Status update on--and insights from--research in the social sciences on

The Governance of SG Deployment

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Incentives

- Addressing climate change requires:
  - reducing emissions (weak incentives)
  - adapting (strong incentives)
  - carbon geoengineering (mixed incentives)
  - solar geoengineering (overly strong incentives?)
- If cooperation fails, there will be too little abatement and too much adaptation; the incentives to geoengineer will be strong, but how will they be expressed?

Governance

- Who gets to decide whether and how solar geoengineering is deployed?
  - States, not private actors.
  - Any state? This is the default, but if a state can geoengineer, others can respond in some other way. This gives rise to a "market outcome."
  - All states collectively? Use of geoengineering proscribed by a peremptory norm in customary international law; implausible.
  - Norms? Favored by Victor (2008), but norms emerge from practice.
  - UNSC? May act to maintain “peace and security,” either to deploy geoengineering or to prevent a state from deploying it; P5 veto.
  - Treaties? Binding only on the countries that give their consent.

"Free Driver" Equilibrium

- Assuming states have a right to act, and no responsibility not to harm, the country preferring the coolest global temperature will (in a Nash equilibrium) determine temperature for the world (Wagner and Weitzman 2012; Weitzman 2015).
- This outcome is inefficient.
- In this setting, other countries are passive, lacking any "come back," which seems implausible.

The "Market Outcome"

- Heyen, Horton, and Moreno-Cruz (2018) and Bas and Mahajan (2018) assume that any state may deploy solar geoengineering or “counter-geoengineering.” In a two-country model with symmetric and quadratic costs, both papers show that (in the Nash equilibrium) there can be a "climate clash” (HHM-C) or “tug-of-war” (BM) with one country using geoengineering and the other counter-geoengineering.
- BM find that military intervention (cruise missile to destroy a geoengineering facility) may be the preferred counter measure.
- This outcome is also inefficient.

How to do better?

- Weitzman (2015) proposes a voting rule that, under certain conditions, supports an efficient outcome.
    - However, he assumes that all countries participate in and abide by the vote, which is inconsistent with practice.
- Heyen, Horton, and Moreno-Cruz (2018) consider a moratorium treaty and a joint deployment treaty, and show that, depending on preferences, these may be preferred to the Nash equilibrium.
    - However, they assume just two countries (important especially for enforcement) and rule out side payments (important for bargaining and efficiency).
- BM (2018) show that if the game is infinitely repeated then the efficient outcome can be sustained as a SPNE by a “grim” strategy.
    - With more than two countries, a renegotiation-proof equilibrium would be more compelling and may fail to support an efficient outcome.

Another take

- Ricke, Moreno-Cruz, and Caldeira (2013) model a treaty on geoengineering under two regimes, *open* and *exclusive* membership, assuming that all countries gain from some geoengineering, that cooperating countries maximize their collective payoff (with side payments), that non-parties can't geoengineer, and that the agreement enters into force if membership exceeds something like half the world's population.
- Open: any country may join. In this case, everyone joins; the result is efficient.
- Exclusive: Members can exclude non-members.
    - The assumption that non-parties can't geoengineer is implausible.

Two other perspectives

- Lloyd and Oppenheimer (2014) argue for restricted membership on the basis that small-*n* agreements are more effective.
  - A problem if non-members choose to geoengineer on their own. Exclusion will also cast doubt on legitimacy.
- Parson (2014) considers linking governance of geoengineering to emission reductions. For example, requiring that states have a track record of reducing emissions in order to be able to decide about geoengineering.
  - This and other linkage proposals implicitly assume commitment.

Commentary

- I don't feel that we truly understand the governance problem.
- There needs to be more careful consideration of the problem that geoengineering is supposed to solve (reduce "global warming," prevent certain events from occurring, etc.) and of the engineering options.
- Governance considerations will favor interventions that are of more universal benefit (such as preventing collapse of WAIS) and/or that have the smallest spillovers and/or that are difficult to detect (the last possibility being considered by BM).

Treaty options

	Less restrictive	More restrictive	Joint deployment	Coordination
Objectives	Establish basic rules	Establish basic rules to include, possibly, a ban on deployment.	To act with some specific aim.	Coordinate deployment of different technologies.
Entry into force	To include most if not all geoengineering-capable states.	No specific mention of geoengineering-capable states.	Minimum coalition of countries willing to contribute.	Probably all or nearly all countries that can agree on aims.
Key articles	• Right to act; responsibility not to harm • Prior notification • Conflict resolution	Restrictions/prohibitions on deployment.	• Cost-sharing • Rules for decision-making	• Compatibility, standards. • Take into account effects on non-members.
Decisions	Consensus, possibly backed by a vote.	Consensus.	Consensus/unanimity of membership	Consensus/unanimity of membership.
Likely effect	Shift the default, at least slightly.	Very little.	Will likely achieve narrow aims.	Will likely achieve specific aims.

Analogous treaties

Treaty	Type	Key articles	Parties	Effect
Outer Space Treaty (1967/1967)	Less restrictive	• Prohibits WMD in Earth orbit and on Moon and other celestial bodies. • Makes States Parties responsible for national activities, whether undertaken by private or public entities. • States are liable for damages their space objects cause	107, including US, Russia, China, Japan, ESA members.	Helpful
Moon treaty (1979/1984)	More restrictive	Bans exploration and use of celestial bodies without the approval or benefit of other states under the common heritage of mankind principle.	18, all of which lack a space program.	Negligible
Partial Test Ban Treaty (1963/1963)	Less restrictive	Bans testing of nuclear weapons except for underground testing.	126, including US, USSR, and UK initially, but not China and France	Helpful
Comprehensive Test Ban Treaty (1996/____)	More restrictive	• Bans nuclear weapon test explosions in places under a party's jurisdiction. • Bans parties from participating in such tests.	166; many "Annex 2" states are not parties.	Did not prevent tests by India, Pakistan, and North Korea.

Analogous treaties

Treaty	Type	Key articles	Parties	Effect
International Space Station Agreement (1998/1998)	Joint deployment	• Management bodies responsible for design, development, operation, and utilization. • Costs of common system operations shared equitably. • Liability arrangements.	15, including the US, Russia, Japan, Canada, and ESA members.	Successful
Agreement on Use of Galileo and GPS(2004/2004)	Coordination	• Interoperability and radio frequency compatibility to facilitate joint use of the two systems. • Establish design and performance standards. • Except for reasons of national security,, parties shall not restrict use or access.	26, comprising the US and 25 EU states.	Successful
Other bilateral agreements on Galileo	With China, Israel, Ukraine, Morocco, Norway, and Switzerland. The UK will be withdrawing following Brexit. Mainly these are about cost-and benefit-sharing.			

Conclusions

- Governance must involve the countries most inclined to geoengineer.
- For legitimacy, it should also involve the countries most likely to be affected, whether positively or negatively.
- Mutual restraint is a prime motive for agreement about governance.