Economy-wide and international spillovers of the economic impacts of climate change

Topic: Input-Output Modelling: Disaster analyses (1)
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Quantifying the macroeconomic impacts of climate change remains methodologically contentious. Top-down econometric estimates often imply substantially larger damages than bottom-up structural assessments, and recent empirical work has renewed this divergence. This paper asks three interrelated questions: (1) How do top-down and bottom-up climate damage estimates compare when implemented within a consistent global structural framework? (2) What is the relative contribution of different impact channels and production factors to aggregate and sectoral outcomes? (3) How large are international spillovers of climate damages transmitted through global trade and value chains?

To address these questions, we implement alternative climate damage functions in the global recursive-dynamic computable general equilibrium (CGE) model ENVISAGE. The model is calibrated to the GTAP-Power 11 database (2017 benchmark), aggregated to 27 regions (including 19 G20 economies) and 30 sectors. The baseline follows SSP2 projections of GDP and population growth to 2050. We compare two representative damage specifications. The top-down shocks are derived from Casey, Fried, and Goode (2023) and enter the model as total factor productivity (TFP) changes. The bottom-up shocks build on Roson and Sartori (2016), complemented with updated evidence, and are implemented across six biophysical transmission channels: agricultural yield changes, land availability due to sea-level rise, heat impacts on labor productivity, health effects, livestock heat stress, and tourism impacts. The modeling framework allows factor- and sector-specific implementation of damages and systematic decomposition of results.

The analysis makes three contributions. First, we provide a comprehensive decomposition of bottom-up climate impacts across transmission channels, quantifying their direct, indirect, and interaction effects at sectoral and economy-wide levels. Second, we assess international spillovers of climate damages under both approaches, tracing how shocks propagate across countries through trade linkages. Third, we decompose top-down TFP shocks across production factorsâ€”capital, labor, land, and intermediate inputsâ€”highlighting how factor coverage choices affect results.

At the global level, both parameterizations yield comparable aggregate GDP losses by 2050 (approximately 0.4â€“0.6% relative to a no-climate-impact baseline). However, their temporal profiles and structural transmission mechanisms differ. Bottom-up shocks generate stronger near-term impacts, while top-down damages become relatively larger toward mid-century. Importantly, decomposing top-down shocks reveals that intermediate inputs account for the largest share of aggregate damagesâ€”exceeding the combined contribution of capital, labor, and land in many regions. Excluding intermediate inputs substantially dampens both the magnitude and dispersion of country-level impacts.

Channel decomposition further demonstrates strong cross-channel interactions. In agriculture, yield losses alone explain less than 15% of total sectoral damages once economy-wide spillovers are considered; even combining yield and labor productivity effects captures less than two-thirds of total agricultural impacts. No single channel accounts for more than three-quarters of total damages in any sector, underscoring the importance of comprehensive multi-channel modeling. Finally, international spillovers materially shape national outcomes: climate damages transmitted via trade and value chains significantly amplify or offset domestic effects, depending on countriesâ€™

sectoral specialization and trade exposure.

Overall, the results show that similar aggregate GDP impacts can mask substantial methodological differences in transmission channels, factor coverage, and international spillovers. By systematically comparing top-down and bottom-up damage functions within a unified global CGE framework and decomposing impacts across channels and production factors, this study advances methodological transparency in climate-economic assessment and provides guidance for future model-based evaluations of adaptation and mitigation policies.