Removing the Carbon: Optimal emission reductions and carbon dioxide removal in the DICE-2023 model

Jonathan Steininger* Wilfried Rickels†

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Abstract

Atmospheric carbon dioxide removal (CDR) is considered essential for ambitious climate policy and to compensate for expensive-to-eliminate industrial CO_2 emissions. Detailed analysis of different nature-based or rather technical CDR methods is mainly provided by large-scale integrated assessment models derived as part of cost-efficient climate policies to meet certain temperature targets. The consideration of CDR in cost-benefit climate policies is still in its infancy and is primarily limited to generic investigations of CDR. Here, we augment the carbon cycle representation in the most recent version of the DICE model, a neoclassical growth model, and introduced different CDR methods with different carbon storage pathways, direct air carbon capture and storage (DACCS), ocean alkalinity enhancement (OAE) and ocean iron fertilization (OIF). We show that emission reduction through abatement still provides the primary source of tackling climate change efficiently. However, CDR provides great economic use after the complete phase out, and hence after emission reduction can not reduce climate change damages anymore. CDR acts as a tool to bring temperatures after phase-out to pre-industrial levels faster and therefore reduce climate change damage significantly in the long run. While efficient CDR employment has only a minor impact on the SCC in the short run, CDR can decrease the SCC in the long run significantly. We show that the main CDR contribution in our model is provided by DACCS and OAE while OIF is too limited in potential to impact global temperatures. Furthermore, we show how different carbon cycle calibrations impact the efficient deployment level of in particular ocean-based CDR methods, indicating that with rather simple box-model representations, important characteristics of different carbon removal pathways can be analyzed.

Keywords: carbon dioxide removal, climate change mitigation, integrated assessment models, carbon cycle calibration
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*Toulouse School of Economics, Université Toulouse Capitole and Kiel Institute for the World Economy, Kiel, Germany.
†Kiel Institute for the World Economy, Kiel, Germany.