Positive Externalities in the Polycrisis: Effectively Addressing Disaster and Climate Risks for Generating Multiple Resilience Dividends

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Supplementary material: Assumptions and set-up of NICE model analysis

Modeling results presented in Section 3.2.2 were obtained with the use of the Nested Inequality Climate Economy model (NICE), originally introduced by Denning et al. (2015). Here, we use a later version of the model from (Budolfson et al. 2021), implemented in the Julia programming language, within the Mimi integrated assessment modeling framework (https://www.mimiframework.org).

The NICE model is derived from the RICE model (Nordhaus, 2010), a multi-regional medium-complexity benefit-cost optimizing integrated model (BC IAM), geared towards finding an optimal balance between benefits of avoiding adverse effects of climate change in the future and costs of climate mitigation and adaptation action. The NICE model is the extension of, featuring heterogenous populations of 12 RICE regions split into 5 income strata each. Stratification of population by income allows for modeling differentiated impacts of climate damages on richer and poorer sectors of societies. The distribution of climate damages in the NICE model is governed by the constant elasticity of damage parameter ξ. In our study, we set $\xi = 0.5$, in which case climate damages in absolute terms fall mostly on richer strata, as they control more capital, but in relative terms, they disproportionately affect poor.

Policy options available in the NICE model include investment of capital either as inputs to production (savings) or in emission reduction technologies (mitigation). Uninvested capital is consumed, with shares of gross consumption allocated to income strata of regions' populations proportionally to the current level of income inequalities. In our analysis, following (Budolfson et al. 2021), we keep saving rates constant at the level of 25.8%. Regional mitigation policies are based on the global carbon tax, which is optimized to maximize discounted social welfare function (with annual discount rate $\rho = 1.5\%$), the value of which is determined by the levels of utility of consumption attained by individuals in each income distribution quintile across all 12 regions represented in the model. Here we assume utility to be a power function of per capita consumption (with parameter of elasticity of marginal utility of consumption $\eta = 1.5$).

In our study, we consider two scenarios: optimal discounted utilitarian (DU) policy and optimal discounted prioritarian (DP) policy. In the DU scenario, the carbon tax is set in a way which maximizes total welfare, i.e., the sum of individual utilities. The carbon tax is assumed to be revenue- and distribution-neutral, i.e., all collected tax is returned to payers in proportion to their taxed consumption. This is a standard optimal policy considered in the IAM literature, allowing to account for income-related exposure to climate risk (Denning et al. 2015) and the benefits of redistributive interventions to compensate for disproportionate damages, e.g., by recycling revenue of carbon tax (Budolfson et al. 2021). The downside of the strategy of total welfare maximization, however, is that it is insensitive to patterns of utility distribution, which is questionable from the justice and fairness perspective.

The second policy, DP, addresses this deficiency of DU approach. Like discounted utilitarianism, DP approach prefers policies delivering higher discounted stream of welfare but prioritizes improvements to the welfare of disadvantaged groups over comparable welfare

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improvements for the better-off social strata. In DP secnario, the carbon tax is chosen to maximize the prioritarian social welfare function (Adler 2011):

$$\sum P_{t,i,j}(1-\gamma)^{-1}u_{t,i,j}^{1-\gamma}\,(1+\rho)^{t}$$

where $P_{t,i,j}$ and $u_{t,i,j}$ denote, respectively, population and utility of per-capita consumption in income quintile j of region i at time t. The parameter γ is interpreted as inequality aversion, or "marginal rate of moral substitution" (Adler 2011, p.358). If $\gamma = 2$, the above social welfare function becomes the total welfatre. In our analysis, we set γ to 1.5, which is a mild aversion to inequality. Moreover, the carbon tax revenue is distributed on equal per capita basis. This reduces burdens of climate action on poor and allows to reduce income inequalities within regional populations.

References

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