Geoengineering Our Climate?

Ethics, Politics and Governance

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The Economics of Climate Engineering

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Geoengineering Our Climate? is a Working Paper and Opinion Article Series that explores the ethics, politics and governance of geoengineering – the intentional manipulation of the global climate to counteract climatic changes. Relying upon the efforts of over forty contributing authors from academia, policy, and civic environmentalism, our objective for this project is to create a comprehensive yet broadly accessible introduction to the complex societal dimensions associated with the emergence of geoengineering. Our Convening Partner organizations include high-profile institutes from across the global north and south: the Institute for Advanced Sustainability Studies (Germany); the Institute for Science, Innovation and Society, University of Oxford (UK); the Consortium on Science Policy and Outcomes at Arizona State University (US); the Council on Energy, Environment and Water (India), the Research Centre for Sustainable Development of the Chinese Academy of Social Sciences (China), and the Brazilian Research Group on International Relations and Climate Change (Brazil).

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Fast, Cheap, and Imperfect

Unmitigated climate change is extremely costly. Mitigation (the reduction of carbon dioxide and other greenhouse gas emissions at the source) is the only prudent response. While upfront costs can be high, in the long run mitigation is relatively cheap and because it tackles the root cause of the problem, its benefits are permanent and transparent. However, because the effects of mitigation investments are subject to considerable physical and social inertia, they are slow to manifest. Moreover, effective mitigation requires overcoming the well-known "free rider" effect inherent in the most global of global commons problems.

Enter climate engineering in the form of planetary albedo modification, or Solar Radiation Management (SRM). Although it is both cheap and fast, SRM is clearly an imperfect method of countering climate change. Rather than addressing global warming's root cause, it counteracts its effects with additional pollution. But SRM is so cheap that direct private costs largely do not play a role in the decision process of whether (and how) to pursue it.[1] Well-designed SRM systems could cost less than $10 billion per year to stabilize global temperatures. That places implementation within the budget of many countries, making SRM perhaps 100 times cheaper than any emissions reduction program to stabilize global average temperatures below a post-industrial increase of 2°C.[2] It is so fast that it can reduce planetary temperature in days, weeks or months, compared to the decades or centuries that emissions reductions would take to have a similar effect.

"Fast, cheap and imperfect" give SRM virtually the exact opposite economic properties from mitigation. Instead of the "free-rider" effect in which actors are compelled to underprovide mitigation, the chief economic characteristic comes much closer to a "free-driver" effect in which actors are compelled to overprovide SRM.[3] In terms of policy interventions, this means that rather than pursuing individual actors to mitigate counter to their immediate personal interest, the task becomes one of reining in those who want to pursue climate engineering of their own volition.

Economic Tools to Analyze SRM

Two types of standard economic tools are most prominent in the economic analysis of geoengineering: benefit-cost analysis and game theory.

Benefit-cost analysis attempts to weigh the full set of benefits and costs of any policy intervention (in this case, SRM) to make informed decisions. To identify the optimal policy, researchers make assumptions about social benefits and costs associated with both SRM and mitigation, and the damages associated with unmitigated climate change. The optimal policy balances

[1] For example, see Barrett 2008, 2014; Moreno-

[2] Morgan and Ricke 2010; McClellan et al. 2010

[3] Weitzman 2013; Wagner and Weitzman 2015

the benefits of action against the costs associated to the action taken.

Well-known problems exist in the application of conventional benefit-cost analysis to problems of global-scale change.[4] One inherent problem with such analyses is their reliance on an assumption of modest and quantifiable uncertainty.[5] In the case of SRM, estimates of both climate change's damages, and the costs of geoengineering fail to meet this criterion. While we have a relatively good handle of the direct, private costs associated with SRM, the full sets of social costs—and the full social benefits, for that matter—are largely a mystery.[6]

Perhaps an even more fundamental problem with these kinds of benefit-costs analyses is that they largely assume optimally coordinated decisions across regions or countries. In particular, they ask: what are the total benefits and costs of SRM from a benevolent, global social planner's perspective seeking to optimize policy for the world? Reality, of course, does not conform to this assumption.

This is where game-theoretic and political economy studies come to play. Game theory provides a tool to reveal frictions that arise when self-interest actors wish to maximize their own well-being without considering the full effects of their actions on others. Instead of optimizing outcomes from the perspective of a single decision maker, in a game theoretic model multiple players interact and make strategic decisions to optimize their own individual outcomes.

The primary limitation of game theoretic analyses of SRM to date may be a lack of any consensus over the key constraints that would govern strategic interactions in a geoengineered world. Different assumptions about how physical effects of SRM translate into economic damages, what the institutional characteristics of a sustainable geoengineering implementation program would be or even who could feasibly get away with setting the global thermostat without consent from other world powers lead to drastically different conclusions about what outcomes are possible.[7] The sensitivity of the outcomes predicted by game-theoretic analyses to their model constraints implies that as uncertain and unpredictable as the science of SRM may be, political dynamics likely play an even more important factor in shaping the final outcome.

Rogue Actor, Rational Portfolio, and Worst-case Insurance

Current international legal standards do not explicitly restrict any nation from engaging in stratospheric SRM.[8] It is unlikely that even if they did, that such restrictions could effectively block action, just as the Nuclear Non-Proliferation Treaty did not prevent non-signatories like

[4] Morgan et al. 1999
[5] Goes et al. 2011
[6] Moreno-Cruz and Keith 2012; Wagner and Weitzman 2015
[7] Ricke et al. 2013; Millard-Ball 2012; Moreno-Cruz 2012; Urpelainen 2012
[8] Parson and Ernst 2013

India, Israel, North Korea and Pakistan from developing nuclear weapons. Both legally and technically, a single nation or even a wealthy individual could take matters into their own hands. Unilateral SRM deployment could lead to the alleviation of climate change impacts for one group while imposing a mix of externalities on another group without its consent or compensation. Underestimating the full benefits and especially costs may only be a small issue in this situation. Full-on "climate wars"—with geoengineering and counter-geoengineering efforts—would be quite another. This is one of the reasons it is important to understand the potential harm and benefits associated with SRM, not only globally, but also in terms of relative regional effects, and important for responsible actors to develop governing mechanisms for careful, deliberate geoengineering research.

A deliberate approach to SRM may also link into two other potential geoengineering scenarios: SRM as part of a portfolio of strategies to address climate change, or as a deliberate backstop technological response to a global climatic emergency. The two are not mutually exclusive. They also come with their individual challenges.

As a part of a portfolio of strategies, together with mitigation and adaptation, SRM could in theory be used to achieve an 'optimal' response to climate change, minimizing net social cost or maximizing some other global, societal objective.[9] This framing is controversial for a host of reasons. For one, fundamental uncertainties of the underlying climate and ecological science may make a deliberate, deterministic choice difficult to impossible. Another reason is the host of ethical issues involved in intentionally engineering the planet. Moreover, the decision process is murky. There is no single global decision maker for whom an optimum can be defined. Solving any of these challenges is difficult, to say the least.

Political economics could conceive of rational voting mechanisms that do define a globally optimal solution, though the practical difficulties of implementing any such scheme would be daunting.[10] Alternatively, countries could engage in negotiations to create a coalition with enough power to legitimize the "free-driver" intervention while excluding a majority of countries.[11]

A perhaps less controversial argument is that SRM could serve as a form of insurance of last resort, in case of a worst-case climatic scenario. Likely climate outcomes should provide sufficient impetus for action on mitigation. But, it may be the low-probability, high-impact events that dwarf any and all currently projected, average costs. A conservative calibration of what is known about climate sensitivity—the effect on eventual global average temperatures as greenhouse gas concentrations in the atmosphere rise—indicates

[9] Moreno-Cruz et al. 2011; Moreno-Cruz and Keith 2012

[10] Weitzman, forthcoming; Wagner and Weitzman 2015

[11] Ricke et al. 2013

that we are well underway toward a world with a greater-than 10 percent chance of global average temperatures rising above 6°C.[12] Such a scenario may well trigger a host of, irreversible, tipping points, many of which could occur much closer to the vaunted 2°C threshold.[13]

Such tipping elements include the disappearance of Arctic summer sea-ice (a process well underway), rapid decay of the Greenland ice sheet, or the collapse of the ocean's thermohaline circulation. It's clear that the potentially dire economic consequences of such phenomena contribute disproportionately to the risks associated with global warming. The extent to which SRM could stop or slow the progression of extreme climate change after its commencement or detection is unknown. That makes seeking insurance against worst-case scenarios a primary reason cited for investing in SRM research.[14]

The insurance proposal does not come without drawbacks. For example, the technology would be developed by the current generation and would be implemented by a future generation; resulting in time inconsistency and sub-optimal use of the technology by future generations.[15] Nonetheless, the downside risks of unmitigated climate change might be so large that virtually any intervention might pass a benefit-cost test.

From Incredible to Seemingly Inevitable

Perhaps the most apt description of the economics of geoengineering came in one of the very first articles on the topic. Barrett (2008) described it as "incredible," referring to the small costs of SRM. In fact, the costs are so small, they turn the standard economics of climate change as a global commons problem on its head—from the "free rider" to the "free driver" problem.

The very same fundamental market forces that make mitigation action so hard seem to point directly towards an SRM-style intervention. None of this should be misconstrued as an endorsement of this path. Quite the opposite: it's a call for a deliberate step toward a governing mechanism that could guide these market forces in the right direction.[16]

[12] Rogelj et al 2012, Wagner and Weitzman, 2015
[13] Lenton et al. 2008
[14] Morgan and Ricke 2010; Shepherd et al. 2009
[15] Goeschl et al. 2013
[16] Hanafi and Hamburg 2013

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