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OUTLOOK ARTICLE

Multilateral parametric climate risk insurance: a tool to facilitate agreement about deployment of solar geoengineering?

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ABSTRACT
States will disagree about deployment of solar geoengineering, technologies that would reflect a small portion of incoming sunlight to reduce risks of climate change, and most disagreements will be grounded in conflicting interests. States that object to deployment will have many options to oppose it, so states favouring deployment will have a powerful incentive to meet their objections. Objections rooted in opposition to the anticipated unequal consequences of deployment may be met through compensation, yet climate policy is inhospitable to compensation via liability. We propose that multilateral parametric climate risk insurance might be a useful tool to facilitate agreement on solar geoengineering deployment. With parametric insurance, predetermined payouts are triggered when climate indices deviate from set ranges. We suggest that states favouring deployment could underwrite reduced-rate parametric climate insurance. This mechanism would be particularly suited to resolving disagreements based on divergent judgments about the outcomes of proposed implementation. This would be especially relevant in cases where disagreements are rooted in varying levels of trust in climate model predictions of solar geoengineering effectiveness and risks. Negotiations over the pricing and terms of a parametric risk pool would make divergent judgments explicit and quantitative. Reduced-rate insurance would provide a way for states that favour implementation to demonstrate their confidence in solar geoengineering by underwriting risk transfer and ensuring compensation without the need for attribution. This would offer a powerful incentive for states opposing implementation to moderate their opposition.

Key policy insights

- States favouring deployment of solar geoengineering will need to address other states' objections—unilateralism is implausible in practice
- This might be partially achieved using parametric climate risk insurance based on objective indicators
- A sovereign risk pool offering reduced-rate parametric insurance underwritten by states backing deployment could facilitate cooperation on solar geoengineering deployment
- States favouring deployment would demonstrate their confidence in solar geoengineering by supporting the risk pool
- Opposing states would be insured against solar geoengineering risks and proposing states would be incentivized to guard against overconfidence

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Introduction

Solar geoengineering[1] is a controversial technology and states will disagree about its deployment. The possibly unequal distribution of benefits, costs, and risks arising from deployment is likely to be a key source of

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disagreement. Suppose a state, or group of states, wishes to deploy solar geoengineering while other states oppose deployment. How might states favouring deployment ('proposing states') persuade states opposed to deployment ('opposing states') to reduce their opposition? The latter might reasonably demand that proposing states accept liability for harms or offer some measure of credible compensation. Here we suggest that parametric insurance, or insurance with payouts tied to objective indices, might be employed as an instrument to ease disagreement between states over deployment of solar geoengineering.[2]

Solar geoengineering is the idea that humans might deliberately alter the Earth's radiative balance to offset some of the radiative forcing caused by long-lived greenhouse gases (GHGs), with the goal of temporarily reducing climatic changes for a given level of GHG forcing. Methods of solar geoengineering include dispersal of aerosols into the stratosphere, in order to reflect a small amount of incoming sunlight back to space to offset some of the warming caused by GHGs. Other methods include cirrus cloud thinning, aimed at allowing more heat to escape the atmosphere.

Our article is structured as follows. We first provide a summary of solar geoengineering. We then describe the growth of interest in parametric, or index-based, climate insurance. Third, we describe two main reasons that states might oppose deployment of solar geoengineering. Fourth, we review constraints on unilateral action and the consequent need for international cooperation if deployment is to be stable. With these preliminaries out of the way, we then describe a simple proposal, based on existing parametric insurance schemes, with the potential to facilitate agreement between states over deployment of solar geoengineering. Finally, we reflect on the limitations of this proposal in light of the complex reality of international politics.

Solar geoengineering

Scientific knowledge about solar geoengineering remains limited. The proposed technologies have not yet been developed, and debates over their legal, political, and ethical implications, as well as their costs, are at an early stage. However, evidence from climate models strongly suggests that solar geoengineering has the potential to significantly reduce various impacts of climate change (Kravitz et al., 2014; Moreno-Cruz, Ricke, & Keith, 2012; National Research Council, 2015). Reflecting sunlight is not equivalent to reducing atmospheric concentrations of GHGs, so any method of solar geoengineering will produce a regional redistribution of climate benefits and risks that differs from a world without it.

Predicting the effects of solar geoengineering is inherently uncertain. In the cases where solar geoengineering is applied roughly uniformly on a global basis, which is most plausible for stratospheric aerosols, the climate's response, and the uncertainty in that response, is intimately tied to uncertainty in predicting the climate response to GHGs (Ricke, Rowlands, Ingram, Keith, & Morgan, 2012).

Further, any method of achieving solar geoengineering will involve risks that will be unequally distributed. The risks of solar geoengineering fall into two broad categories: first, the side effects of the method used, such as air pollution or ozone loss; and second, 'substitution risks' arising from the imperfect substitution of solar geoengineering for mitigation to achieve a given reduction in radiative forcing. Regional hydrological changes resulting in floods and droughts are an example of the latter category. These are perhaps the most widely discussed concerns about the climate impacts of solar geoengineering, though the evidence to support these concerns is weak in cases where solar geoengineering is applied roughly uniformly (Irvine et al., 2019; Kravitz et al., 2013).

Parametric climate insurance

Over the last decade, parametric insurance has emerged as a novel form of climate risk management. It has been developed and promoted primarily by the disaster risk management community, led by the World Bank, for whom it has been viewed as an innovative instrument with the potential to help poor and vulnerable households, communities, and countries respond better to the prospect and occurrence of extreme events (World Bank, 2017). Parametric, or index-based, insurance relies on the use of objective environmental indices to protect policyholders from financial loss: if the value of a specific, spatially fixed indicator reaches certain predefined levels, payouts which vary according to previously agreed index-based formulas are automatically triggered to compensate injured parties for damages they are assumed to have suffered (Linnerooth-Bayer & Hochrainer-Stigler, 2015). Traditional loss assessment plays no role, resulting in lower transaction costs but also in 'basis risk,' or the possibility that an index fails to sufficiently reflect actual damages causing real losses to go uncompensated.

Parametric insurance initially took the form of weather derivatives offered by private insurers to protect against crop losses in industrialized countries. The disaster risk community adopted the approach and pioneered a set of small-scale rainfall-based crop insurance programmes intended to bolster the resilience of developing country farmers by protecting them against weather shocks. Such schemes have since multiplied and evolved. Today, three intergovernmental climate risk insurance (CRI) schemes based on indexed disbursement are operated by vulnerable states (backed by private reinsurers) in the Caribbean, Africa, and the Pacific to protect themselves against extreme events like tropical cyclones. These multilateral schemes are steadily expanding in terms of membership (a total 59 sovereign states currently belong to the three risk pools) and available coverage. Payouts in the Caribbean were $61.4 million[3] in 2017.

Parametric insurance, including arrangements among states, is now central in discussions of loss and damage from climate change, where it is distinguished from conventional liability by five key advantages: 1) it does not require causation to be demonstrated—attribution is a nonissue; 2) it can cover catastrophic losses; 3) it is oriented toward protecting against future harms (rather than resolving disputes over past damages); 4) it is fundamentally contractual in that the insured agrees to pay a premium to the insurer in exchange for coverage against one or more contingencies (as opposed to the adversarial nature of legal liability); and 5) it is predictable (Horton, 2018; see also Mechler, Bouwer, Schinko, Surminski, & Linnerooth-Bayer, 2019; and Surminski, Bouwer, & Linnerooth-Bayer, 2016). Since the estimates of future climate risks required for parametric insurance cannot be based solely on historical (actuarial) data, and private insurers might therefore either charge premiums that were unaffordable or consider such risks uninsurable, states and multilateral bodies have provided public backing for these schemes.

Disagreeing about deployment

The reasons countries might object to a proposed deployment of solar geoengineering may be usefully sorted into two broad categories: interests and values.

First, *interests*: a country might object if, according its analysis, the likely effects of the proposed deployment would make it worse off either in an absolute sense, or relative to other countries with whom it competes. In theory, proposing and opposing states may share the view that a proposed implementation scheme would negatively affect the latter. In practice, since solar geoengineering will typically be characterized by significant uncertainty about outcomes, disagreements based on conflicting interests will most likely derive from divergent judgments about expected outcomes.

Divergent judgments about outcomes may stem from multiple sources. One important source is likely to be the concern that pursuing solar geoengineering will reduce incentives to cut GHG emissions—this is often referred to as 'moral hazard,' but 'mitigation obstruction' is a more accurate term (Morrow, 2014). A coastal state, for example, might conclude that deployment of solar geoengineering would result in reduced emissions abatement, greater atmospheric concentrations of carbon dioxide, and more severe ocean acidification, which in turn could damage important fisheries, undermine food security, etc. For this state, such risks may outweigh any expected benefits from solar geoengineering, and lead it to oppose deployment.

Disagreements about the probable distributions of benefits, costs, and risks tied to specific deployment schemes are likely to be a driving force behind conflicting assessments of expected deployment outcomes. Such disagreements will be grounded in differing perceptions of substitution risks such as regional hydrological changes. Additional sources of interest-based objections to solar geoengineering could include concerns about inadequate technological development, the possibility of 'unknown unknowns,' and other issues that lead states to conclude that deployment would leave them worse off.

Second, *values*: objections to deployment might be based on principled opposition grounded in philosophy, religion, or culture, for instance, concerns about hubris or 'messing with nature.' In this case, opposition is tied to ideas that cannot be meaningfully reduced to simple estimates of net impact. These norms may be domestic or international in origin, and they may intersect with more material notions of national interest, but their deep-seated cultural roots make them resistant to revision. Disagreement stemming from principled opposition cannot plausibly be resolved by any adjustment—e.g. reduction in the pace—of a proposed deployment.

Decision-making in international politics tends to be based less on values and more on interests (Keohane, 1997). This generalization applies across the issue area spectrum, including climate policy, and it seems safe to assume it will apply to solar geoengineering as well. We therefore anticipate that most disagreements about deployment will be based on perceptions of interests. Values are nevertheless relevant because conceptualizations of interests at the national level are powerfully shaped by political struggles involving state and nonstate actors in which values play a central role.

The importance of reaching agreement

Although some forms of solar geoengineering could technically be implemented by a single country, unilateral deployment is implausible in practice (Horton, 2011; Parson & Ernst, 2013). Actions taken by one state with the potential to alter the material foundations of another are strongly contested as a matter of course, as demonstrated by countless international disputes over transboundary pollution, water use, and resource extraction. Solar geoengineering would entail deliberately altering the physical composition—at a minimum, the energy balance—of other countries' territories, with socioeconomic consequences and national security implications.

Unilateral deployment would likely trigger strong responses. We view the possibility of military conflict as exceedingly unlikely due to the diffuse and indirect nature of the security implications of solar geoengineering, but in a globalized world characterized by complex interdependence, states have a wide variety of political and economic tools with which to express dissatisfaction. Deployment in the face of broad political opposition might therefore entail very high costs. The proposing states would have a strong interest in gaining agreement from the opposing states.

Insofar as disagreement is rooted in divergent judgments regarding the distribution of benefits, costs, and risks resulting from deployment (based on differing perceptions of substitution risks), opposition may be addressed by compensation. The essence of compensation is a bargain in which opposing states set aside their objections in exchange for something they regard as comparably valuable. In theory, proposing states could win agreement from opposing states by assuming liability as a form of compensation. But while liability could conceivably be adapted to solar geoengineering, doing so successfully would require overcoming a number of significant challenges reflected in broader debates about climate liability. The most difficult challenge arguably relates to causation: liability generally assumes deterministic, 'but for' causation, but solar geoengineering and climate science more broadly rest on probabilistic causation (Horton, Parker, & Keith, 2015). Growing recognition of such problems lies behind the increasing prominence of parametric insurance in climate policy (Horton, 2018).

A solar geoengineering parametric sovereign risk pool

We propose that a particularly effective and appropriate form of compensation would be for proposing states to ensure the availability of reduced-rate parametric climate insurance for any state that wants it. Negotiations over the cost and terms of coverage would serve as a de facto forum for negotiations over those interest-based objections to solar geoengineering grounded in opposition to the anticipated distributional effects of deployment. Indexed risks could then be tied to payouts triggered by weather events that exceed specified thresholds, whether due to solar geoengineering, climate change, and/or natural variability. In exchange for reduced-rate insurance, insured states would agree not to obstruct deployment.

Suppose, as seems plausible based on climate model predictions, that a spatially uniform deployment of solar geoengineering at a 'moderate' level sufficient to reduce but not reverse GHG-driven climate change, could curtail expected increases in the frequency and intensity of tropical cyclones, floods, and droughts (Irvine et al., 2019; Keith & MacMartin, 2015). In theory, then, deployment of solar geoengineering should reduce climate risks covered by CRI relative to a counterfactual world without solar geoengineering, and as those risks are reduced the cost of premiums should fall in comparison. Changes in the cost of insurance for climate risks thus represent a direct measure of the effectiveness of solar geoengineering at reducing those risks.

A multilateral parametric risk pool for solar geoengineering could be structured as follows. Proposing states would offer to guarantee the availability of parametric CRI to any state that wants it, with premium levels that are reduced compared to the rates that are actuarially projected to obtain in a world without solar geoengineering. We refer to the reduced-rate insurance offered by proposing states as 'solar geoengineering insurance,' in contrast to "business as usual (BAU) insurance," although in both cases the insurance would cover climate events independent of cause. BAU insurance rates would be relatively higher, reflecting a greater expected level of climate harm, while solar geoengineering insurance rates would be relatively lower reflecting a reduced expected level of climate harm. States that purchased solar geoengineering insurance would agree to drop their opposition to deployment, and would pay premiums into a centralized fund with multilateral governance. Proposing states would cover additional costs associated with the reduced-rate solar geoengineering insurance. When payouts were triggered, the fund would automatically disburse money to states covered by solar geoengineering insurance. Solar geoengineering insurance policy periods may conceivably be at least a decade.

Now consider the following highly simplified scenario. Proposing states would like to deploy solar geoengineering with the goal of cutting the global average rate of growth of radiative forcing by half (Irvine et al., 2019; Keith & MacMartin, 2015). The intervention is proposed as a complement to ongoing mitigation measures, not as a primary response to climate change. States favouring deployment, based on climate model estimates that suggest solar geoengineering will reduce risks, will negotiate with states who oppose deployment, based on tangible concerns stemming from structural uncertainties in the models relating to substitution risks. These concerns will often be linked to intangible but legitimate concerns about the political aspects of deliberate interference with the Earth system, including fear of technocratic overconfidence. The proposing states wish to persuade opposing states to reduce their opposition.

The specific features of a solar geoengineering risk pool would depend on the status of CRI. If multilateral CRI schemes continue to expand in membership, coverage, and capital, then solar geoengineering insurance would need to be integrated into an existing system. Integration might be challenging given the links between parametric insurance and debates about loss and damage, and responsibility for historical emissions. Conversely, if multilateral CRI fades from the policy landscape, then states would need to construct new institutions for climate risk management. In either case, implementation would be demanding and uncertain.

How might a solar geoengineering risk pool help alleviate concerns about deployment? In part, the simple fact of proposing states offering reduced-rate solar geoengineering insurance—and thus accepting a financial risk if solar geoengineering fails—would serve as a powerful demonstration of their confidence that solar geoengineering would actually reduce risks.

More concretely, opposing states would be presented with the following choice. On the one hand, they could continue to purchase BAU insurance at rates that would increase over time as climate change worsens. On the other hand, they could purchase reduced-rate solar geoengineering insurance in return for pledging not to obstruct solar geoengineering. If they chose the latter option, their worst-case outcome—climate risks exacerbated by solar geoengineering—would be at least partially compensated by the payouts from solar geoengineering insurance. Their best-case outcome, by contrast, would be climate risks reduced by solar geoengineering and reduced insurance costs. If solar geoengineering turns out to work as predicted, opposing countries would benefit relative to a world without solar geoengineering, and if it does not, then their losses would be at least partially compensated. This benefit would be a powerful incentive for states to moderate their opposition to deployment.

But why would proposing states support a risk pool? Proposing states would face a different choice. On the one hand, they could ignore objections from opposing states and engage in unilateral deployment, likely leading to retaliation and disrupted implementation. On the other hand, if proposing states sought to meet objections through a risk pool, their worst-case outcome would be failed solar geoengineering deployment plus the subsidies or discounts required to cover the full costs of solar geoengineering insurance. Their best-case outcome, however, would be successful solar geoengineering deployment at no additional cost, since solar geoengineering insurance would cover payouts for (reduced) climate damages. Proposing states would have a powerful incentive to conduct research to reduce uncertainty about solar geoengineering before backing the risk pool.

The type of risk pool described here would enable proposing states to address concerns that solar geoengineering deployment might harm opposing states' interests by offering protection against salient climate risks. Such concerns are the most likely international political obstacles to implementation. In essence, parametric insurance allows conflicting judgments about the efficacy of solar geoengineering to be operationalized as insurable risks, which can then be underwritten, transferred, compensated, and managed in a common institutional framework. Since opposing states may gain more from purchasing solar geoengineering insurance than from blocking deployment—whether or not deployment is successful—countries that fear the effects of solar geoengineering will have strong incentives to cooperate.

Limitations of the proposal

Our proposal is but one of many conceivable combinations of solar geoengineering and parametric insurance, and our analysis is highly simplified in several ways. First, we adopt a binary categorization in which states either propose or oppose solar geoengineering deployment. In reality, there will be a spectrum along which some may advocate, some may object, some may manage to do both, and some may take no position at all. Second, we implicitly assume that countries have roughly equal power. Yet a credible proposal to deploy would require the backing of at least one strong state with the requisite capabilities. And similarly, credible opposition would require at least one strong state. Third, we consider climate and solar geoengineering alone, generally ignoring the fact that international negotiations never occur in isolation. States negotiating about solar geoengineering would simultaneously be dealing with issues such as trade, human rights, and intellectual property.

The scheme we propose is designed to address opposition to solar geoengineering based on countries' assessments that deployment will distribute benefits, costs, and risks, particularly substitution risks like floods or droughts, in ways that will undermine their interests. Importantly, our proposal is not designed to address other interest-based objections such as mitigation obstruction, which might be moderated using other devices, for example, 'pay to play linkage' (Parson, 2014). Nor is our proposal intended to address value-based objections such as resistance to 'messing with nature,' which may prove to be more intractable.

Our analysis fails to address several additional issues. We do not address the possibility that a country might feign opposition in order to obtain coverage even if it favoured deployment. Such behaviour might be deterred by limiting sovereign rights to participate in decisions about deployment in proportion to the amount of reduced-rate coverage a state purchases. However, this may be problematic from a procedural justice perspective.

We also neglect to consider how our proposal might interact with existing parametric climate insurance, in particular intergovernmental CRI schemes. This proposal becomes more credible if parametric insurance grows in importance as a means of addressing loss and damage from climate change. While parametric schemes currently enjoy political support underpinned by a record of successful disaster response, these mechanisms remain new, limited, and vulnerable to basis risk. They are also politically vulnerable. Some civil society groups have criticized elements of CRI institutional design, the opportunity costs of parametric insurance, and other aspects of risk transfer in the disaster context (e.g. ActionAid, 2017).

Perhaps most importantly, we downplay the significance of values in motivating state behaviour. This is not because we consider values to be unimportant in world politics, but rather because we believe focusing on interests yields greater insight into why states act as they do and how this leads to specific outcomes. Such a focus seems particularly warranted in light of the powerful ways that interests may be affected by risks from climate change and solar geoengineering. Regardless, international relations, including potential deployment of solar geoengineering, should also be evaluated against normative criteria. Distributive, procedural, and other forms of justice are particularly crucial considerations in decisions about solar geoengineering (Horton & Keith, 2016). Indeed, corrective justice (Weinrib, 2002), a topic which has received inadequate attention from solar geoengineering researchers up to now, might be an especially important consideration in evaluating the compensation scheme we describe here. We welcome justice-centered and other critiques of our proposal.

Notes

1. We use the term 'solar geoengineering' rather than 'solar radiation management' or 'solar radiation modification' (the latter is now preferred by the Intergovernmental Panel on Climate Change) so as to acknowledge widespread use of the term 'geoengineering' while restricting its application to solar radiation (as opposed to large-scale carbon dioxide removal).
2. As with climate change itself, some losses associated with solar geoengineering cannot be effectively compensated by any financial mechanism, and hence fall outside the scheme we propose.
3. CCRIF SPC, *Annual Report: 2016-17*, vii (CCRIF SPC 2017).

Disclosure statement

No potential conflict of interest was reported by the authors.

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