



Long-Term Legacy of Climate Overshoot on Economic Productivity: An Emulator-Based Modeling Approach

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Most climate change mitigation scenarios aimed at limiting end-of-century warming to 1.5°C involve overshoots, that is they temporarily exceed 1.5°C of warming. Despite the prevalence of overshoot pathways, their effects on economic productivity have not been systematically assessed yet. Furthermore, existing assessments of future economic risks do not systematically explore the full spectrum of physically plausible outcomes under given emission pathways and thereby run the risk of underestimating high-end risks. In this study, we rely on coupled climate model emulators representing the full physical climate uncertainty chain to assess the GDP per capita growth under a range of policy relevant emission scenarios, seven of which are characterized by overshoot.

Using the emulators FaIR and MESMER, the emission scenarios were translated into a large ensemble of spatially resolved annual temperatures that captures both model uncertainty and natural variability on both global and local scales. Building on standard approaches to empirically estimate the effect of temperature on GDP per capita growth, we incorporate parametric uncertainties in the economic response and link these empirical estimates with the overshoot scenarios. The resulting dataset allows for the examination of local and regional impacts (and associated uncertainties) of overshoot scenarios on economic productivity, including the timing and magnitude of temperature threshold exceedance.

We find a legacy of overshoot in future GDP gains way beyond the end of the temperature overshoot. We also report heavy tailed risks of economic damages when considering the full range of plausible physical outcomes. Under all but the most stringent scenarios there is a non-negligible risk for near-stalling of 21st century per capita growth for particularly vulnerable countries.

We find that near-term warming rates (2020-2040) play a pivotal role in shaping future GDP per capita gains. Across overshoot scenarios, by 2100 GDP per capita levels are lower with rising warming rates, while the magnitude of the GDP per capita gain is linked to the extent of the overshoot. Our results highlight the critical importance of near-term emission reductions to limit economic risks posed by climate change over the 21st century. A temperature overshoot poses substantial risks of a long-term legacy of economic damages for decades to come.