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On the scope of climate finance to facilitate international agreement on climate change

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ABSTRACT

Can the promise of climate finance help secure an international climate agreement that makes all parties better off? This paper shows that incentive compatible, financial transfers are always feasible and can facilitate a globally efficient agreement if they are bounded by the *net* benefits of avoided climate damages and forgone economic growth. In contrast, climate finance will generally come up short when based on conventional arguments that seek compensation for foregone economic growth, climate damages (i.e., "loss and damage"), or both. Empirical evidence is provided with a calibrated simulation using the C-DICE integrated assessment model.

1. Introduction

Finance plays an increasingly important role in international negotiations about climate change (Zahar, 2017). This is driven in large part by the need for significant financial resources to achieve mitigation and adaptation goals (WEF, 2013). There are, however, political reasons as well. As part of the 2009 Copenhagen Accord, developed countries committed to scaling up public and private climate-related finance targeted for developing countries to $100 billion per year by 2020 (UNFCCC, 2010). This was necessary to overcome a critical impasse to meaningful agreement within the United Nations Framework Convention on Climate Change (UNFCCC): the partition between developed and developing countries (i.e., the partition between so-called Annex I and non-Annex I countries), whereby the former had sole responsibility for global mitigation activities (Bodansky, 2010). Six years later, as part of the 2015 Paris Agreement, both developed and developing countries made commitments to reduce greenhouse-gas emissions, but only after reaffirming that developed countries would follow through on their prior financial commitments and agree to even greater amounts through 2025 (UNFCCC, 2016). While debate continues about the type of financial flows that should count, and how they should be measured (Westphal et al., 2015; Oliver et al., 2018; Weikmans and Roberts, 2019), the role of climate finance becomes more important with each ensuing Conference of the Parties (COP).

This paper provides a framework for evaluating the feasibility of climate finance to facilitate international agreement. Can the promise of climate finance help secure an agreement that makes all parties better off? The question is considered in a setting where climate finance represents a form of international transfers, and individual countries must agree on the extent to which they and all others reduce emissions.

The conceptual model yields two main findings. The first is that financial transfers are always feasible and can facilitate a globally efficient climate agreement if they are bounded by the *net* benefits of avoided climate damages and forgone economic growth. Nevertheless, the most common arguments in support of international climate finance typically appeal to different rationales: compensation for foregone economic growth, compensation for climate damages (i.e., "loss and damage"), or both. While such compensation might take the form of simple transfers, it can also represent payments to fund mitigation or adaption activities, where the latter is taking on greater importance in the context of international negotiations. The second and more novel finding is that climate finance based on these alternative benchmarks will generally not be feasible in a way that is incentive compatible and helps facilitate an efficient agreement. Empirical evidence of these main findings is provided with a calibrated simulation using the C-DICE integrated assessment model (Nordhaus, 2015).

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2. Conceptual model

A simple, static model is sufficient to illustrate the fundamental insights. Assume there are $n \geq 2$ countries indexed $i = 1, \ldots, n$. Each country has emissions x_i. The aggregate level of emissions, $X = \sum_{i=1}^{n} x_i = x_i + X_{-i}$, is a global public bad. This means that any country's emissions affect all countries. The damages of aggregate emissions to country i are $D_i(X) = \alpha_i X$, where $\alpha_i > 0$, and the linearity assumption is made for simplicity. The benefits of emissions in country i are $B_i(x_i)$, where $B_i'(x_i) > 0$ and $B_i''(x_i) < 0$. Both the benefits and damages are measured in equivalent monetary units.

To solve for the globally efficient level of emissions in each country, one must choose x_i for all i that maximizes the global net benefits according to

$$\max_{x_1,\ldots,x_n} \sum_{i=1}^{n} B_i(x_i) - \sum_{i=1}^{n}(\alpha_i x_i).$$

The n conditions that define an interior solution can be combined such that

$$B_1'(x_1^*) = \cdots = B_n'(x_i^*) = \sum_{i=1}^{n} \alpha_i. \quad (1)$$

This means that the marginal benefit of emissions is equated across all countries, and it equals the sum of the marginal damages. The right-hand side of (1) is often interpreted as the global SCC (Kotchen, 2018), and the whole equation is a variant of the classic Samuelson (1954) condition for a public bad.

Each individual country is not, however, concerned with maximizing the global net benefits. It is focused on maximizing its own, according to

$$\max_{x_i} B_i(x_i) - \alpha_i(x_i + X_{-i}),$$

where X_{-i} is taken as given, and the solution will satisfy

$$B_i'(\hat{x}_i) = \alpha_i \text{ for all } i. \quad (2)$$

Eq. (1) defines the efficient level of emissions for all countries, whereas Eq. (2) defines the equilibrium levels. It is straightforward to see that the equilibrium emissions are inefficiently high, that is, $\hat{x}_i > x_i^*$ for all i. This follows because $B_i''(x_i) < 0$ and $\alpha_i < \sum_{i=1}^{n} \alpha_i$. The result also follows intuitively because no country has an incentive to internalize the marginal damages that its own emissions impose on other countries.

With this setup in place, climate finance can play a role as transfers based on the net benefits that countries experience with a shift from equilibrium to efficient emissions. While such a shift could make all countries better-off, this need not be the case. To see this, define the net benefits for each country in the respective scenarios as $\hat{v}_i \equiv B_i(\hat{x}_i) - \alpha_i \hat{X}$ and $v_i^* \equiv B_i(x_i^*) - \alpha_i X^*$. It follows that whether a country is made better- or worse-off depends on the sign of

$$v_i^* - \hat{v}_i = \alpha_i(\hat{X} - X^*) - \int_{x_i^*}^{\hat{x}_i} B_i'(z)dz. \quad (3)$$

The first term is always positive because of lower damages with globally efficient emissions. The second term is negative because of lost benefits that a country experiences from lowering its emissions. The larger the latter relative to the former, the more likely that a country would not benefit from implementation of globally efficient emissions.

An important result, which follows by Pareto optimality, is that solving (1) means

$$\sum_{i=1}^{n}(v_i^* - \hat{v}_i) > 0. \quad (4)$$

This creates the opportunity for climate finance in the form of transfer payments to guarantee that an agreement on globally efficient emissions will be incentive compatible for all countries. In particular, there will always exist a set of transfer payments $(\tau_1, \ldots, \tau_n)$ such that $\sum_{i=1}^{n} \tau_i = 0$ and $v_i^* - \hat{v}_i + \tau_i \geq 0$ for all i, holding strictly for at least one country. In other words, transfer payments in the form of climate finance that are based on the difference in *net* benefits are always possible such that every country can be made better-off with an efficient global agreement. Other papers consider various aspect of equivalent transfers in the context of international climate agreements (e.g., Barrett, 1992; Hoel and Schneider, 1997; Barrett and Stavins, 2003); however, the primary focus here is on the limitations of transfers built on a different foundation.

The two alternative reference points are based compensation for foregone economic growth or for climate damages. A country's foregone economic growth is given by $\int_{x_i^*}^{\hat{x}_i} B_i'(z)dz$. Moreover, conditional on an efficient agreement, each country still experiences climate damages of $\alpha_i X^*$. The question of whether these alternative bases for climate finance within the UNFCCC context are feasible hinges on a comparison between the net benefits in (3) summed over the developed countries and the magnitudes of the other measures summed over developing countries.

Letting N denote the set of developed countries (defined according to some definition), the question of feasibility based on compensation for forgone economic growth depends on whether

$$\sum_{i \in N}(v_i^* - \hat{v}_i) > \sum_{i \notin N} \int_{x_i^*}^{\hat{x}_i} B_i'(z)dz,$$

holds, and nothing guarantees the left-hand side will be greater. The condition for feasibility based on loss and damage depends on whether

$$\sum_{i \in N}(v_i^* - \hat{v}_i) > \sum_{i \notin N} \alpha_i X^*,$$

holds, and again, nothing rules out the possibility for the inequality to hold in either direction.

3. Empirical evidence

A calibrated simulation based on the C-DICE integrated assessment model (Nordhaus, 2015) provides empirical evidence on the amounts and feasibility of the different notions of climate finance. The model's basic functional form and parameterization assumptions are employed, yet all other features of the model are excluded. There are 15 countries (or regions), each of which has its own benefit and damage functions that conform to the properties of $B_i(x_i)$ and $D_i(x_i)$.

In particular, the benefit functions take the form

$$B_i(x_i) = q_i - q_i\lambda_i \left(\frac{\bar{x}_i - x_i}{\bar{x}_i}\right)^2,$$

where q_i is gross domestic product (GDP), λ_i is the abatement cost parameter, and the term in parentheses represents the emissions control rate relative to an uncontrolled baseline, denoted as $\bar{x}_i$. The abatement cost parameter comes from a McKinsey evaluation described in Nordhaus (2015) and represents the averaged values for the 2020 and 2030 estimates. The unscaled values found in Table B-4 of Nordhaus (2015) are used here. It is straightforward to verify that the benefit functions satisfy the required properties for all i at emissions levels $x_i \leq \bar{x}_i$. The setup is such that reducing emissions below baseline levels (i.e., abatement at levels $\bar{x}_i - x_i$) has a cost in terms of lower GDP, and the translation to costs differs across countries according to λ_i.

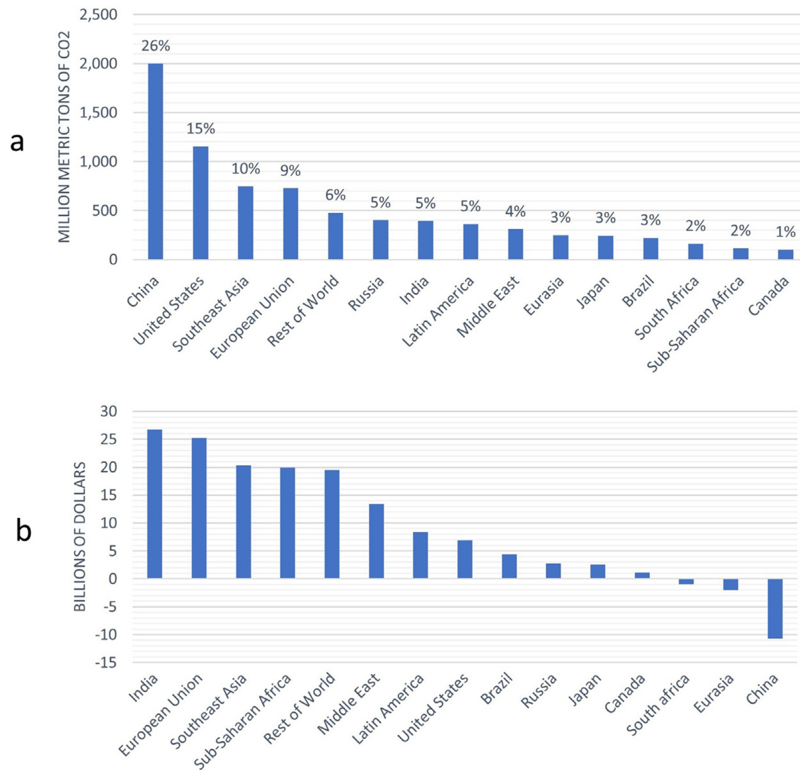

Fig. 1. The reduction in emissions for each country or region when moving from the initial equilibrium to globally efficient emissions, along with the respective percentages of the total emissions reduction (panel a). The net benefits to each country or region of moving from the initial equilibrium to globally efficient emissions, measured in 2011 US$ (panel b).

Damages for each country follow the linear specification, $\alpha_i X$, where each country experiences a portion α_i of the global SCC equal to $\sum_{i=1}^{15} \alpha_i$. The proportional shares of the SCC are based on an averaging of those used in several different models, including DICE, FUND, and PAGE, as described in Nordhaus (2014). They are near proportional to the GDP of each country or region, with deviations based on assessments of geographic differences in susceptibility to climate damages. For the global SCC, the results here are based on an estimate of $40US, which is approximately in line with the United States Government's Interagency Working Group (IWGSSC, 2013) estimates. Other estimates are easy to employ and generally just rescale the magnitude of the main results. The model is calibrated to the base year of 2011, as in the original C-DICE setup.

The globally efficient level of emissions is 22 percent lower than the equilibrium level of emissions. The largest share of the reduction comes from China (26 percent), followed by the United States (15 percent) Southeast Asia (10 percent), and the European Union (9 percent) (Fig. 1a). Most countries experience a positive net benefit (Fig. 1b). Those that do not are China, Eurasia, and South Africa because of relatively high abatement costs, low benefits from avoided climate damages, or both. Nevertheless, as established in Eq. (4), the overall gains exceed the losses. The numerical results show that the condition is satisfied by a wide margin and which countries would need compensation.

Turning to the alternative benchmarks for climate finance, the developed and developing countries are treated differently. I use the UNFCCC historic definition of the Annex I and non-Annex I partition to distinguish between the two sets of countries, respectively. Transfers are assumed to come from developed countries to compensate developing countries for foregone economic growth or climate damages. It turns out, however, that the net benefits accruing to the developed countries are insufficient to cover the foregone GDP to the developing countries (Fig. 2a). China experiences the greatest loss ($44B), which is itself greater than the combined net benefits to all the developed countries ($36.6B). This means that compensation based on this criterion is not feasible within the context of redistributing benefits from a globally efficient agreement. The same result applies when considering the loss and damage criterion, but the shortfall is far greater in this case (Fig. 2b). The net benefits to all developed countries is only 5 percent of the total climate damages experienced by all developing countries.

Beyond providing insight into the relative magnitudes of the different categories of benefits and costs, these results underscore the important political economy implications of any given country being designated developed or developing. While the partition between groups is unclear in some of the more recent climate negotiations, the UNFCCC's historic designation of Annex 1 or non-Annex 1 continues to hold sway and determines the negotiating starting point for whether a country is to pay or receive compensation. Nevertheless, with compensation based on the overall net benefits, the results show how all countries can be made better-off without any reliance on such partitioning.

4. Conclusion

This paper identifies the potential scope of climate finance to serve as transfer payments that can facilitate an efficient international agreement to address climate change. The framework identifies limitations of basing climate finance on anything other than the overall net benefits of an agreement that accounts for both economic growth and climate damages. Importantly, the analysis shows how nothing guarantees sufficient scope for compensating payments based solely on foregone economic growth or loss and damage. Indeed, results of the calibrated simulation suggest such payments are not incentive compatible because donor countries do not benefit enough from having an agreement

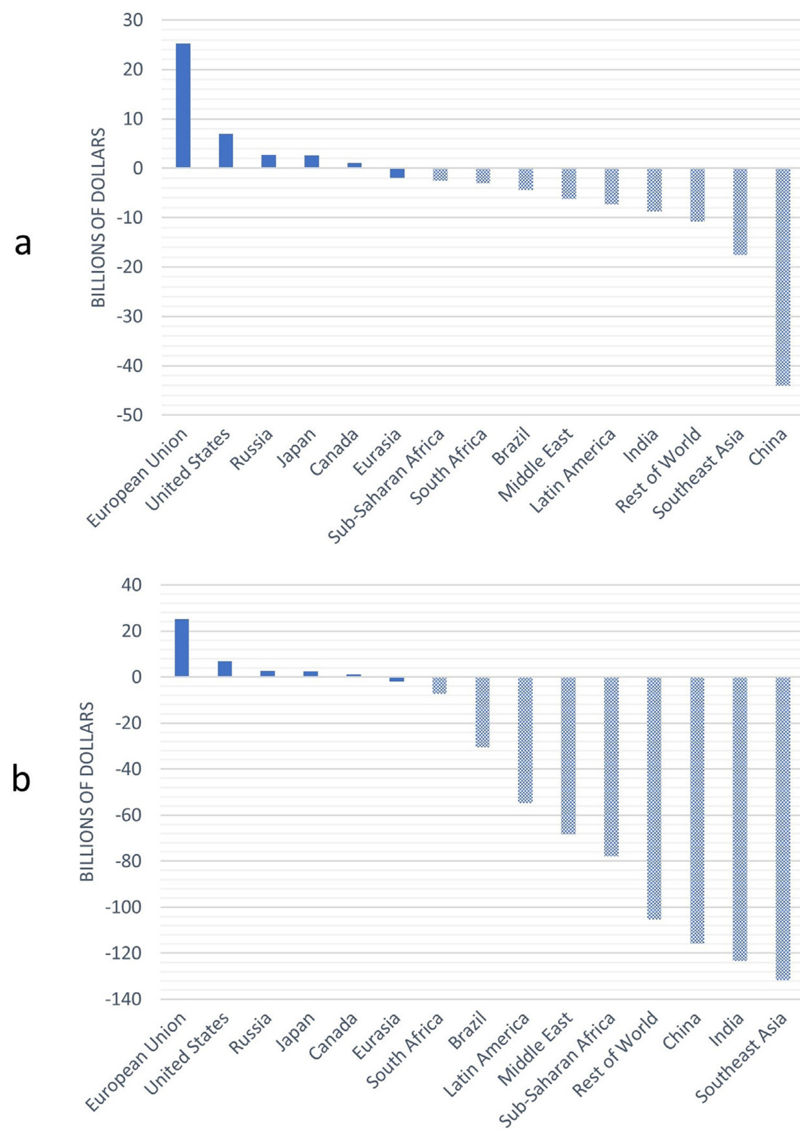

Fig. 2. The net benefits to developed countries or regions (Annex I in solid) of moving from the initial equilibrium to globally efficient emissions. These benefits are less than the foregone economic growth (panel a) and climate loss and damage (panel b) to developing countries or regions (non-Annex I in shaded).

to justify the transfers. In contrast, appropriately calibrated climate finance can provide beneficial opportunities for both donor and recipient countries.

Two caveats are worth making in conclusion. The first is that climate finance is treated here as simple transfers based on climate-related outcomes, but climate finance might also directly fund mitigation and adaptation activities, where pressure for greater emphasis on the latter has been increasing over time in international negotiations. In such cases, the benefit and cost functions for recipient countries would be endogenous to financial transfers. Nevertheless, given the relatively small magnitudes of climate finance currently at play, accounting for such effects is unlikely to change the pattern of results presented here, but integrating them in such a framework could be important in future research. The second caveat is to note the implicit assumption that the scope for transfer payments is limited to the net benefits that arise within the confines of an international agreement. The conclusions, therefore, do not account for alternative and potentially important justifications for climate finance that fall outside the model, as would be the case, for example, with notions of climate justice or reparations for historic emissions.

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