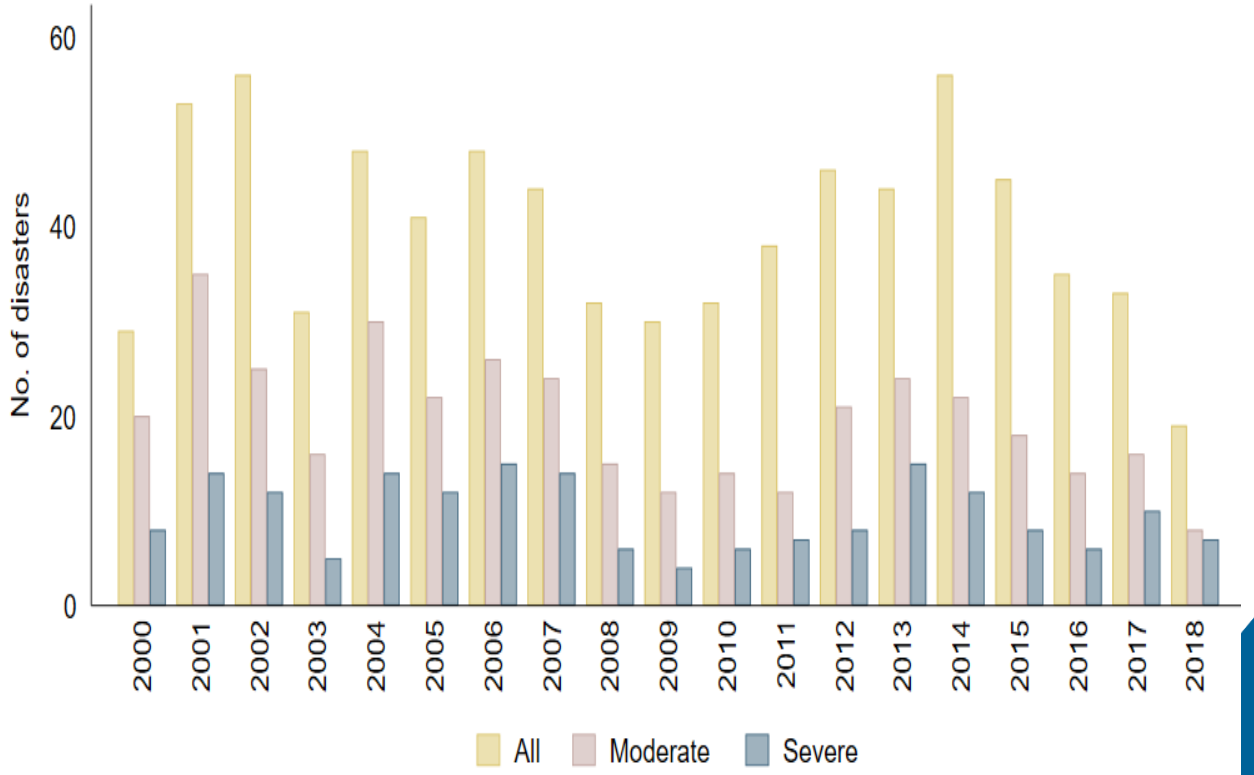
A focus on intense disasters (e.g., Becker & Mauro, 2006; Panwar & Sen, 2019).

$$Intensity_k = 100 * ((Fatalities_k + Total\ affected_k)/(Population_i))$$

Distribution of disaster intensity



Total unique disasters by year



Empirical model

Local projection estimator (Jordà, 2005):

$$GDP_{ic,t+k} - GDP_{ic,,t-1} = \beta_1 \Delta GDP_{ic,t-1} + \beta_2 Disaster_{ic,t} + \beta_3 Disaster_{ic,t-1} + \beta_4 \boldsymbol{X}_{ic,t-1} + \beta_5 \boldsymbol{Y}_{c,t-1} + \gamma_1 \sum_{i \neq j} w_{i,j}\, Disaster_{j,c,t} + \gamma_2 \sum_{i \neq j} w_{i,j}\, Disaster_{j,c,t-1} + \delta_i + \delta_t + \varepsilon_{ic,t}$$

$$k = \{0, \dots, 5\}$$

- $GDP_{ic,t+k} - GDP_{ic,,t-1}$: Long difference in the macroeconomic outcome (log)
  - GDP, employment, migration, sectoral GVA
- $Disaster_{i,c,t}$: Natural disaster count (direct effect)
- $\sum_{i \neq j} w_{i,j}\, Disaster_{j,c,t}$: Weighted matrix of external disasters (spillover effect)
- $\Delta GDP_{i,c,t-1}$: lagged change in macroeconomic outcome
- $\boldsymbol{X}_{i,c,t}$: set of region level controls, including GDP per capita, GDP growth
- $\boldsymbol{Y}_{c,t}$: set of country level controls, including debt, output gap and GDP per capita
- δ_i, δ_t region and time fixed effects

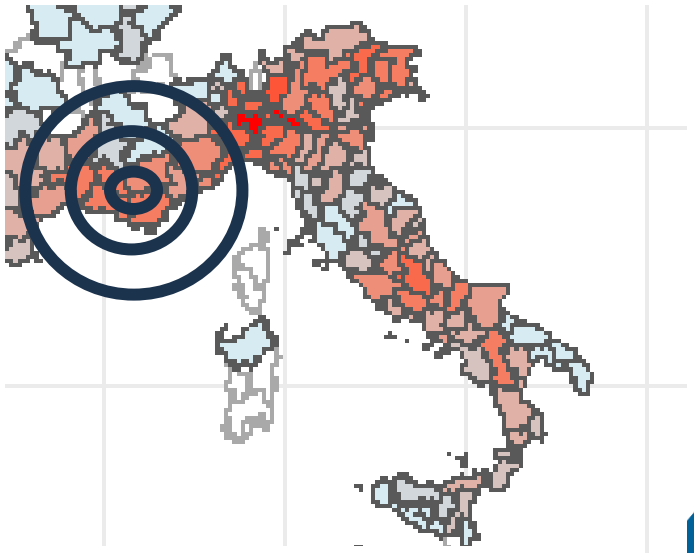
Empirical model: spatial effects

We augment the equation with a spillover variable:

$$GDP_{ic,t+k} - GDP_{ic,,t-1} = \beta_1 \Delta GDP_{ic,t-1} + \beta_2 Disaster_{ic,t} + \beta_3 Disaster_{ic,t-1} + \beta_4 \boldsymbol{X}_{ic,t-1} + \beta_5 \boldsymbol{Y}_{c,t-1} + \gamma_1 \sum_{i \neq j} w_{i,j}\, Disaster_{j,c,t} + \gamma_2 \sum_{i \neq j} w_{i,j}\, Disaster_{j,c,t-1} + \delta_i + \delta_t + \varepsilon_{ic,t}$$

$$k = \{0, \dots, 5\}$$

- $\boldsymbol{w_{i,j}} = \begin{cases} \frac{\frac{1}{dist_{i,j}}}{\sum_j \frac{1}{dist_{i,j}}} & if\ 0 < dist_{i,j} < x\ km \\ 0 & otherwise \end{cases}$
- To avoid double counting, we focus only on *external disasters*
- We use 100, 200, 500 and 1000 km thresholds



- **Distance decay**, where further away regions affect a given region less

Strong and persistent negative impacts on regional GDP

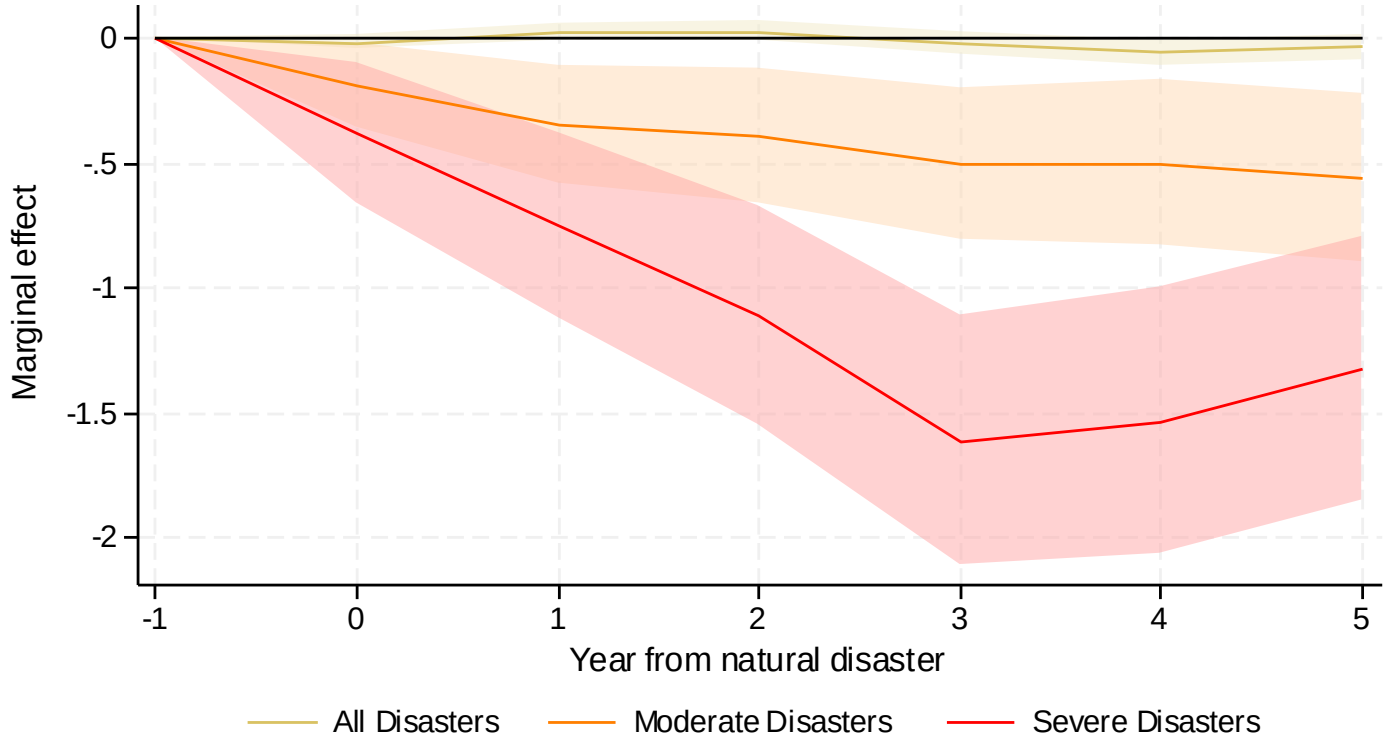
- Immediate impact: -0.4%
- Peak impact (3 years): -1.6%
- Long-term effect (5 years): -1.3%

Non-linearity in disaster severity:

- Severe: -1.6%
- Moderate: -0.5%

Robustness:

- Alternative clustering (Conley SEs)
- 5 lags and leads of shock variable



Notes: figure shows the response of the level of regional real GDP to a severe natural disaster. Impulse responses can be interpreted as percentage deviation from trend GDP. Estimation is on annual data 2001-2021 using local projections (horizon length 5 years, regional and year fixed effects, standard errors clustered at region-year level). Sample: 31 OECD countries, 1665 regions.

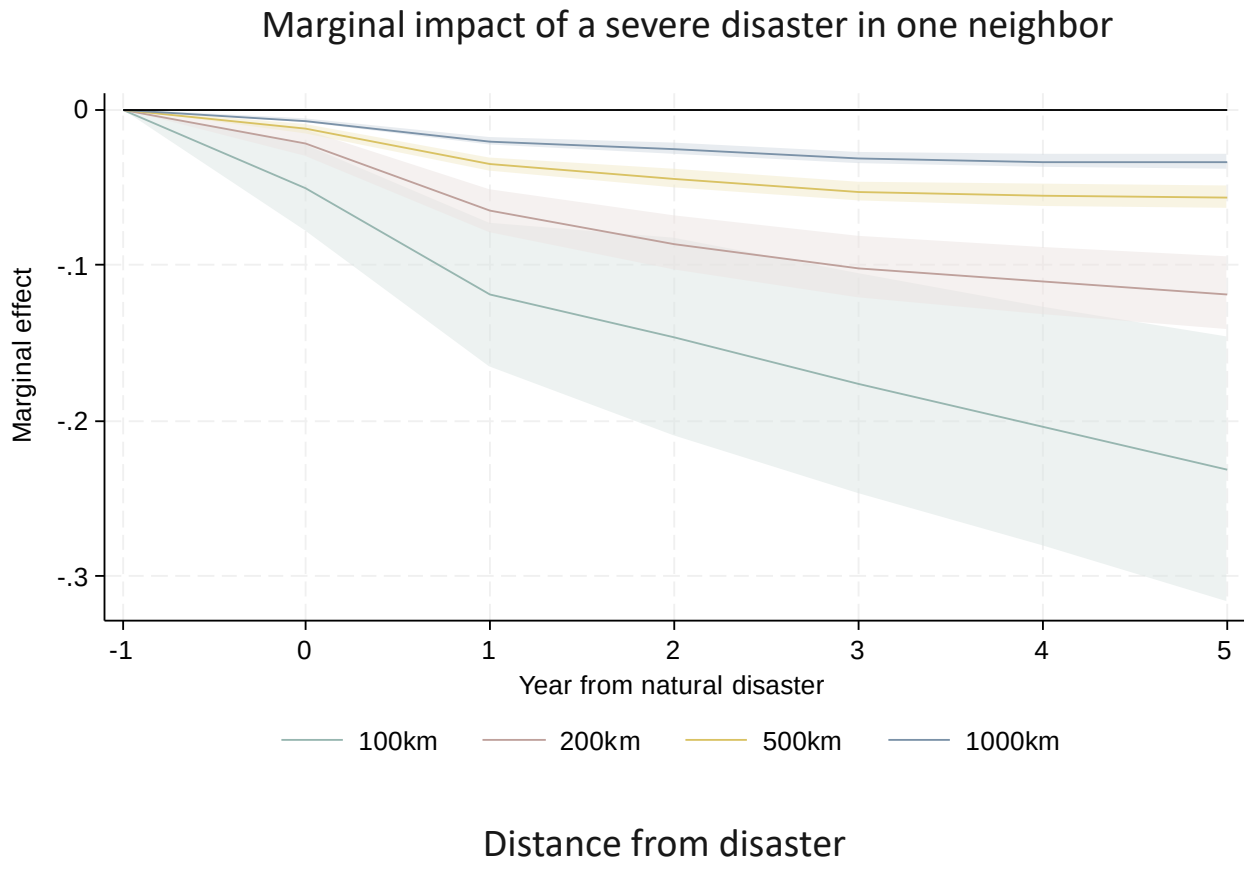
Disasters also negatively affect GDP of neighbouring regions

Negative spillover effects, larger for closer neighbors.

Magnitude of spillover effect decreases with distance threshold:

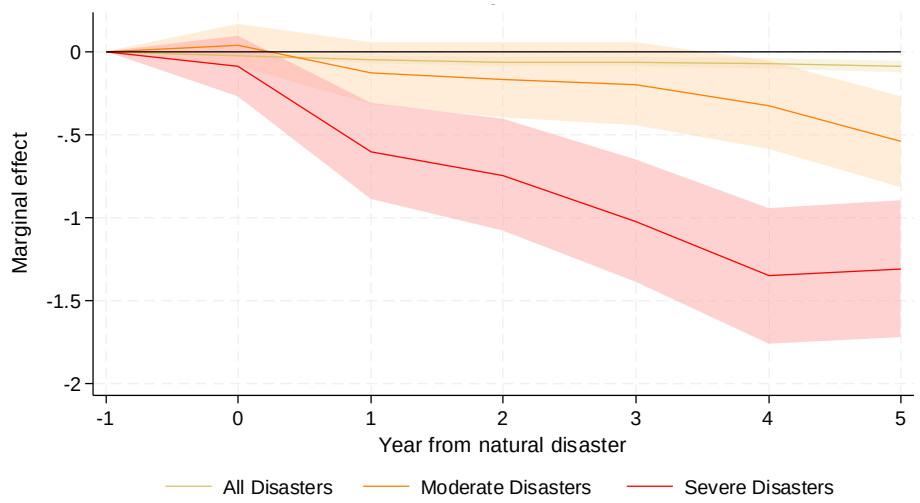
- 100km: -0.2%
- 200km: -0.1%
- 500km: >-0.1%

Smaller negative spillover effects also present for less severe disasters.

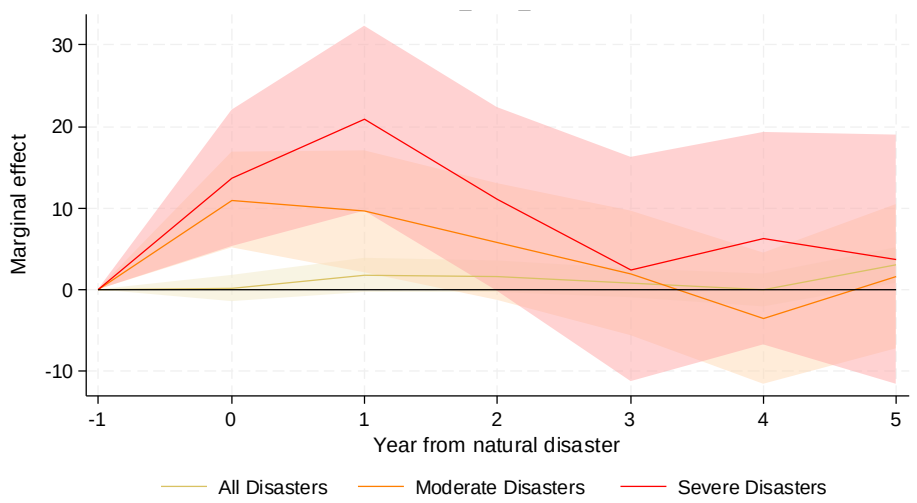


Labour markets are a key transmission channel

Negative effect of natural disasters on regional **employment**



Positive effect of natural disasters on **net outward migration**



There is also evidence of a small decline in labour productivity.

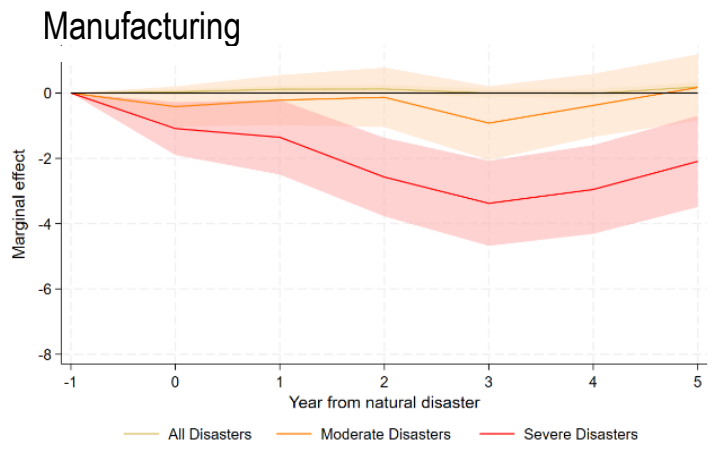
The costs of disasters vary by sector

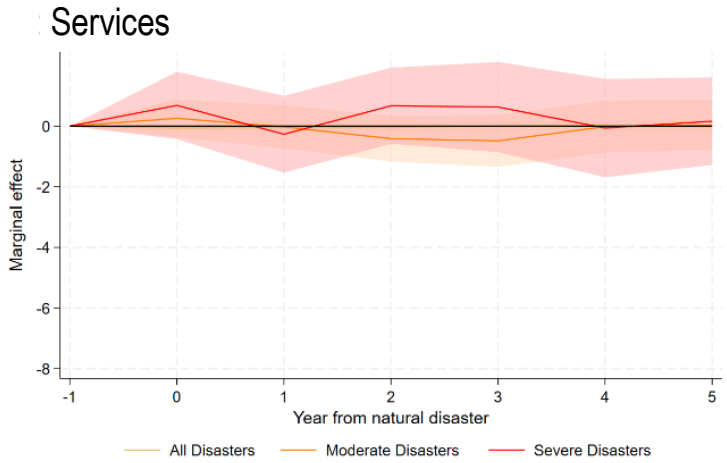
Manufacturing and construction are most severely affected

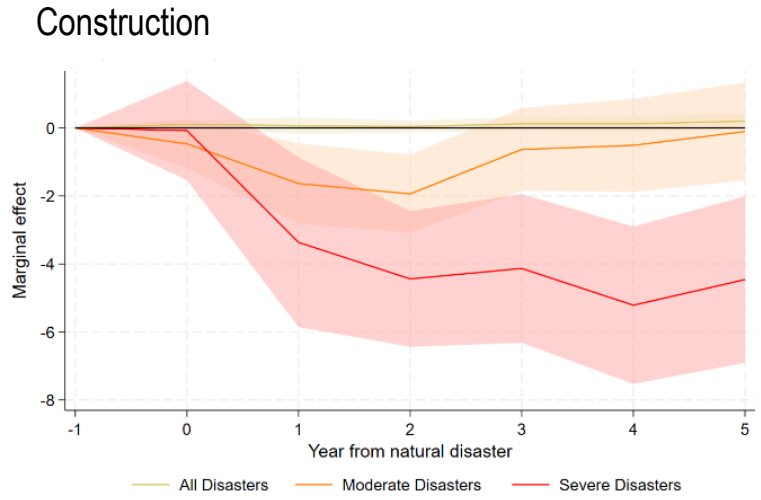
Construction: reconstruction boost is outweighed by reduced demand

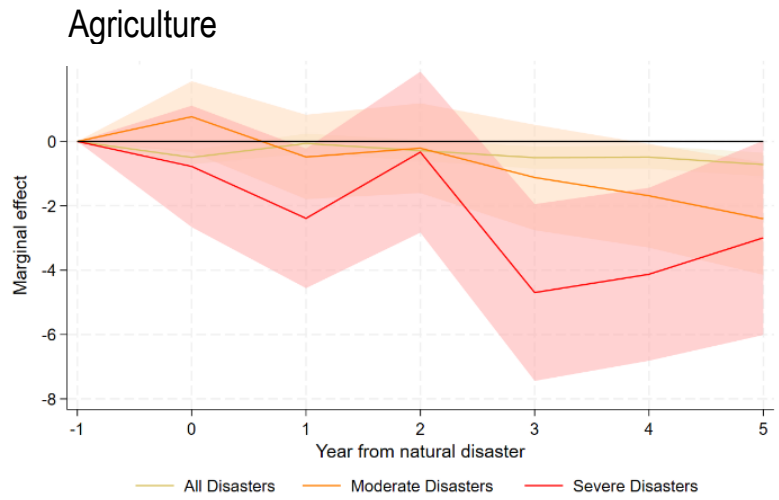
Agricultural output declines

Services are resillient (less reliant on physical capital)



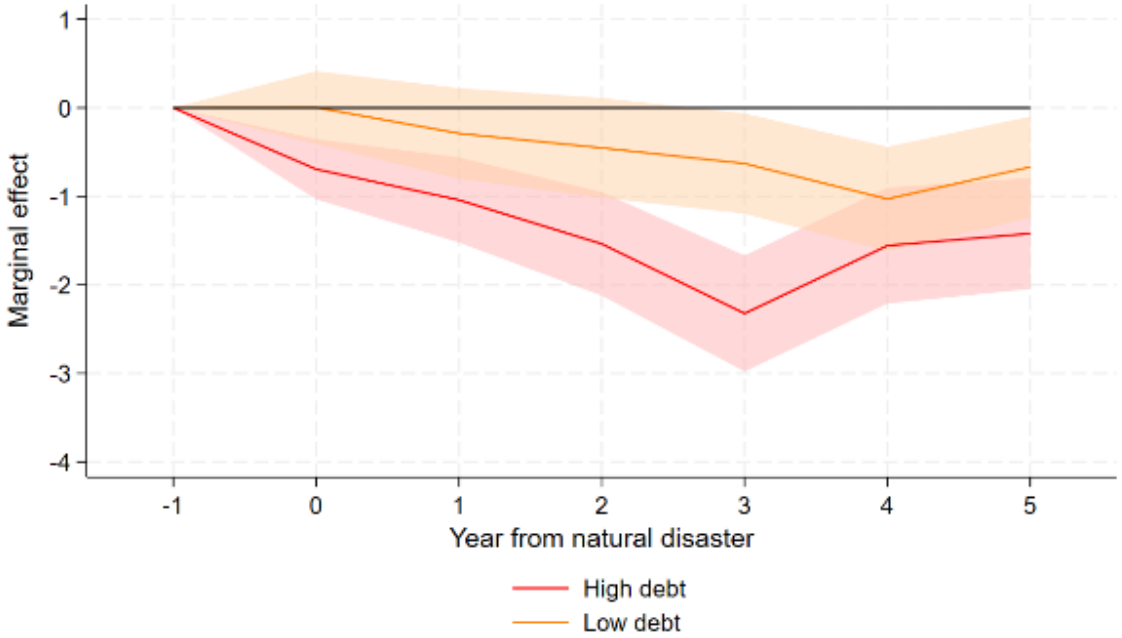






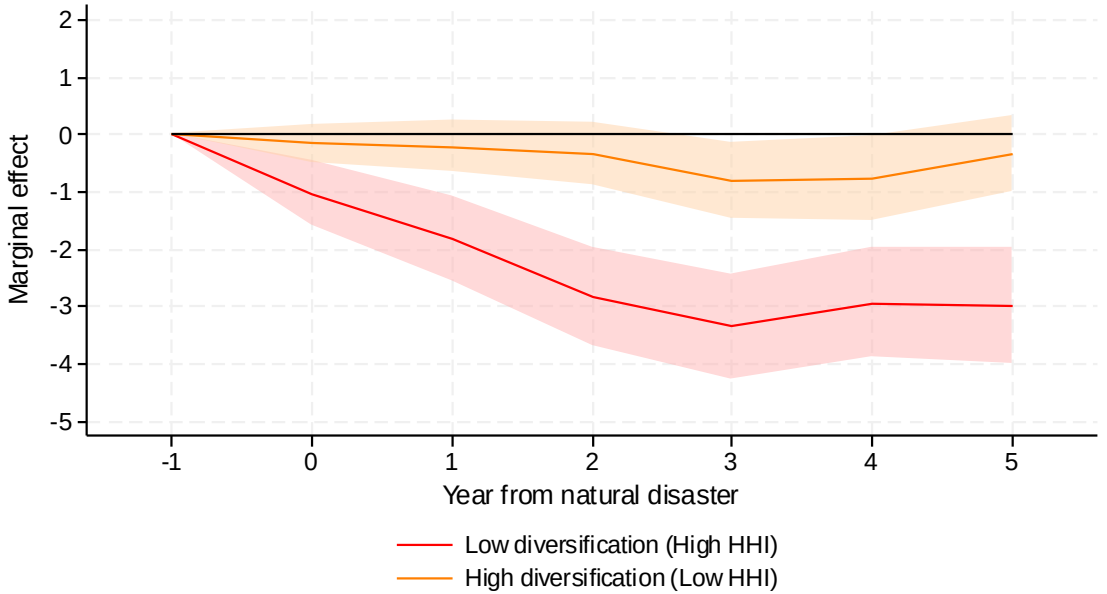
Fiscal space and economic conditions affect GDP impacts

Fiscal space (Government debt)



High debt countries are more severely affected

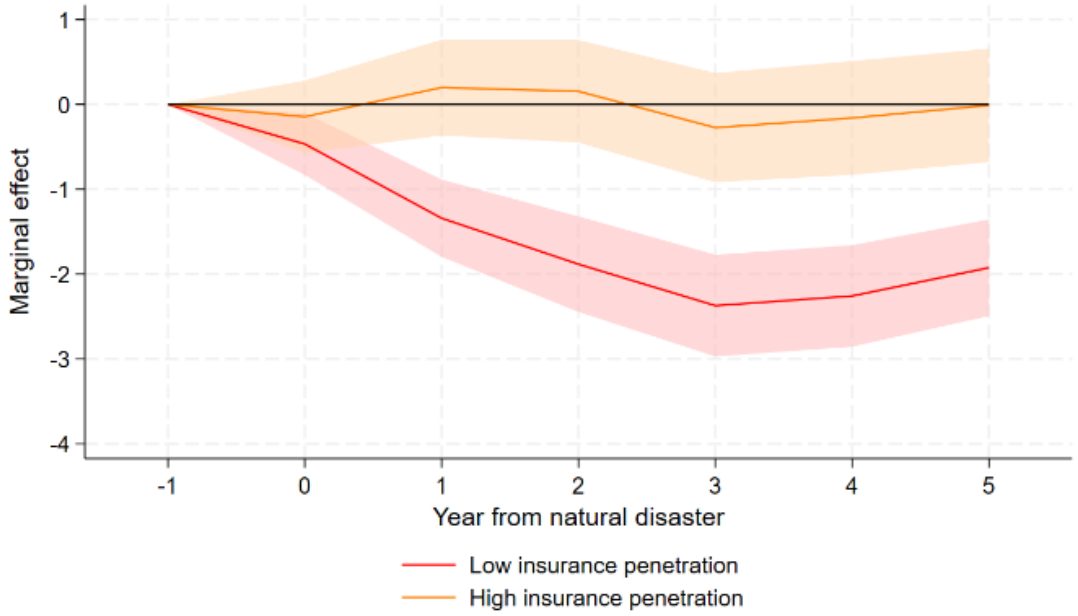
Economic Diversification (Herfindahl-Hirschman Index)



Diversified production structures help reduce risks

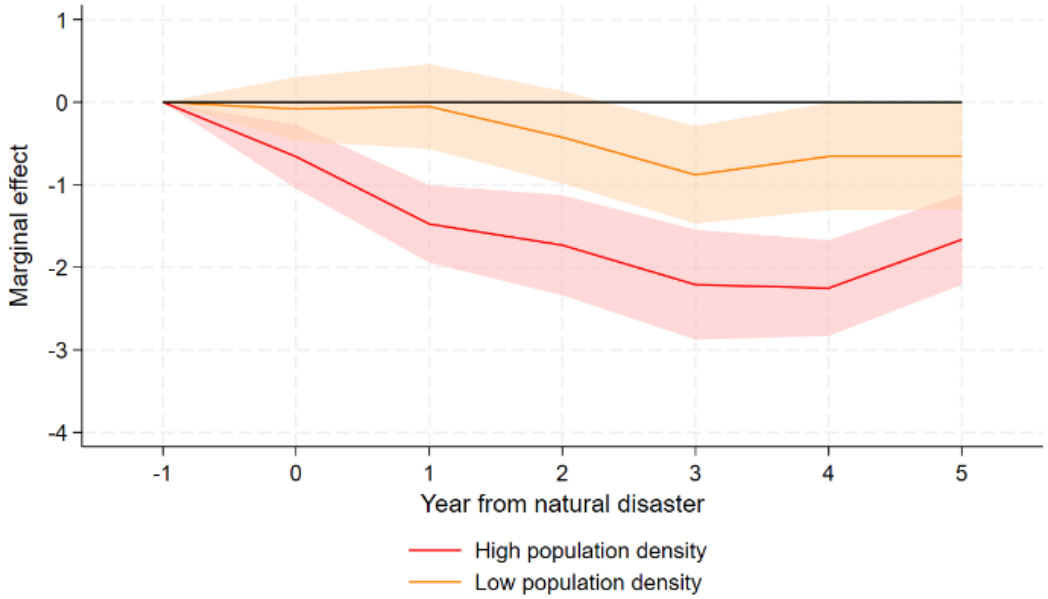
… as do insurance markets and urban planning

Insurance penetration



Developed insurance markets help absorb shocks

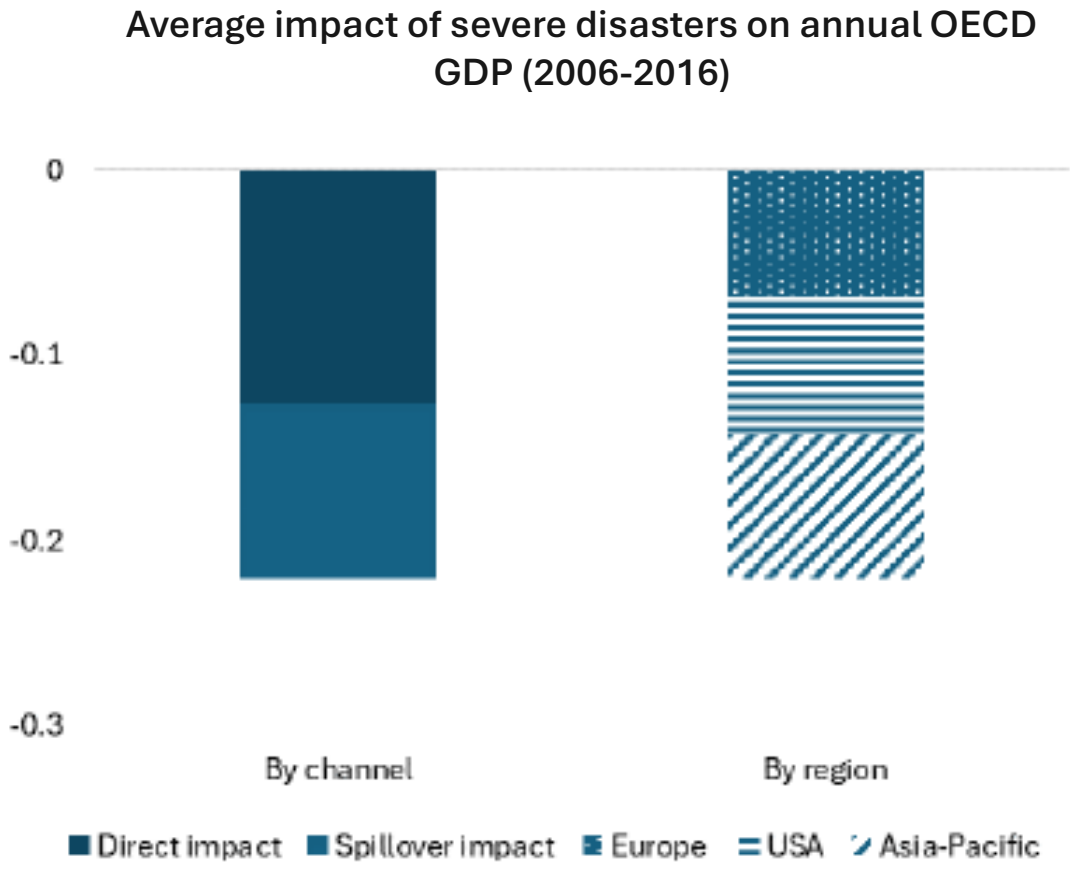
Population density



Less densely populated regions experience smaller impacts

Material impacts on national GDP in OECD countries

- Aggregate impact of historical severe disasters across OECD countries:
  GDP impact of -0.2% per year.
- 60% from direct impacts vs 40% from spatial **spillover effects.**
- **Importance of accounting for the impacts of extreme weather events in climate damage assessments.**



Policy implications

Large costs imply barriers to adaptation actions may require intervention, like subsidies, regulation, information, direct provision	Effective warning systems Adaptive & resillient infrastructure
Spatial impacts matter and are negative	Policy coordination
Dense regions suffer the most	Resilient spatial planning
Insurance penetration significantly reduces costs	Insurance availability and affordability
Fiscal space aids recovery	Sound public finances

Thank you!

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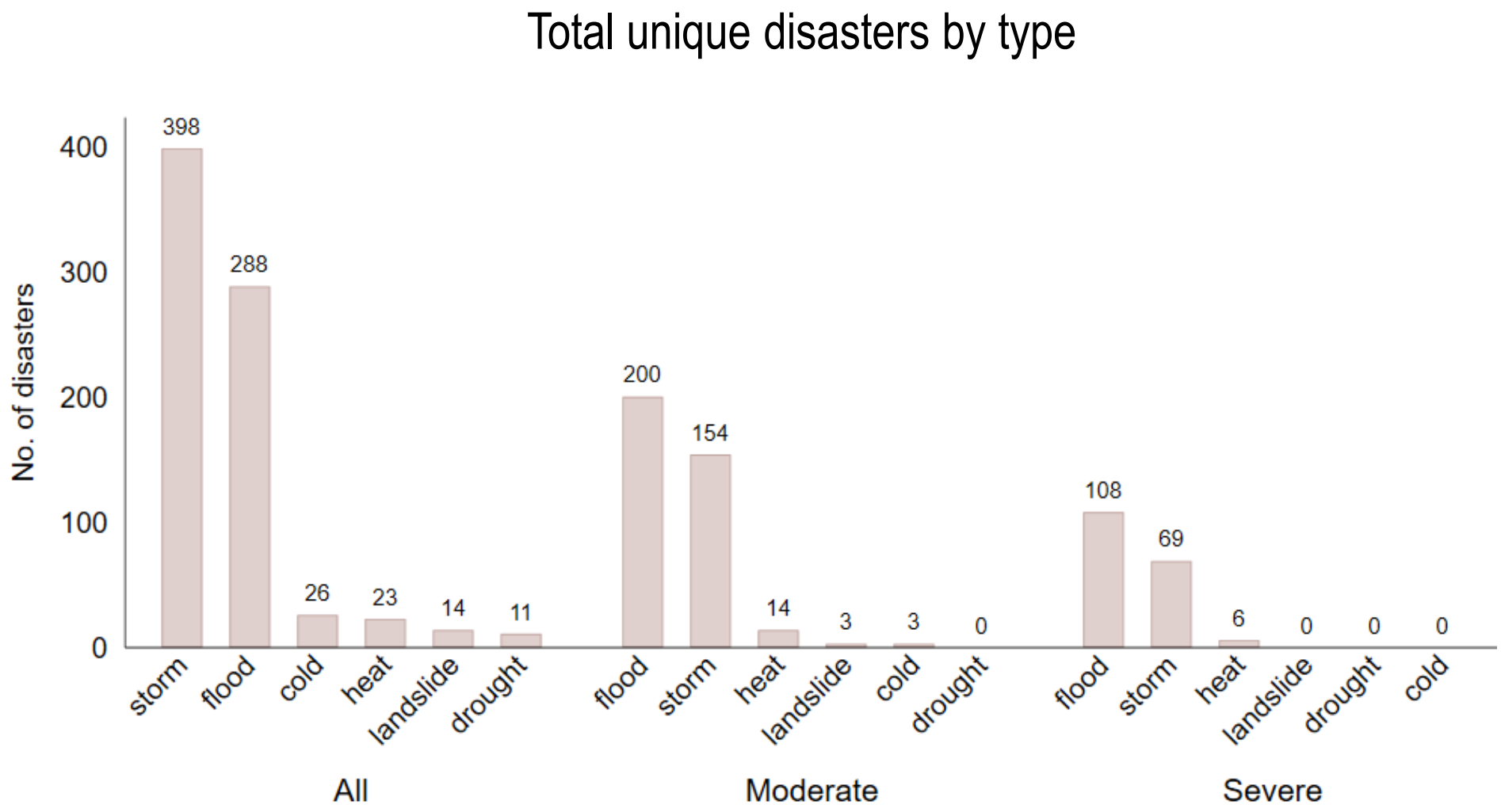
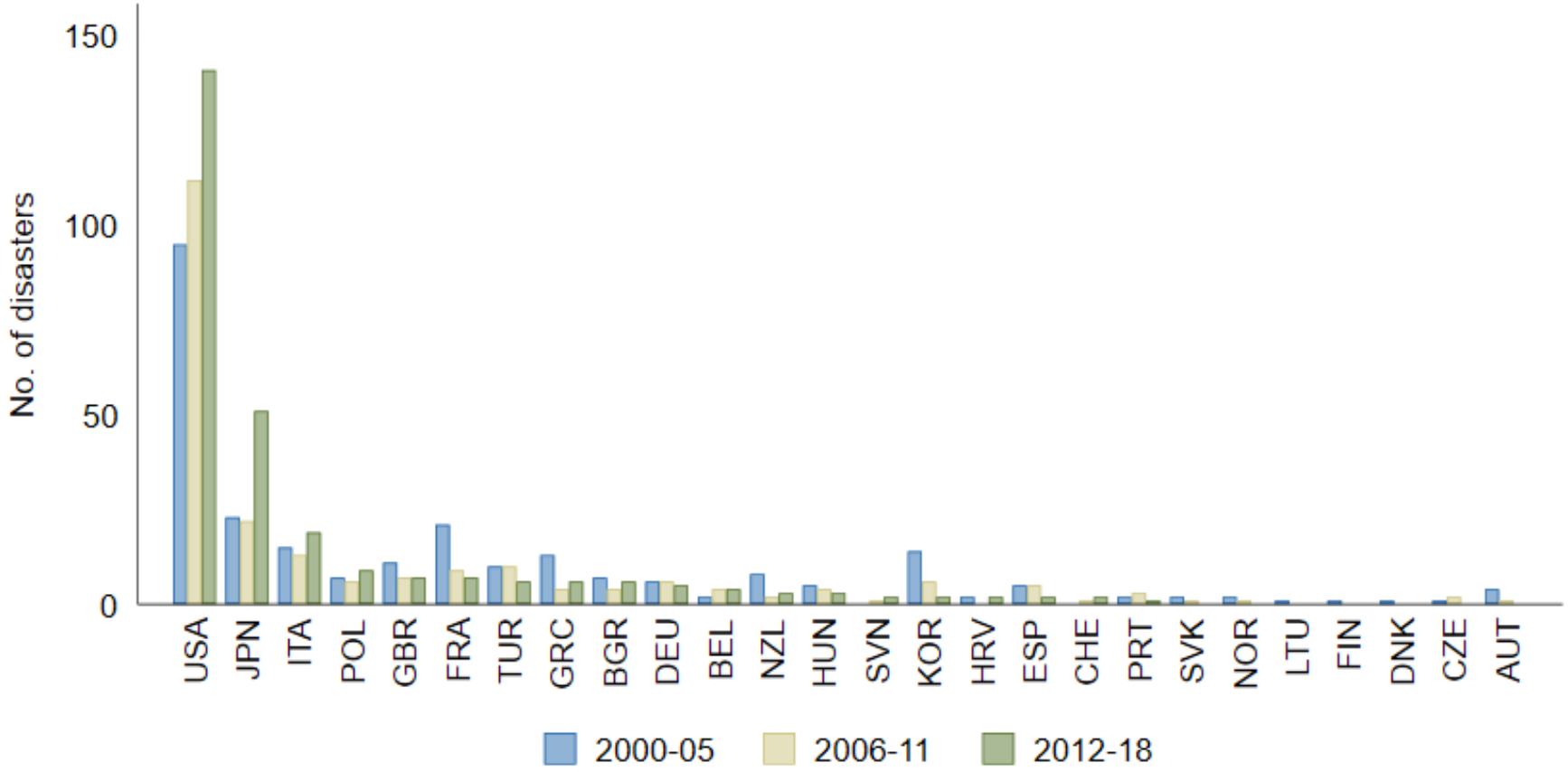
Dataset of disaster-region pairs across OECD countries



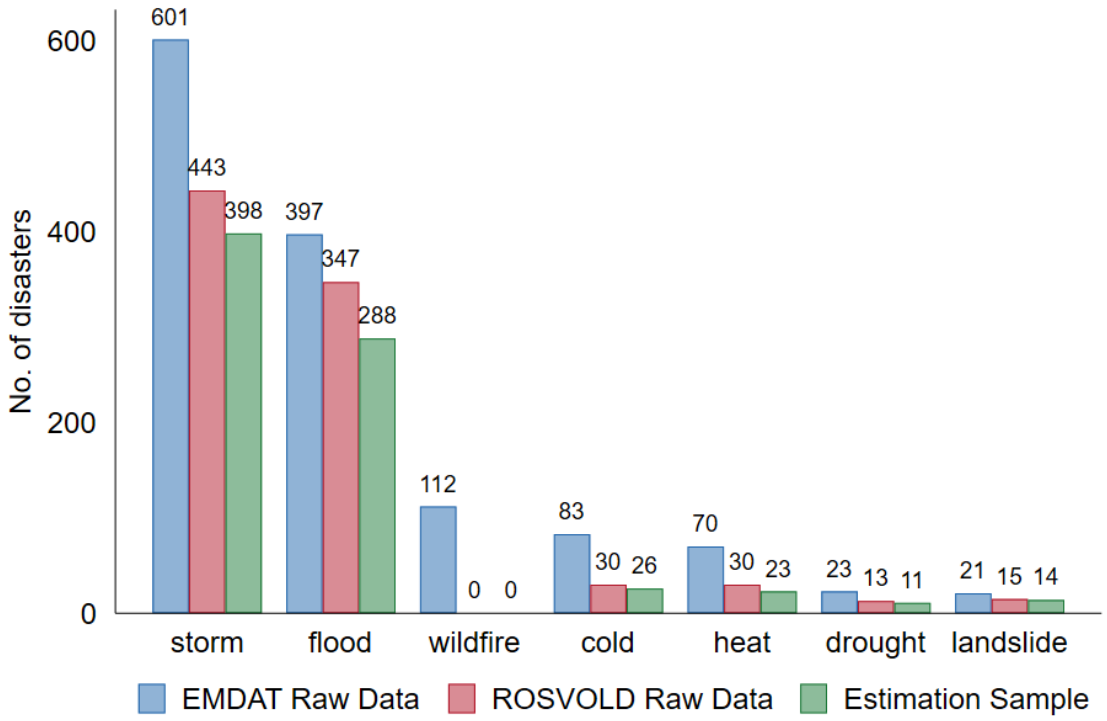
Dataset of disaster-region pairs across OECD countries

Total unique disasters by country



Dataset of disaster-region pairs across OECD countries

Total unique disasters by type of disaster across samples



- Regional and national **macroeconomic & demographic** information (GDP, Employment, Population, Migration, Debt): 2000-2021

Regional GDP

- Each disaster affects more than one region: 6210 (all), 1660 (moderate), and 640 (severe) region-disaster observations

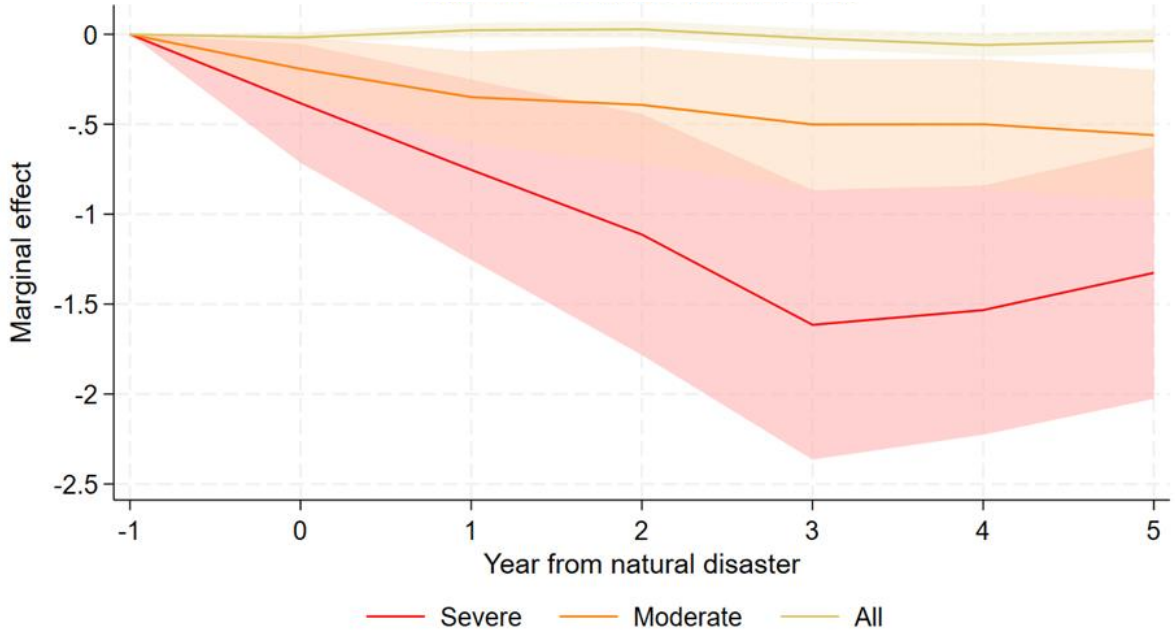
Disaster-region pairs

Final dataset for estimation : 1665 regions across 33 countries for the years 2000-2021

Robustness

Alternative clustering

Panel A: Conley standard errors



Panel B: Clustering at larger TL2 region level