

Carbon dioxide removal and directed technical change*

Rik Rozendaal Sjak Smulders
Leiden University Tilburg University

January 16, 2026

Abstract

To meet climate goals novel carbon dioxide removal (CDR) technologies are needed, which are currently too expensive to be competitive. This paper proposes an economic model that features directed technical change and CDR, which is modeled as a public good. Climate change can be mitigated by emission reductions and by removals. Climate policies impact researchers' decisions whether to innovate in clean energy, dirty energy or CDR. We show that the socially optimal pathway involves immediate investment in CDR research while postponing deployment until costs converge with emission reduction, typically late in the century. If R&D cannot be subsidized independently, early deployment becomes necessary to trigger cost reductions, even at high initial costs. Our analysis provides policy insights on the timing of CDR deployment, temperature overshoot and the inefficiency of integrating CDR into carbon markets under certain constraints.

*Email: r.l.rozendaal@law.leidenuniv.nl and j.a.smulders@tilburguniversity.edu. We thank conference and seminar participants at the University of East Anglia, Tilburg University, DEARE Day (Wageningen), the Energy and Climate Economics and Business Days (Groningen), the Workshop on Climate Change and Economic Growth (Aarhus) for excellent comments and suggestions.