Climate Damage Spillovers through Production and Investment Networks

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Abstract

Recent evidence suggests that climate damages are far larger when measured with global rather than local temperature, and that national economies suffer from weather abroad. Which channels carry such damages across borders, and how large can they be? We study sector-specific climate damages, entering production multiplicatively, in a multi-region, multi-sector DSGE model with production and investment networks, centred on the euro area and the United States. At first order, a foreign damage reduces domestic real income through the terms of trade and the networks; by the estimates of Strobel (2026), this exposure has risen sharply with integration. We discipline the model with two observed climate shocks whose international transmission is documented: global harvest shocks, which move world food prices and euro-area inflation, and El Niño, whose probabilistic forecasts make both the anticipation of damages and the uncertainty around them observable. We thus distinguish realised damages, news about future damages and uncertainty about them. We then quantify three further effects: the nonlinear amplification of large, simultaneous damages under the complementarities we estimate; the difference between damages to output and damages to capital, whose reconstruction demand runs through the investment network; and the share of the gap between global and local damage estimates that trade and networks can account for.

Motivation and question

Two recent findings have changed the assessment of climate damages. Bilal and Känzig (2026) find that one degree of global warming lowers world GDP by more than 20 percent in the long run, an order of magnitude more than estimates based on country-level temperature; they attribute the difference to the strong correlation of global temperature with extreme events. Neal, Newell and Pitman (2025) add global weather to standard growth regressions and find that projected losses in world GDP by 2100 under a high-emissions scenario rise from about 11 to about 40 percent, because trade insulates against local but not against simultaneous shocks. Both findings are reduced-form: they show that damages travel across borders, not through which channels or how far.

We ask:

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> How much of the harm that climate damages and climate uncertainty do to a country originates abroad, and how do trade, production and investment networks transmit – and, for large shocks, amplify – it?

The question matters for policy because physical-risk scenarios at central banks typically map damages country by country, and because the damage functions behind them are uncertain: the retraction of a widely used estimate in 2025 led the Network for Greening the Financial System to caution users of its scenarios. A structural model can say which share of a country's exposure comes from abroad and which mechanisms decide it, largely independently of the level of the damage function.

Approach

Model. We build on EMuSe, the environmental multi-sector DSGE model developed at the Deutsche Bundesbank (Hinterlang et al., 2023). Sectors are linked within and across regions by an input-output network for intermediates and an investment network that records which sectors supply the capital goods of which buyers. The number of regions and sectors is a design choice: isolating the regions most exposed to a given shock – major agricultural exporters, or the economies hit directly by El Niño – from the euro area, the United States and the rest of the world calls for three or four regions, which we weigh against sectoral detail, also with a view to the nonlinear solution. Goods from different regions are imperfect substitutes, and each region's trade is balanced in the aggregate. EMuSe's damage function is so far the same across sectors and European countries; we make it sector- and region-specific.

Damages. Output damages enter each sector's production multiplicatively, as in Nordhaus:

$$Y_{s,t} = (1 - D_s(T_t))\, F_s(\cdot)$$

Capital damages reduce the sectoral capital stock, and its reconstruction is built through the investment network:

$$K_{s,t+1} = (1 - \delta)\, K_{s,t} \left(1 - D_s^K(T_t)\right) + I_{s,t}$$

Temperature paths are exogenous and follow standard emissions scenarios. Because the level of damages is uncertain, we bracket it with a low calibration in the spirit of Nordhaus and a high one consistent with Bilal and Känzig, and we let the sectoral pattern follow the exposure of agriculture, construction, outdoor work and energy.

Data and parameters. Production and investment networks come from the OECD inter-country input-output tables and the EU KLEMS and INTANProd capital accounts, as constructed in a companion paper (Strobel, 2026), aggregated to the regions and sectors each question requires. We use its estimated elasticities of substitution, which lie below one.

Solution. Realised damages and news about future damages enter at first order in the full network model, which delivers the incidence decomposition; a perfect-foresight solution of the nonlinear model handles large and persistent damages. Uncertainty – a time-varying probability of large damages under Epstein-Zin preferences – requires a higher-order or global solution, which we compute in a condensed version with fewer sectors and regions.

Discipline from observed climate shocks

Before applying the model to warming scenarios, we confront it with climate shocks whose international transmission has been estimated.

- **Global harvest shocks.** De Winne and Peersman (2016) build a global index of food production and find that a rise in world food commodity prices lowers US output by about twice as much as an oil price increase. Using global harvest shocks as an instrument, Peersman (2022) finds that food commodity price shocks explain almost 30 percent of medium-term euro-area inflation volatility, through the food chain, a depreciation of the euro and rising wages. Across 75 countries, harvest and weather shocks abroad depress activity more in advanced economies and less in net agricultural exporters, through the terms of trade; the effects are a multiple of the share of food in household spending. In our model these are productivity shocks to agriculture in the regions where harvests fail. Matching the estimated responses disciplines the transmission channels, and the networks and wage dynamics offer an explanation for why the effects exceed the food share.
- **El Niño.** Cashin, Mohaddes and Raissi (2017) find heterogeneous effects: directly hit economies such as Australia, India and Indonesia lose output, while the United States gains directly and Europe through spillovers from its trading partners, with commodity prices and inflation rising. Callahan and Mankin (2023) find losses that are disproportionate and persistent for strong events. Because El Niño is forecast months ahead with stated probabilities, it separates the anticipation of damages from their realisation: revisions of the forecasts serve as news about damages, and the forecast probabilities discipline a time-varying risk of large damages (Gourio, 2012) for the analysis of uncertainty.
- **Synchronised breadbasket failures.** Certain jet-stream patterns raise the risk of simultaneous heat waves across major breadbaskets (Kornhuber et al., 2020), and the probability of multiple failures in wheat, maize and soybeans has risen (Gaupp et al., 2020). Trade smooths a failure in one region but not simultaneous failures – the large, correlated shock for which contribution 3 measures nonlinear amplification.

Expected contributions

1. The cross-border incidence of damages, and its rise with integration. At first order a damage is a negative productivity shock, so the transmission analysis of Strobel (2026) applies directly. There, the response of German real income on impact to a uniform productivity change in all sectors abroad, per unit of the domestic Domar weight, rose from 0.34 with the 1995 networks to 0.50 with the 2019 networks, while the response to the same change at home fell from 0.76 to 0.62. Read as damages, the foreign part of the real-income loss from a uniform global damage rose from about 31 to about 45 percent. For a uniform global damage the national loss stays close to the GDP measure; sector- and region-specific damages – heavier in agriculture and in warmer regions – shift it through the terms of trade. We quantify this redistribution across damage scenarios.

2. How much of the global-local gap can trade and networks explain? Setting a simultaneous global damage against a local one of the same size gives the share of national losses that arrives through trade and networks. Set beside the reduced-form gap between global and local estimates, this shows how much of that gap transmission can account for, and how much must come from the extreme events that Bilal and Känzig emphasise.

3. Nonlinear amplification of large damages. By Hulten's theorem the networks do not change aggregate damages at first order. With the elasticities below one that Strobel (2026)

estimate, complementarities amplify large negative shocks at second order (Baqaee and Farhi, 2019). Climate damages are large, simultaneous and persistent; we measure the amplification against the first-order solution and against an aggregate Nordhaus damage function.

4. Damages to capital and reconstruction. A damage to the capital stock creates reconstruction demand. The investment network decides who meets it – domestic construction, domestic or imported equipment – and thereby how the burden is shared across borders and how the terms of trade and inflation respond. We compare this with an output damage of the same size.

5. Anticipation and uncertainty. Climate damages are partly foreseen. News about future damages – an El Niño forecast, for instance – can move investment, the terms of trade and real income before any damage occurs, at home and, through the networks, abroad. We measure these anticipation effects against those of realised damages, and ask whether uncertainty about the realisation adds materially to them; this second-moment analysis uses a condensed version of the model and the dispersion implied by the forecast probabilities.

Relation to the literature

We connect three literatures that have so far been studied apart.

- **Reduced-form damages across borders.** Bilal and Känzig (2026) and Neal, Newell and Pitman (2025) show that damages are much larger once global conditions are accounted for. We provide the structural channels and an upper bound on what trade and networks contribute.
- **Propagation of physical risks through input-output linkages.** Fahr, Senner and Vismara (ECB Working Paper 2942) combine country-level GDP-at-risk with a global input-output model built on the same OECD tables; studies of floods and of heat in agriculture find propagation along supply chains. These approaches simulate quantities. We add prices, the terms of trade, an investment network and the distinction between real income and real GDP, which decides national incidence.
- **Climate change in quantitative spatial models.** Conte, Desmet, Nagy and Rossi-Hansberg (2021) and Cruz and Rossi-Hansberg (2024) study adaptation through trade, specialisation and migration over centuries. We focus on the macroeconomic horizon of years to decades, with production and investment networks.

On the modelling side we draw on the nonlinear production-network literature (Baqaee and Farhi, 2019) and on the multi-sector models used at central banks for climate analysis, which have so far concentrated on transition risk.

Status and timeline

The model, the networks and the elasticities exist and are documented in Strobel (2026); its transmission machinery delivers the first-order incidence results of contribution 1 directly. The sector- and region-specific damage functions and the capital-damage block are the new elements.

- **Winter 2026/27:** damage scenarios and first-order incidence results for the euro area and the United States.

- **Spring 2027:** nonlinear solution for large damages; capital damages and reconstruction; news about damages; the condensed model for uncertainty.
- **June 2027:** complete draft for the seminar.

The paper is not under consideration elsewhere.

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