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CO_2 removal and 1.5°C: Sharing the Gains from Interregional Cooperation using a Game-Theoretic Approach

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Abstract

Under the 2015 Paris Agreement, most nations have committed to limiting global warming to well below 2°C, and ideally to 1.5°C above pre-industrial levels [1]. To achieve this, the latest IPCC Special Report on Global Warming of 1.5°C [2] has demonstrated that carbon dioxide removal (CDR) — the direct removal of CO_2 from the atmosphere — will be an indispensable component of future climate change mitigation pathways. Among almost all 1.5°C-consistent scenarios, CDR has been estimated to range between 189–1,186 $GtCO_2$ by 2100 in integrated assessment models (IAMs). To attain that target, a mix of technologies will have to be deployed, predominantly on Bioenergy with Carbon Capture and Storage (BECCS) and Afforestation/Reforestation (AR) [2–4] and possibly Direct Air Capture and Carbon Storage (DACCS), ocean fertilization, enhanced weathering (EW), biochar or soil carbon sequestration.

During COP26, the rulebook for Article 6 of the Paris Agreement was completed. It sets market and non-market rules for international cooperation, which is frequently emphasized as critical to achieving a cost-effective deployment of CDR (Fajardy and Mac Dowell, 2020, Torvanger 2019) International cooperation is deemed to make it possible to leverage interregional differences in conditions and endowments to lower the total cost of CDR. However, such cooperation can only succeed if a mutually fair distribution of the costs and benefits can be achieved.

The purpose of this paper is thus to investigate the feasibility of such a cooperation. Our approach follows three successive steps. First, we provide a model-based assessment of the collective gains that can be achieved by such an international cooperation.

Second, we investigate whether the conditions for such a mutually acceptable sharing of that collective benefit hold. Lastly, we evaluate several alternative gain-sharing options and compare their performances.

Our findings convey important policy implications pertaining to the elaboration of relevant, pragmatic recommendations to envisage CDR deployment. They also provide useful guidance to policymakers and international negotiators.

Methods

Our analysis is based on the application of cooperative game-theoretic notions [13]. Cooperative game theory analyses the distribution of gains resulting from cooperation between economic players. Its application requires an application of the cost (respectively benefits) that can collectively be incurred (respectively obtained) by any subgroup of regions. Indeed, if a certain subgroup of regions assesses that it pays more than it could do by itself then this group may abandon the negotiations with the other regions and opt for a stand-alone attitude (i.e., develop its own CDR).

In this paper, we consider a group of regions in Brazil, China, the European Union (EU-27 and the UK), India and the United States. To compute the costs and benefits obtained by each region and each group of regions, we specify and solve several instances of a detailed, large-scale model. We use the Modelling and Optimization of Negative Emissions Technologies (MONET) framework [14], which determines the least-costly deployment of a portfolio of CDR options across.

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