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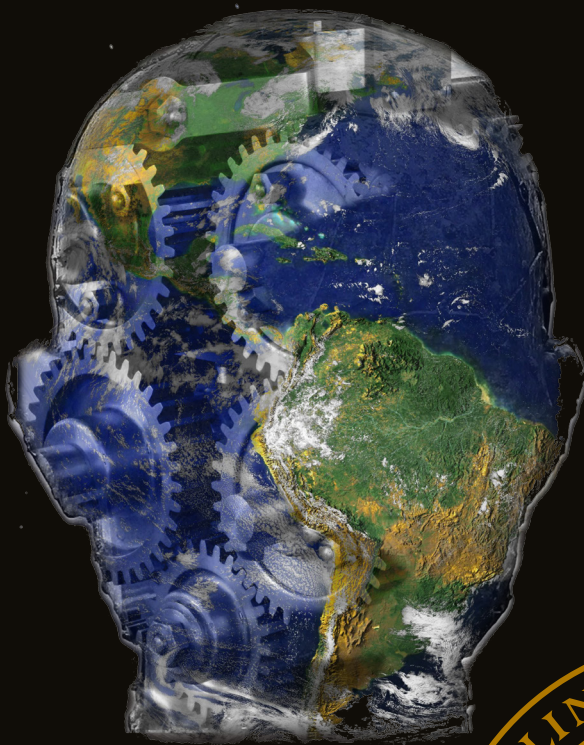
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The Emergent Politics of Geoengineering

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The Emergent Politics of Geoengineering

Ina Möller



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DOCTORAL DISSERTATION

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Abstract <p>This thesis examines the role of science in the earliest stages of the political process. It does this by studying the emergence of 'geoengineering' on the political agenda. The term describes a set of ideas on how to stabilize global temperature by intervening into the Earth's natural systems, and was subject to a strong taboo in the scientific community until the mid-2000s. Yet within a decade, it has become relevant to international climate politics. To understand how this transition took place, the thesis uses mixed-methods to study the causal mechanisms by which geoengineering became an object of governance. Paper I describes the internal dynamics of a scientific community that helped transform geoengineering into a distinct, salient and malleable governance object. It explains how social cohesion, brokerage and diversity acted as important mechanisms in this process. Paper II studies the role of authoritative scientific assessments in making geoengineering a normal and relevant topic for research. It shows how such assessments act as a form of de facto governance in shaping the activities of a research landscape. Paper III identifies similarities and differences in the way that different sub-areas of climate change policy are governed. It suggests that, if a problem structure is perceived to be malign, this makes it less conducive to public governance. Conversely, if a problem structure comes to be perceived as more benign, this facilitates public governance. Paper IV examines the role of problem definition and 'institutional fit', evaluating how geoengineering matches with the expectations of government actors. It discusses three areas where such fit is lacking, and how this makes it difficult for government officials to form a political position on geoengineering. The results of this study flow into the description of a pattern that seems to be important at many different stages of the opinion-shaping process. This pattern includes the introduction of a topic to a new audience; the audience's heated debate around this topic; the intervention of an actor with authority; and the streamlining of the audience's debate according to the authoritative actor's judgement. Found at many different levels of the political process, the pattern may explain why some topics become subject to political decision making, and others do not.</p>			
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Ina Möller



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Cover illustration: NASA satellite image of planet Earth, rendered to take the shape of a human head and the internal workings of a machine.

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emergent *adjective* [1] in the process of coming into being or becoming prominent. [2] having properties as a whole that are more complex than the properties of its individual contributing parts. [3] arising unexpectedly, especially if also calling for immediate reaction.

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Popular Summary

When people hear the word ‘politics’, they usually think of politicians and governments who make decisions that affect their lives. While these are the most visible products of the political process, there are many things that happen before such a decision is made. Companies lobby politicians to take their interests into account. Protesters go to the streets, pressuring leaders into taking action. The media’s use of images and headlines affects the issues that governments prioritise.

The study of politics means the study of all these things, and how they get us to wherever we are now. The results of this study help us identify patterns of how we think society might work more generally. Using these patterns, we can try to explain events in other areas, or try to predict how society might act in the future.

One important part of the political process is the generation of scientific knowledge. It adds to the process by which politicians and governments determine what to make decisions about. Usually, we think of this as a very good thing. After all, science has helped us see that using certain chemicals destroys the ozone layer, and that this leads to more cancer. It has helped us understand that the way in which we use land affects the creatures that live there, and that their loss has negative impacts on our economy and our well-being. And it has helped us realise that burning oil and coal increases global temperature, leading to heat waves, hurricanes and rising sea levels. Thanks to science, politicians have crafted international agreements through which they try to address these problems.

Perhaps because we think of science as a very good thing, we don’t usually see it as being something political. However, science is dependent on governments for providing research funding, and so it needs to adapt to the expectations that governments have. And in order for science to influence governmental decision making, it needs to take part in the same opinion-shaping process that companies, protesters and the media also take part in. Scientists need to lobby, coordinate and frame their work

so that it has a chance of being heard through the din of other voices.

In this thesis, I study the role of science in the political process. To better understand its political behaviour, I study the emergence of an issue called ‘geoengineering’. This term describes a set of ideas on how to stop the global temperature from rising by intentionally changing the Earth’s natural systems. Examples include planting huge amounts of biomass to absorb greenhouse gases from the air, or spreading reflective particles through the atmosphere to reduce the amount of incoming sunlight. Geoengineering is particularly interesting because it was subject to a strong taboo in the scientific community until the mid-2000s. Yet within a decade, it has come to be seen as an important issue that politicians need to make decisions about.

My aim in this thesis is to understand how geoengineering made it to the agenda of governments. To do this, I study the mechanisms by which geoengineering became more widely relevant. I begin by describing the internal dynamics of a scientific community that helped transform geoengineering into a so-called ‘governance object’. I then study the role of authoritative scientific assessments in making geoengineering a normal and relevant topic for research. From there, I move on to find similarities and differences in the way that different sub-areas of climate change policy are governed. And finally, I examine problem definition and ‘institutional fit’, evaluating how geoengineering matches with the expectations of government actors.

The results of this study flow into the description of a pattern that seems to be important at many different stages of the opinion-shaping process. This pattern includes the introduction of a topic to a new audience; the audience’s heated debate around this topic; the intervention of an actor with authority; and the streamlining of the audience’s debate according to the authoritative actor’s judgement. This pattern might help us understand why some topics become subject to political decision making, and others don’t.

List of Papers

- Paper I Transforming geoengineering into a governance object: what role for epistemic communities?
Ina Möller, Unpublished Manuscript
- Paper II De facto governance: how authoritative assessments construct climate engineering as an object of governance
Aarti Gupta & Ina Möller (2019), Environmental Politics, 28:3, 480–501
- Paper III Institutional complexity and private authority in global climate governance: the cases of climate engineering, REDD+ and short-lived climate pollutants
Fariborz Zelli, Ina Möller & Harro van Asselt (2017), Environmental Politics, 26:4, 669–693
- Paper IV Political perspectives on geoengineering: navigating problem definition and institutional fit
Ina Möller, Under Review

Abbreviations

BECCS	Bioenergy with Carbon Capture and Storage
C2G2	Carnegie Climate Geoengineering Governance Initiative
CBD	United Nations Convention on Biological Diversity
CDR	Carbon Dioxide Removal
IPCC	Intergovernmental Panel on Climate Change
NAS	National Academy of Sciences
NETs	Negative Emissions Technologies
REDD+	Reduction of Emissions through Deforestation and Forest Degradation
SAI	Stratospheric Aerosol Injection
SIDS	Small Island Developing States
SLCP	Short Lived Climate Pollutants
SRM	Solar Radiation Management
SRMGI	Solar Radiation Management Governance Initiative
UNEA	United Nations Environment Assembly
UNFCCC	United Nations Framework Convention on Climate Change

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The Emergent Politics of Geoengineering

1 Introduction

WHAT WOULD IT BE LIKE if we had a simple solution to climate change? Not one based on hopes that renewable energy will rapidly sweep coal and oil into history books, or that the global population will voluntarily transition to a lifestyle free of fossil fuels. Instead, a solution that circumvents the uncertainties of how society will act, and simply cleans up the atmosphere. Or at least postpones the worst effects until a better solution is found. After all, climate change is widely recognised as ‘one of the greatest challenges of our time’, and some might say that great challenges call for great actions.

This thesis explores the emergence of a policy option widely known as *geoengineering*. Representing an umbrella term for global-scale, intentional interventions into the Earth’s climatic system, geoengineering – if it comes to pass – would be the greatest coordinated engineering attempt in the history of humankind. Despite having been subject to a taboo for many years, suggestions to address climate change by enhancing natural systems’ capacity to absorb carbon dioxide, or to increase the planet’s reflectivity, have recently found hearing amongst

a broader scientific audience. The most widely discussed approaches include removing carbon dioxide through large-scale, industrial processing of biomass ('Bioenergy with Carbon Capture and Storage' – BECCS), and dispersing reflective particles in the stratosphere to marginally reduce the amount of incoming sunlight ('Stratospheric Aerosol Injection' – SAI). They now play a prominent role in widely used projections of how society might accomplish the 2 degree and 1.5 degree targets in global temperature rise (IPCC 2018). In this way, they provide the motivation for governments to invest money and time into their research.

The most recent developments in this field include the initiation of an £8.6 million research program on technologies to remove greenhouse gases from the atmosphere, funded by the British Natural Environment Research Council (2018), and the launch of an assessment programme to determine a research agenda for sunlight reflection strategies, led by the United States National Academy of Sciences (2018). These initiatives add to a recent inquiry by the British Parliament into carbon capture, usage and storage, and a hearing on albedo enhancement measures in the United States Congress. Also at international level, developments around geoengineering are taking place. In March 2019, the Swiss government, backed by Burkina Faso, Micronesia, Georgia, Lichtenstein, Mali, Mexico, Montenegro, Niger, South Korea and Senegal, attempted to initiate an investigation into geoengineering science and governance at the fourth annual meeting of the United Nations Environment Assembly (Stefanini 2019). Although the proposal was blocked by the United States and Saudi Arabia, their effort adds to the list of indicators that geoengineering technologies are becoming an issue in global environmental politics.

1.1 Aim and approach

How did geoengineering arrive on the global political agenda? Observers who try to answer this question commonly point to the increasing urgency of climate change (e.g. Parson 2014, Burns &

Nicholson 2016). Yet a comparison in the amount of publications on climate change in general and on geoengineering in particular indicates that this is cannot be the only explanation. Figure 1 shows that between 1991 and 2013, the geoengineering literature grew more than six times faster than the climate change literature overall. The concept has experienced a remarkable increase in attention within a very short time span, compared to a more steady (though also steep) rise in attention to climate change overall. The stark difference in growth rates indicates that there are additional dynamics at play. It is these dynamics that are the subject of study in this thesis.

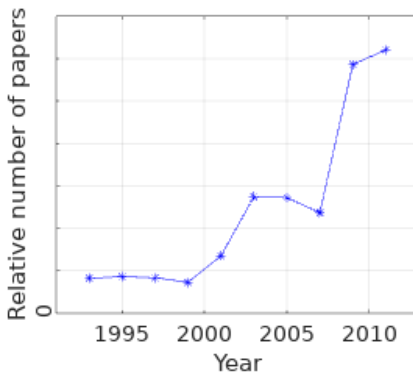


Figure 1: Number of geo-engineering publications in relation to number of climate change publications. The data is derived from bibliometric studies published by Oldham et al. (2014) and Haunschild et al. (2016).

My overarching aim is to understand the processes by which the idea to intentionally manipulate natural systems at global scale evolved from a thought shared by a small group of individuals, into a topic that is likely to shape the future of climate politics. To answer this question, I study the social dynamics by which an idea can transform from a scientific thought experiment into a globally relevant governance object. I do this by first identifying and analysing the mechanisms that enabled geoengineering to become widely shared amongst a scientific community, and then examining the mechanisms by which the concept became relevant to government actors and public governance.

The principal innovation of this approach is that it adds an empirical perspective to the extensive amount of legal and nor-

mative studies in the field of geoengineering governance research. Work in the former area has focused primarily on identifying and characterising legal instruments that are available to govern geoengineering technologies, and studies like Lin (2009) or Redgwell (2011) identify a catalogue of agreements and hard law relevant to geoengineering. These prominently include broad frameworks such as UN Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), but also more narrow instruments, such as the Convention on Environmental Modification or the Montreal Protocol for the protection of the Ozone Layer. Fewer scholars have engaged with soft law and the role of international norms, although studies like Brent et al. (2015) highlight their importance.

Work in the latter area has focused primarily on identifying governance gaps, suggesting designs for norms and institutions to improve the geoengineering governance landscape. Different theoretical perspectives tend to prioritise different solutions. While studies like Morrow et al. (2009) or Burns (2016) highlight the need for ethical principles and multilateral agreement, Victor (2009) or Parson & Ernst (2013) highlight the need for effectiveness and minilateral clubs. Those who take a middle-path suggest a need for polycentric governance (Nicholson et al. 2018) or global financial incentives driven by individual nation states (Honegger & Reiner 2018).

In contrast to many publications on geoengineering governance, the thesis does not evaluate the legal governance landscape, nor does it intend to find new governance solutions. Instead, it studies and theorises the earliest stage of the policy process in a critical analysis of why we are discussing geoengineering in the first place. ‘Governance’, rather than being a normative goal, is understood as the steering of societal behaviour through openly recognised rules and hidden steering mechanisms. Politics is understood as the competition for opinion-shaping that takes place in creating and strengthening or weakening these steering mechanisms. Power is understood as the capacity to shape the way that people speak and think. Both science and government are considered realms where governance, politics and

power play a role.

The results of my inquiry are presented in the form of four papers, linked in their exploration of how geoengineering as a concept is established and ‘made real’ by the activities of different actors. Each paper identifies a number of social processes that contribute to shaping the emergent politics of geoengineering. They range from the internal workings of expert networks (so-called ‘epistemic communities’), to political expectations in international negotiations. In aiming to capture the dynamics by which an object of global governance is born, they examine both the scientific and the governmental side of early-stage policy making.

Paper I analyses the evolution and establishment of geoengineering in the context of an epistemic community. The paper maps a network of individuals who have substantially engaged with the geoengineering concept over twelve years and analyses the network’s internal dynamics through an analytical framework of social cohesion, brokerage and diversity. It describes how mechanisms of maintaining discursive order and attracting new members contributed to establishing geoengineering as a distinct and salient research area. The ensuing diversity and later engagement with a rivalling community of climate scientists further helped transform geoengineering into a set of malleable governance objects that resonate with the normative surroundings of mainstream climate science and politics. In addition to these mechanisms, it points out two important structural conditions, namely the understanding of climate change as a geophysical problem and the co-dependency of climate science and climate politics, as explanatory factors.

Paper II examines the role of authoritative scientific assessments in governing the geoengineering research landscape. The paper analyses two geoengineering assessments issued by prominent scientific organisations (the British Royal Society and the US National Academy of Sciences), conceptualising them as authoritative interventions in the context of contested scientific and ethical debates. It highlights how, through processes of demarcation and categorisation, the assessments legitimise and en-

courage the study of geoengineering. By steering the focus away from questions of ethics or politics, the assessments contribute to rendering geoengineering as a normal object of scientific inquiry. The paper argues that through this kind of intervention, authoritative scientific assessments constitute a source of ‘de facto’ governance that shapes the foundations upon which ‘de jure’ governance is designed. For this reason, authoritative scientific assessments should be more front and centre of governance research.

Paper III compares geoengineering to two other emerging climate policy fields, namely the reduction of emissions through deforestation and forest degradation (REDD+) and short lived climate pollutants. The paper theorises the relative importance of public and private authority in the emerging global governance architecture of these three climate policy areas. It argues that the perceived problem-structure of a policy area plays a fundamental role in determining to what degree public actors are willing to initiate (global) governance of an issue area. Malign problems, characterised by conflicts over values and relative goods, are less conducive to public governance than benign problems, characterised by conflicts over means and absolute goods. The definition and redefinition of the problem structure, in particular its transition from malign to benign, therefore constitutes an important factor in determining the shape of global climate governance.

Paper IV studies the way in which geoengineering resonates with the normative and institutional context of government officials. The paper identifies the ‘fit’ of problem definitions with their institutional context as an important condition for policy issues to become part of the political agenda. It discusses three areas where institutional fit for geoengineering is (still) lacking. The first is a mismatch between the categorisation of geoengineering technologies into Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR), and the structure of the international legal architecture. Whereas the former is motivated by a geophysical understanding of the climate system, the latter is motivated by questions of jurisdiction and procedure.

The second is a concern for reputation, trust and the position of major powers. While government officials recognise the potential importance of geoengineering governance, political uncertainty about these issues makes it difficult to raise the issue in an international forum. The third is a dissonance between large-scale transboundary interventions and the precautionary norms of environmental governance. In order to find political traction, geoengineering – commonly framed in terms of a risk-risk assessment – must be framed in terms that emphasise risk reduction and the increase of overall benefit.

1.2 Geoengineering as a research puzzle

The emergence of geoengineering technologies on the scientific and political agenda is intriguing for several reasons. Firstly, the large-scale modification of natural systems in the name of environmental protection strays substantially from norms that have shaped environmental policy making since the 1970s. In the post-modern era, environmentalist thought evolved out of an increased understanding of the planet's physical vulnerability and an emphasis on humility. It has been associated mostly with *reducing* human impact, removing man-made sources of pollution and restoring nature to its original state. Geoengineering technologies, by contrast, aim to strategically *increase* human impact on the planet in order to counteract the effects of another human impact. Their assumptions about the role of humankind are thus more similar to those of the post-world war modernist age, where a belief in human capacity to master nature prevailed. Their rise on the agenda can thus be understood as a challenge, or 'contestation', of traditional ideas about environmental protection (for a background on this, see Baskin 2016, Falkner 2012). It thus serves as an interesting case study of how this apparent contestation has taken place.

Secondly, geoengineering as a concept has experienced a remarkable increase in attention and status in a very short amount of time. During the 1990s, the concept existed primarily in the form of an idea sometimes mentioned in the corridors of scien-

tific conferences. Only few were willing to speak and write about it openly, and those who did expressed their ideas in the form of cautionary questions of ‘if’, ‘should’ or ‘could’ (e.g. Schneider 1996). Today, almost all low temperature emissions pathways presented by the Intergovernmental Panel on Climate Change (IPCC) include large-scale removal of carbon dioxide from the atmosphere. Also solar radiation management, the idea to stabilise temperatures by engulfing the Earth in a layer of reflective particles, has moved from being a scientific outcast into receiving substantial discussion in the IPCC’s report on 1.5 degrees. Within less than a decade, the concept transformed from a mere thought experiment into an issue at the heart of climate change science. This makes geoengineering an interesting case to study from a policy cycle perspective.

Thirdly, the normality with which geoengineering technologies are being proposed in mainstream climate science deserves to be problematised. Geoengineering literally means *planetary engineering*, and the suggestions being put forward include scales of human coordination that have no historical precedent. The amount of land needed to absorb the 10–20 gigatonnes of carbon dioxide per year projected in the IPCC’s models has been estimated to be at 400–500 million hectares of biomass plantations (Vaughan & Gough 2015). By comparison, the total amount of arable land in the United States or India is about 150 million hectares. This implies a massive change in global agriculture and infrastructure scheduled to take place within about fifty years. Also solar radiation management has considerable implications for social systems. Once the process of reflectivity enhancement is initiated, it cannot be stopped before greenhouse gas concentrations have stabilised at the same level, or lower, as when the process was first initiated (Jones et al. 2013). Implementation would therefore coerce the continuation of a planetary-scale intervention until emissions concentrations are low enough to be able to stop the process, a length of time that is currently not determinable.

1.3 Main contributions

Theoretically, the thesis contributes to the study of global governance by providing insights about causal mechanisms in the constitution of new governance objects. International relations literature in this field highlights the importance of political culture and community in explaining why institutions take certain forms, emphasising global norms and their contestation as important explanatory factors (e.g. Finnemore 1996, Wiener 2004). The more policy oriented literature highlights the importance of framing and interpretation, as well as political expectations and a logic of appropriateness (e.g. Schön & Rein 1994, March & Olsen 2011). By studying linkages between individual and collective behaviour in the case of geoengineering, I bring these literatures together and identify mechanisms by which such factors play a role in steering collective action. I thereby shed light on the question *why* we govern the things we govern, describing a causal pathway through which a concept can be transformed into a globally relevant governance object.

In the process, I use a conceptual demarcation of governance that distinguishes between *de jure* and *de facto* steering mechanisms, the former being identifiable by their intention to govern, the latter by their steering effect. Originally used by Rip & Amerom (2010) to describe the field of nanotechnology in a context of science and technology studies, Aarti Gupta and I first use this distinction in a context of political science. By highlighting a difference between governance by intention and governance by effect, we demonstrate the value of studying steering mechanisms that are not conventionally thought of as governance. This opens a conceptual pathway towards studying the more ‘obscure’ mechanisms and authorities of governance discussed by James Rosenau (1995) in his early treatise on global governance.

Methodologically, the thesis contributes to the empirical study of governance by demonstrating how mixed methods within one case study can be used to capture the hidden dynamics of governance processes. Its main innovation is perhaps to explicitly look for and analyse relationships between the individual and the

collective. I study this relationship in the interactions between individual researchers and a collective epistemic community, between individual assessments and the wider research landscape, and between individual decision makers and their wider context of political negotiation. The methods I use show how, by taking an actor-oriented perspective, one can explore and study the structures that influence a given set of actors' behaviour, and how the actions of those individuals can contribute to the steering of a wider community.

In terms of data, the thesis contributes to the geoengineering literature with some of the first insights to government actors' reasoning around the geoengineering concept. By conducting interviews with government officials and observations of political deliberations, I add empirical material to the analysis of policy documents conducted by Huttunen et al. (2014) and interviews with scientific advisers conducted by Himmelsbach (2018). The thesis also contributes a map of the epistemic community around geoengineering that is based on members who actively participate in geoengineering conferences and events. Combined with qualitative data on the community's activities and the reasoning of its members, it adds important insights about the network's internal dynamics. It thereby improves our understanding of a community that has, to date, been studied primarily using bibliometric data (Belter & Seidel 2013, Oldham et al. 2014).

Empirically, the thesis provides a number of insights that are relevant to our broader understanding of how governance works, and why political actors at the global level begin to form institutions around a certain issue area in the first place. They can be summarised in the following points:

1. The creation of a distinct governance object is dependent on creating discursive order, meaning that participants in the research and policy field converge on the same terms, definitions and assumptions. **Paper I** explains how narratives of attraction and narratives of common cause serve as ordering mechanisms within epistemic communities. The ensuing cohesion amongst the community lets a mere idea

be transformed into a more substantial concept. Through repetition within the community, introduction to new audiences by knowledge brokers, and incremental adaptation to new contexts, the concept gains power to attract research interest and funding, eventually leading to the establishment of a widely shared object of thought.

2. The demarcations and priorities used in prominent authoritative assessments can provide a *de facto* source of steering for entire research landscapes. **Paper II** shows how, in moments where the authority of the epistemic community and its common narrative is contested, or multiple object definitions begin to exist in parallel, endorsement of one definition over others by an authoritative institution can reinforce discursive order in the wider field of inquiry. This maintains the object's distinctiveness and further increases its saliency through legitimation by an authoritative organisation. For this reason, authoritative scientific assessments should be taken into account when analysing the governance landscape of a given issue area.
3. If a governance object is to effectively move from the realm of science into the realm of government, the problem definitions associated with it need to resonate with the institutional surrounding. **Paper III** shows how differences in the *de jure* governance landscape of policy fields can be linked to the problem structure associated with the given object, positing that policy fields with benign problem structures are more easily integrated into the public governance structure than fields with malign problem structures. **Paper IV** explains why this is the case. It demonstrates the importance of one actor's uncertainty about the expectations of other actors; not knowing other actor's opinions about a value-laden object makes it difficult to introduce the object into the realm of public decision making. It also highlights the importance of already existing institutions and norms. In order to initiate a pub-

lic governance mechanism, the problem definitions around a governance object must connect with already accepted agendas and narratives.

In terms of relevance for practice, I hope that explaining the emergence of geoengineering on the global agenda can contribute to a more reflected decision making process. Although I do not provide explicit recommendations as to how the issue should be governed, I have found that providing an new perspective to an otherwise very streamlined, technical problem narrative can help in forming a political position towards it.

The need for geoengineering research is legitimised by a conceptualisation of climate change being a problem of carbon sources and sinks or degrees of planetary reflectivity. It is accompanied by rationalist narratives of rogue states that might use geoengineering technologies for their own benefit. These are the most common reasons for which international governance of geoengineering is being advocated for. But these perspectives do not account for the more complex conditions of political culture and international norms. They assume away the historical context of global politics and ignore political expectations in the multilateral negotiation process.

The 2015 Paris Accord represents a peace agreement in the international community. Despite obvious differences in historical responsibility, actors from around the world are coming together in an effort to tackle a monumental challenge. It would be unfortunate if these efforts were undermined through new accusations of responsibility avoidance and the suggestion of a technical solution that is unlikely to be politically or socially feasible. The decision making process should not let itself be steered by problem narratives of global solutions or rogue actors, but instead recognise these narratives as a part of the political process in which geoengineering was made into a governance object. Once this is clear, it becomes easier to evaluate the pros and cons of integrating geoengineering into the global political agenda.

2 Theory

MY OVERARCHING AIM is to explain how geoengineering transformed from a tentative thought experiment to a potential climate policy option. I do this through a lens of global governance, a field which has been defined as the study of ‘how rules are created, produced, sustained, and refined, how these rules help define the purpose of collective action, and how these rules control the activities of international, transnational, and increasingly domestic action’ (Barnett & Sikkink 2011, 764). More specifically, I take part in an increasingly shared endeavour amongst governance scholars to understand the construction of *what is to be governed*, i.e. how a problem gets defined and placed on the international agenda. In this endeavour I am particularly interested in origins of so-called ‘governance objects’. In section 2.1, I explain my meta-theoretical understanding of the relation between agency and structure, and how this understanding provides the foundation for further theoretical and methodological inquiry. In section 2.2, I discuss the concept of governance and how it can be used to conceptualise different kinds of societal steering. In section 2.3, I briefly review the literature that is relevant to steering in the earliest phase of the political process. In section 2.4, I propose an analytical framework that integrates insights from different schools of thought, and that I subsequently use to point out the theoretical contributions of the papers.

2.1 Agency and structure

At the basis of every social scientific endeavour lies an assumption about the relationship between agents and the structures that surround them. Are agents free to think and do what they want? Or are their actions defined by the context that they act in? Most likely, the answer is something in between. In this thesis, agency and structure are understood to be mutually constituted. Agency cannot exist without structure, and structure is irrelevant without the potential for agency. I therefore broadly build on Giddens (1984) early theory of structuration and the

‘two-sides of the same coin’ analogy, but lean towards the theoretical developments of Hay (2002), who places the *interaction* between actors and the context in which they find themselves at the centre of attention. Rather than bracketing one side of the coin off (as Giddens originally suggests), agency and structure are studied simultaneously.

Informed by the very useful discussion of meta-theory in Marsh (2010), my understanding of agency and structure boils down to a mutually constitutive definition in which agency is the ability of an actor to recognise, use or change a given structure. At the same time, there are necessarily structures that the actor does not recognise as such, and that steer the actor’s actions without the actor reflecting upon this. Yet this divide is not static. Those structures that are ‘invisible’ can become ‘visible’ through communication and learning, and in particular through exposure to new ideas. This conceptualisation is illustrated in Figure 2.

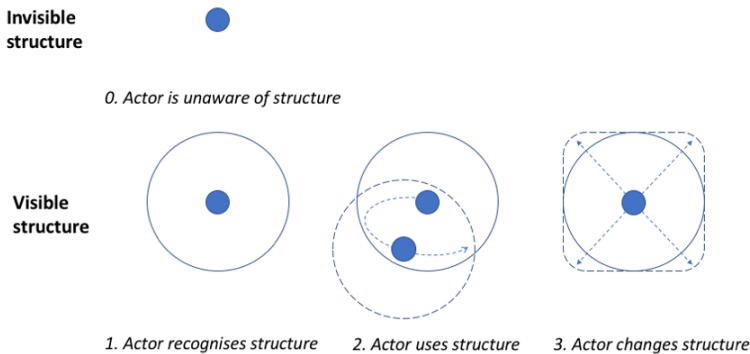


Figure 2: A mutually constitutive understanding of agency and structure.

I think of actors as individual people or specific groups of people. This means that agency is never abstract; it is intrinsically linked to a particular person at a certain point in time and space, and dependent on that person being aware of (some of)

the structure that surrounds them. I mention this because in international relations, states or organisations are conceptualised as actors, while here, they would be conceptualised as groups or networks. Basically, I assume that to understand a state's behaviour at international level, one needs to study the actors that represent this state in the political process.¹

I think of structures as commonly accepted narratives, expectations or incentives that guide an actor's behaviour. 'Invisible' structures are taken for granted, and thereby un-associated with the possibility of change or questioning. Although an actor may act according to them, the actor is not aware of the fact that whatever assumption they are basing their actions on could be different. Once a structure is recognised for what it is, actors can choose to question it, to use it to their own advantage, or to attempt to change it.

Using an individual-level conceptualisation of actors makes it easier to study the dynamics between individuals that lead to social change. It provides theoretical room for actors to navigate and use the social structures that are 'visible' to them in pursuit of individual or collective goals, but also makes it easier to recognise which 'invisible' structures these individuals might be conforming to without being aware that they are. Defining structure through agency at the individual level also provides a place to begin searching for those parts of the context that explain individual people's behaviour, without making too many assumptions about which structures matter and which ones don't.

One example of how this perspective is helpful can be found in **paper IV**. Here, I study the structures that shape political decision making about geoengineering through the reflections and deliberations of government officials. When comparing interviews and observations, it becomes clear that there are overlaps

¹There is also a growing literature on objects (or 'actants') that are considered to have agency, but this kind of conceptualisation goes beyond what I find useful for my own research. I think that objects can have effects on people's behaviour, but their lack of goal-oriented action excludes them (in my mind) from the agency definition.

in the structures that inform the decision making process for officials from different countries. These include, most prominently, an understanding of political expectations and ‘rules of the game’ in environmental policy making. With respect to the structures associated with geoengineering, there is more difference. Actors who have followed the issue over long periods of time are aware, for example, that the benign characterisation of carbon dioxide removal facilitates its integration into climate policy. They are able to strategically use this fact, or question and criticise it. By contrast, actors who are less familiar with the field assume that this narrative is a given fact and do not question it.

This example highlights how agency and structure differ amongst the actors involved in transforming a given issue area. While some individuals recognise certain structures and are able or willing to use or change them, other individuals may be introduced to or surrounded by a structure and follow its impulse, without being aware that the structure could be different. Both types of individuals are important for understanding change in a community’s collective behaviour, and their interactions are important components of understanding processes of social steering.

2.2 Conceptualising governance

In this thesis, governance serves as a concept to summarise the mechanisms that steer societal behaviour. My understanding of it is based on an essay by James Rosenau (1995, 15), who defines governance as ‘the process whereby an organization or society steers itself, and the dynamics of communication and control that are central to this process’. It is thus a wider conceptualisation than the explicit, goal-oriented mechanisms of setting rules or providing incentives that are usually associated with governing. Instead, it also encompasses the more nuanced, less visible, and perhaps not always directly recognisable (or intentional) forms of societal steering. The reason why I use such a broad conceptualisation is precisely because I am interested in explaining societal change rather than providing advice on how to steer towards a certain outcome. As I see it, the former is

a necessary condition for effectively enabling the latter. In this thesis, governance is therefore not understood as a normative goal, but as an empirical phenomenon.

De jure and de facto governance

Because governance and its many kinds of societal steering are difficult to grasp, Aarti Gupta and I suggest to differentiate between *de jure* and *de facto* governance in **paper II**. *De jure* governance comprises the kinds of governance that we usually associate with governing: explicit, intentional, targeted interventions that aim to steer societal behaviour in a certain direction. This comprises both soft and hard as well as public and private forms of explicit steering, based on institutionalised codes of conduct, collective agreements, rules, laws and legal norms. It is recognisable in its source and form as a clearly defined attempt to introduce order.

By contrast, *de facto* governance has been defined by Arie Rip (2018) as ‘[scattered] actions and interactions and how these add up to outcomes at the collective level that function as governance arrangements’. Rather than explicit and targeted interventions, *de facto* governance represents a form of steering that is neither mandated, nor openly pursued, nor directed at a certain target, but that nevertheless has visible steering effects resulting in some form of order. This kind of steering is based on mechanisms that are not explicitly aimed at governing society, but that nevertheless do so.

Concrete examples of the two types of governance are studied in the four papers. The less explicit processes of *de facto* governance are examined in **paper I** and **paper II**, where social dynamics in epistemic communities and the discursive interventions of authoritative assessments are conceptualised as steering mechanisms with ordering effects. The more explicit processes of *de jure* governance are examined in **paper III** and **paper IV**, where the governance architecture of different climate policies is compared, and where hurdles and opportunities for initiating public steering mechanisms are explored.

Why is it important to study both types? Most definitions of governance are based on the intentionality of the governor, and the aim to reach a given collective outcome. In this perspective, only an intentional effort to steer behaviour is considered an act of governance (see Kooiman 1999). But intentionality is sometimes difficult to determine, and the effect of an intentional act of governance could be very different from the intended outcome. The difference between unintended steering effects and steering effects that are created by unintended acts of governance is therefore blurry. Yet both effects result in the change and development of society.

As discussed in section 2.1 on agency and structure, the study of *de facto* governance can help in recognising some of the structures that push societal behaviour in certain directions, and that sometimes provide the unacknowledged foundations that lead to *de jure* governance. Conceptualising both as a form of governance enables the researcher to acknowledge interactions and interdependencies between the two, and provides a way of recognising the ‘authorities that are obscure’ and the ‘systems of rule that are emergent’ as originally described by Rosenau (1995).

Authority and legitimacy

Two important terms that are linked to the concept of governance and frequently used in the papers are *authority* and *legitimacy*. In **paper III**, we define public authority as ‘a recognised institutional competence to make decisions or interpretations in the name of the collective interest’, based on Raz (2009). We define private authority as ‘the creation of actual rules, standards, guidelines, or practices that other actors adopt’, based on Green (2014). In summary, authority can be understood as a characteristic attributed to a leader or maker of rules that induces others to follow their example. It essentially acts as a form of currency in the governance process and is linked to an actor’s ability to influence collective behaviour.

Legitimacy, here more often discussed in terms of legitimation, provides a way of building or enhancing authority. In the Hand-

book of International Environmental Law, legitimacy is defined as ‘the justification and acceptance of political authority’. The Handbook further states that ‘a legitimate institution is one that has a right to govern – for example, based on tradition, expertise, legality, or public accountability – rather than one relying on the mere exercise of power’. This also applies to ‘the more informal networks and rule structures that exercise authority over others’ (Bodansky et al. 2008, 705). Legitimacy and legitimation thus point to the process of constructing authority; i.e. the process of highlighting why a certain actor or institution should be considered authoritative.

An example of the effects of authority and legitimacy can be found in **paper II**, where we discuss the role of authoritative scientific assessments in governing the development of research on geoengineering. Here, authority is invoked through the scientific tradition and expertise associated with the publishing organisations. The reports act as an authoritative intervention in a chaotic discussion, inducing partakers of the discussion to lay down their differences and follow the report’s suggested definitions and categorisations. They also serve as a source of legitimacy for subsequent research projects, which rely on the report’s engagement to justify their own endeavours.

This provides one interesting example of how agents can use structure to increase their own legitimacy and thereby improve their steering capacity. By publishing under the name of an authoritative organisation, individuals can amplify their opinion on a given subject. This opinion becomes recognised by others as authoritative, based on the reputation attributed to the publishing organisation. After publication, the authors can refer to the report in order to legitimise their own activities, emphasising how an authoritative organisation has recognised the topic to be worthy of further inquiry and how it has laid out certain pathways that deserve to be investigated. As the authors themselves chose the pathways, these are likely to mirror their own positions. They thereby increase their own authority in the field and induce others to follow their example.

2.3 The earliest stage of the political process

Societal steering takes place at all levels of society and in all parts of the political process, but my particular interest is its function in the earliest stages of global politics. Simply put, I want to understand the steering mechanisms by which an abstract idea becomes relevant enough to make it a *thing* in the international policy process.

What kind of ‘thing’ geoengineering is, and what literature is most appropriate to build on, has been difficult to determine. It is most commonly defined as ‘the deliberate large-scale intervention in the Earth’s climate system, in order to moderate climate warming’ (Shepherd et al. 2009, ix) and subdivided into carbon dioxide removal and solar radiation management. Therefore a technology-focused theory of emergence or innovation might be appropriate. Yet to study a technology’s emergence, the technology must exist in one form or another, and geoengineering is, to date, primarily an object of the mind. Beyond computer models, a few experiments in ocean fertilisation and small number of direct air capture installations, geoengineering has not made it into the material world.² Still, it has significant political potency, making it more akin to the ideational objects studied in political science. We can therefore ask: is geoengineering an idea, a policy, a norm, or something else entirely?

Emerging policies, emerging norms

On the one hand, the proposal to use geoengineering has the characteristics of a policy, or a ‘set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them’ (Howlett & Ramesh 2003, 6). It can be understood as a means of addressing climate change, comparable to other policies like the expansion of renewable energy, the phase-out of fossil fuels, the building of dams,

²Some of these material manifestations, climate models in particular, are nevertheless very interesting to study. New materialist perspectives on these can be found in Beck & Mahony (2017) or Haikola et al. (2018), but they are not at the center of attention in this thesis.

or the taxation of meat and aeroplane fuel.

Conceptualised as a policy, the most appropriate literature to theorise its emergence would be agenda setting, often considered as the first stage of a five step policy cycle (followed by policy formulation, decision making, policy implementation, and monitoring and evaluation). Howlett & Ramesh (2003) define agenda setting as the process by which a problem becomes recognised by the government. Whereas this process was originally thought of as linear and deterministic, scholars like Rochefort & Cobb (1994) and Schön & Rein (1994) have provided a more sociological perspective in which frames and problem definitions are important and different policy actors compete for influence. In this competition, the outcome is not necessarily determined by the best idea, but by the abilities and resources of competing actors.

The agenda setting literature highlights the importance of policy entrepreneurs in this process: political actors that manage to introduce significant change or disruption to established ways of doing things. Mintrom and Norman (2009, 650) note that policy entrepreneurs distinguish themselves from other actors ‘through their desire to significantly change current ways of doing things in their area of interest’. They do this by being socially perceptive (e.g. by recognising and using windows of opportunity), paying close attention to problem definition, building teams and coalitions, and leading by example. Equally interesting is the role of so-called ‘discourse coalitions’ or ‘advocacy coalitions’, describing groups of actors that engage in a common policy endeavour and their role in shaping the policy process (Hajer 1993, Sabatier 1998). Recent studies in this area highlight the importance of converging on common narratives as a way of navigating complex institutional landscapes (Zelli et al. 2019), but also the role of internal polarisation for explaining major policy change (Leifeld 2013).

On the other hand, geoengineering is seen by critics as substantially different from conventional mitigation or adaptation policies, and some observing NGOs have characterised it as a ‘big bad fix’ (Wetter & Zundel 2017). As mentioned in the in-

troductioin, geoengineering technologies aim to address climate change by enhancing the human footprint, rather than reducing it. In this sense, it can be understood as a contestation of dominant norms in environmental politics, such as the precautionary principle or the minimisation of transboundary harm.

Conceptualised as a norm, or a contestation of a norm, the most appropriate way to theorise its emergence would be based on the literature about norm dynamics. A norm is defined as ‘a standard of appropriate behaviour for actors with a given identity’ (Finnemore & Sikkink 1998, 891). The classic model of the norm life cycle, proposed by Finnemore & Sikkink (1998), begins with norm emergence, before leading to norm cascade (or diffusion) and internalisation. More recent models also include strengthening, weakening or erosion of norms at later stages in the cycle, primarily through processes of norm contestation (Wiener 2004).

Norms are understood to be products of ‘strategic social construction’, dependent on interpretation and translation into concrete behaviour (Finnemore & Sikkink 1998). Sometimes new norms are thought to originate out of old norms, or at least that congruence with existing norms is beneficial for a new norms success (Acharya 2004). Other times, they are thought to originate out of controversial discursive negotiations between actors, leading to mutual understandings that can result in new norms or in the re-interpretation of old norms (Elgström 2000). Similar to the agenda setting literature, norm emergence is commonly explained through the activity of norm entrepreneurs who benefit from changes in structure and windows of opportunity. These are described as ‘key driving forces for norm development’, and their success is attributed to the ‘agents’ perception, situation analysis, goal setting, and intentional action’ (Müller & Wunderlich 2013). Beyond individual norm entrepreneurs, scholars in this field have highlighted the importance of transnational advocacy networks, analysing their internal dynamics in the quest for explaining normative change (Keck & Sikkink 1999, Carpenter 2007).

The two literatures name similar factors in the policy and

norm emergence process, both highlighting processes of interpretation and framing, dedicated entrepreneurs who engage in the strategic advocacy of new ideas, and the convergence or polarisation of issue networks. Their main difference is the scale at which they operate. While agenda setting is a theory primarily used in national contexts, norm emergence is studied primarily in the international context. Geoengineering already plays a role in both. Its presence can simultaneously be found in research policies and inquiries of parliaments in the United States, the United Kingdom and Germany, as well as negotiations of international bodies like the CBD, the London Protocol, and the UNFCCC. Therefore, it is not clear which literature is most applicable to explaining its emergence.

Governance objects and knowledge networks

To circumvent having to define geoengineering as either a policy or a norm, I have settled on conceptualising it as a *governance object*. Both **paper I** and **paper II** use this term, inspired by the tradition of discussing objects in science and technology studies (Jasanoff 2006) and by the recent work of Bentley Allan (2017), who uses the term ‘governance object’ to discuss the emergence of climate change as a politically relevant idea. Most political science literature on the constitution of objects focuses on structural factors like discourses and narratives, with scholars like Lövbrand et al. (2009) or Oels (2013) providing valuable critical analyses of objects like ‘the Earth system’ or ‘climate refugees’. Yet, I think that this term can also be helpful in taking a more agency-oriented approach.

The term ‘governance object’ provides a simple conceptualisation of a *thing* (from ecosystem services to women’s rights) that becomes subject to political decision making at any level, making it possible to mix and apply insights from both the national policy cycle and the international norms life cycle literature. It also highlights how the shape of an eventually successful governance object affects the resulting politics around it, and that this shape is determined by political processes in which social

actors are involved. As Allan (2017, 133) argues, ‘the production of governance objects is neither natural nor inevitable and has important effects on how global problems are understood and governed’.

In terms of defining where such a governance object might originate, I draw inspiration from the many scholars of environmental politics who study transnational knowledge networks. Most prominently, this includes the study of epistemic communities (Haas 1992) and the study of transnational advocacy networks (Keck & Sikkink 1999). An integrated definition distilled from the different literatures might describe knowledge networks as communities of actors that share normative beliefs and a common policy enterprise, and that are linked by a certain idea of how the world works. They also have many things in common when it comes to a diversity in participating actors, contacts with government, and strategies of knowledge diffusion (Stone 2002).

The underlying theoretical assumption in the study of transnational knowledge networks and their influence on the governance process is that the advocacy of knowledge, framed in a certain way, induces learning amongst policy makers and shapes the realities and assumptions based on which they make decisions. What distinguishes them (and this is perhaps the reason why different literatures have evolved around different types of networks) seems to be their source of legitimacy. For example, Antoniades (2003) argues that epistemic communities are different from other types of networks because of their authoritative claim on (scientific) knowledge. Meanwhile, policy networks might draw their legitimacy from experience in the policy making process, and advocacy networks from the types of people they represent.

Although providing many useful insights about the dynamics of transnational politics, the literature on knowledge networks also faces criticisms that need to be accounted for. Science and technology studies scholars like Lidskog & Sundqvist (2015) critique the unidirectional causality (i.e. knowledge or science influencing policy) that is often assumed in the epistemic com-

munities literature. They instead highlight the politics of making knowledge, describing the way that government shapes the framework and motivations in which the generation of (scientific) knowledge takes place. Jasanoff (2005) further explains how, in increasingly complex issue areas that are characterised by uncertainty, science cannot be independent or objective. Knowledge creation and framing is always linked to political circumstance, and scientists are often asked to be experts that offer balanced opinions based on less-than-perfect knowledge. The results that come out of this process are increasingly less about what is most technically defensible, but rather about whose recommendations should be accepted as credible and authoritative.

The recognition that the science-policy interface is determined by dynamics of credibility and authority links back nicely to the agenda setting and norm emergence processes discussed earlier. The emergence of a policy or norm (or indeed a scientific governance object like geoengineering) can be described as a political process of framing and problem definition in which success is attributable to the resources and abilities of knowledge entrepreneurs. These resources might very well include scientific currency like credibility and authority, but also access to government, the ability to recognise windows of opportunity, and the ability to form teams and coalitions. At the same time, rationality is always bounded and not all structures are visible. Even knowledge entrepreneurs are steered in ways that they may not be aware of, or cannot resist.

The knowledge we have about policies, norms and the science-policy interface implies that the arrival of geoengineering on the political agenda is unlikely to be a simple case of power listening to truth. Nor is it a pure and inevitable reaction to the urgency of climate change. Instead, the theory points to a set of intricate interactions between actors and structures, leaders and followers, problem definitions and institutional contexts, that deserve to be unravelled. Building on this knowledge, I suggest a simple analytical framework that can guide investigation into these interactions and that serves as a way to identify the contributions of the four papers.

2.4 An analytical framework for object emergence

What happens when we bring the agenda setting, norm emergence, and science-policy interface literatures together? It turns out that their insights are not so fundamentally different. Common elements can be found throughout, indicating that there are more basic social processes at work. In Figure 3, I summarise these processes very generally along two dimensions: an ‘actor’ dimension, ranging between focus on leadership and focus on community, and an ‘object’ dimension, ranging between focus on dissonance and focus on resonance with the surrounding structure.

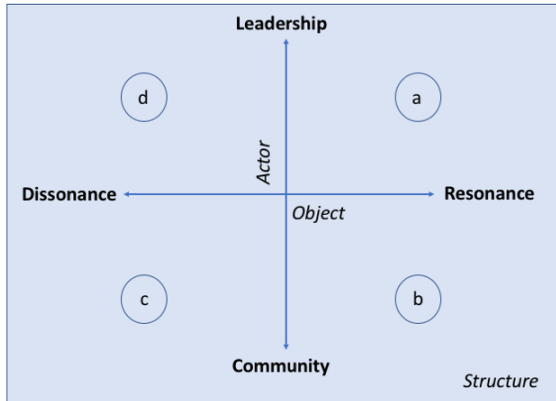


Figure 3: Dimensions of interaction in studying object emergence.

The result is an analytical map of the norm/policy/object emergence literature, summarised in the form of an actor and an object dimension on top of a structural background. Each dimension comprises two ends that link to observations recurrently made in the different literatures. Leadership is often studied in the form of entrepreneurship, while community is often studied in the form of networks or coalitions. Dissonance is often studied in the form of contestation and controversial deliberation, while resonance is studied in the form of advocacy, strategic problem

definition and framing.

The ends of each dimension open up a field of interaction between actors and objects, comprising, for example, the strategic framing by leaders to enhance the resonance of an object (a), discourse coalitions between communities that are shaped through mutually resonating objects (b), rivalry between communities around objects that are in dissonance with each other (c), and the contestation of established norms by opinion leaders (d). In all fields, interactions can be evaluated against a structural background. I use this simple figure to indicate which processes are studied in the different papers, and how they make theoretical contributions to the literature.

The *actor dimension* is most explicitly studied in **paper II**. Here, Aarti Gupta and I identify authoritative assessments as sources of leadership that shape the scientific community. We thereby highlight a form of entrepreneurship that is not commonly discussed in the governance literature. We posit that authoritative assessments put forward certain categorisations and demarcations that are subsequently used and referred to by other actors who engage with the object in question. The common use of the demarcation results in an increase of discursive cohesion within the geoengineering research community and introduces order to a previously chaotic discursive field. In this sense, authoritative assessments can be thought of as a source of *de facto* governance with steering effects, despite the fact that they are not considered as explicit rules with intentions of governing.

The *object dimension* is most explicitly studied in **paper III**. Here, Fariborz Zelli, Harro van Asselt and I study the problem structure of three different policy issues (or objects) in the field of climate change, proposing that their different constellations of public and private *de jure* governance modes can be linked to their problem structure. Translated to Figure 3, malign or benign problem structures can be thought of as either dissonating or resonating with the institutional or normative context. Our contribution here is that benign problem structures, i.e. those that resonate with the surrounding institutional and normative structure, are more easily integrated into public forms

of governance than malign problem structures. For this reason, issues with malign problem structures are more likely to (first) be governed or addressed through private authority. However, governance through private authority may result in discursive shift and a redefinition of the problem structure towards a more benign framing, in the wake of which the issue might transition into the realm of public authority.

The *interaction between resonance, leadership and dissonance*, (a) and (d), is most explicitly studied in **paper IV**, although from a different perspective than is commonly the case. Rather than retrospectively analysing the activities of successful policy or norm entrepreneurs, I study the potential for government officials to propose or champion geoengineering as an object of governance. Here, I focus particularly on the resonance and dissonance of the geoengineering object with government actors' institutional surroundings. I then explain how these interactions present opportunities and obstacles for initiating a multilateral decision making process on geoengineering. In the paper, I highlight the importance of institutional fit, concluding that the introduction of a new object necessitates the building of bridges to existing institutions and expectations in order to become viable for political discussion.

The *interaction between resonance, community and dissonance*, (b) and (c), is most explicitly studied in **paper I**. Here I examine the formation of an epistemic community around the geoengineering object, identifying mechanisms of cohesion, brokerage and diversity that link to dynamics of resonance or dissonance in the community's discourse around the geoengineering object. I highlight how both resonance and dissonance are needed to create a successful governance object. Resonance (or discursive cohesion) within a community is necessary for the object to gain initial traction. Dissonance (or controversial deliberation) enables the adaptation of the object towards fitting a wider audience, and enables increasing fit with the broader institutional structure.

3 Method

TO UNCOVER THE POLITICS embedded in the emergence of geo-engineering, my research design needed to allow for studying the evolution of the geoengineering object, the activities of actors engaged with it, and structures that determined their behaviour. Because geoengineering is a recent phenomenon, it also required gathering primary data and immersion into a complex field of multiple scientific disciplines, actors and ideas. I thus opted for a single case study, in which I use process tracing, realised with both quantitative and qualitative methods, to empirically uncover causal mechanisms. This open-ended, iterative approach to research has provided the necessary space and reflexivity to discover important social dynamics that would have stayed invisible in a comparative or statistical approach. It also provided the opportunity to develop theory that might be applicable to other issue areas. Section 3.1 gives a short reasoning for the use of single case studies and process tracing as a way of uncovering causal mechanisms. Section 3.2 gives a brief introduction to the different methods used, including social network analysis, document analysis, observations and interviews. Section 3.3 provides reflections on advantages and disadvantages of the approach.

3.1 Studying causal mechanisms

Following George & Bennet (2005, 17), I understand a case as ‘an instance of a class of events’ or a phenomenon of scientific interest that is studied by a researcher in order to develop theory regarding the causes of similarity or difference among instances of that class of events. I thus treat geoengineering as a case of governance object emergence, and the conclusions I draw from it are meant to provide insights about mechanisms that may play a role in other cases of governance object emergence.

In explaining the mechanism-based approach, the authors cite the statistician Wesley Salmon and his explanation that such an approach essentially means going ‘beyond phenomenal descriptive knowledge into knowledge of things that are not open to

immediate inspection', 'open[ing] up the black boxes of nature to reveal their inner workings' and 'exhibit[ing] the ways in which the things we want to explain come about' (135). They themselves define causal mechanisms as

'ultimately unobservable physical, social, or psychological processes through which agents with causal capacities operate, but only in specific contexts or conditions, to transfer energy, information, or matter to other entities. In so doing, the causal agent changes the affected entity's characteristics, capacities, or propensities in ways that persist until subsequent causal mechanisms act upon it.' (137)

A causal *mechanism* is thus different from a causal *effect*, which is a concept more commonly used in statistical analyses and comparative case studies. Whereas a causal effect refers to the changes in outcome variable brought about by changes in the value of an independent variable, a causal mechanism refers to the interaction of multiple variables over a certain period of time and within a certain type of space. Simply put, the mechanism-based approach tries to identify and understand the many cogs (and their interactions) that make one variable influence another.

George & Bennett (2005) suggest that the most appropriate method for finding causal mechanisms in single case studies is process tracing. Essentially, this means beginning with a certain event and tracing the historical pathway through which the event emerged. But in doing so, process tracing is meant to go beyond depicting a historical narrative. By extracting explicit lines of reasoning from the observed sequence of events, it turns the account into 'an analytical explanation couched in theoretical variables that have been identified in a research design' (Bennett & George 1997, 6). By examining archival documents, interview transcripts and other historical sources, the researcher tests whether the causal pathway hypothesised by a given theory holds.

The obvious challenge in conducting a George & Bennett style process tracing exercise for geoengineering is the novelty of the

issue area and the continuous evolution of the subject matter. However, more recent discussions of process tracing have pointed to the merit of using a larger variety of methods (both quantitative and qualitative) as a way of studying contemporary change (Collier 2011). Also the increasing recognition that social systems are likely to be *complex*, rather than *linear*, raises questions whether a simple tracing of historical pathways is appropriate. Instead, social scientists have emphasised the need for methods that take a more holistic, or systemic approach (e.g. Bousquet & Curtis 2011). Whereas qualitative research accounts for complex systems with discourse analysis, quantitative research is increasingly moving towards the use of network analysis or agent based modelling. In my own process tracing exercise, I thus opted to combine a number of different methods so as to gain a more systemic perspective.

3.2 Toolbox of methods

The methods used in this thesis cover four different approaches. Social network analysis was used to gain a sense of the community in which the idea evolved. Document analysis was used to analyse the evolution of the geoengineering concept. Participant observations at scientific and political conferences were used to understand social interactions within and between communities. Interviews with scientists and policy makers served to elicit individual-level modes of reasoning, and to gain a better understanding into the temporal process of the field's development. A short description of each method follows.

Social Network Analysis

Social network analysis is a method used to map actors and their social relations. In this thesis, it served primarily as a way to gain oversight of the actors involved and provided a feeling for 'who is who' in the network. These insights served as an important basis for formulating questions in subsequent qualitative analysis, and the theory on social networks and social interac-

tion contributed to better understanding the dynamics that take place within communities of social actors.

The empirical aim of using social network analysis was to assess how many people were actively involved in the geoengineering field, what kinds of organisations were taking part, how the network is organised, and whether there are central figures that might have had an influence on the network as a whole. My use of it was inspired by studies of policy emergence and entrepreneurship in social networks as conducted by Paterson et al. (2013) or Christopoulos & Ingold (2015). I also drew inspiration from network-based studies of epistemic communities, also called ‘invisible colleges’ (Price 1986, Zuccala 2006), and transnational advocacy networks (Wong 2008, Carpenter 2011). Some of these studies were particularly useful for inspiration on how to study a network that has no predefined boundaries, and how to think about processes of opinion-forming within a social network.

Social network analysis assumes that the behaviour and effect of an actor is not so much related to variables pertaining to the individual, but rather to the position that an actor occupies in a network. It is a way of uncovering underlying patterns of interactions and relations in groups. The method situates an individual actor (a ‘node’) within a social context (a ‘network’) and ties that actor to other actors via some kind of relation (a ‘tie’). Based on network theory, the positions of individual nodes in the network make it possible to infer probable paths of influence between the individuals in a network, and can contribute to explaining the behaviour of a network as a whole (Borgatti et al. 2009). The positions of a node vis à vis the rest of the network are captured using so-called ‘centrality measures’. One of these measures is termed ‘betweenness centrality’, and represents the potential to broker and thereby colour the information that passes between loosely connected groups. I use this measure in **paper I** to identify important knowledge brokers within the community.

The data that I used to conduct the social network analysis was based on the attendance lists of geoengineering events. I found that event-based data has several advantages over other

network approaches. It can capture the involvement of non-scientific actors from governments or NGOs who do not publish in the scientific literature, providing an advantage to using bibliometric data (i.e. publications and co-authorship). It can trace participation and connections over time, providing an advantage over survey-based data. The information is also often publicly available. On the other hand, event based data makes it difficult to infer causality, as it provides only undirected links between nodes. By attributing a connection between two actors based on the common attendance of an event, one cannot say anything about directions of information flow. The method is therefore used primarily to draw a boundary around the object of inquiry (i.e. the epistemic community), to identify which actors and organisations are actively engaged in the community, and which actors seem to play an important role. The results are subsequently corroborated and explored using more qualitative forms of data.

Document analysis

Document analysis served as a way to study the evolution of the geoengineering object. The definitions, categorisations and references around geoengineering used in research articles, scientific assessments and papers published by government actors constituted an important source of information to pin-point the origins of the idea and to identify changes in the way that geoengineering is understood and defined.

If I look back on the process, this was an iterative procedure in which I read contemporary studies on geoengineering, identified the studies that were highly cited, reverse-snowballed to sources that those highly cited studies referred to, and assessed the referred studies in comparison to other studies addressing the same issue and published within a similar time-frame. The complete analysis took place over the course of several years and contributed to results discussed in **paper II and III**.

One principal outcome of this snow-balling procedure was the realisation that authoritative assessment reports act as major in-

fluencers on the streamlining of an idea, and the realisation that they contribute to ordering a previously contested discussion. Once I became aware of this, we used document analysis more specifically to analyse the contents and arguments of authoritative assessment reports and compare them to the structures and framings of subsequent research projects and government inquiries. The results of this exercise are discussed in **paper II**.

Another important outcome derived from document analysis was an understanding of major debates and technology characterisations, as well as an overview of the formal governance structures that exist around geoengineering. Secondary literature, in the form of discursive studies (e.g. Sikka 2012, Anshelm & Hansson 2014) and legal analyses (e.g. Redgwell 2011, Brent et al. 2015), as well as primary literature in the form of codes of conduct suggested by individual scholars or research groups (Rayner et al. 2013, Hubert & Reichwein 2015), provided the foundations for understanding the discursive and institutional architecture around geoengineering. These insights were used in **paper III**, where we analysed the field's institutional composition with respect to its problem structure.

Participant observations

Observations of participants at geoengineering events served as a way to study the micro-level dynamics that took place within the geoengineering community. The aim was to gain a better understanding of how members of the community engaged with each other, how they behaved towards potentially 'new' members of the community, and how they behaved towards actors who clearly had a different idea on geoengineering research as a whole. These mechanisms in turn served to better understand the social dynamics of resonance and dissonance around the geoengineering object.

Much of the data gathered for this stage can be considered ethnographic, as described by Jones & Watt (2010). By getting to know the people in the network, engaging in professional conversations and following the main debates over several years, I

gained an in-depth understanding of the language and dynamics used within the community. This contributed greatly to gaining access to both events and to researchers. I was thereby able to share own experiences with interviewees and conversation partners, enabling deeper reflexivity and contextualisation than if I had stayed outside the community and collected data through surveys or structured questionnaires. Furthermore, it helped me understand some of the core conflicts, dilemmas and motivations that shape the geoengineering community.

Concrete episodes of observatory field work amounted to three large conferences (each lasting 4-5 days) and several smaller events, some of which were streamed online. My field-work focused mainly on identifying areas and effects of resonance and dissonance around the geoengineering object. In practice, this meant taking notes about the content and type of arguments and justifications used in debates that arose at the conference, but also recording more nuanced forms of social conflict.

Examples of this included events where (critical) arguments were cut short or events where an actor's scientific or intellectual capacity or integrity was questioned. When I could, I noted the audiences reactions to these tense intermezzos (including attempts to de-escalate the situation) and asked observers about their interpretation of what they had just seen. Sometimes I had the opportunity to ask the participants of the debate themselves about their interpretation of what just happened. An important part of these observations was also noticing what was not said, including awkward silences after a comment or question that was obviously not appropriate, or whole topics that the participants at the conference seemed to be actively avoiding. The insights gained from observations flowed into **paper I** (particularly scientific events) and **paper IV** (particularly government events).

Interviews

In addition to participant observations and on-the-spot conversations at scientific conferences, I collected a small set of more structured and in-depth interviews with both scientists and gov-

ernment officials. The interviews were meant to gain a better understanding of different actors' reasoning around the geoengineering governance object and their experiences with the knowledge network. They also served as way to better fathom the timeline of events and discourses around geoengineering, and the processes by which certain narratives spread from person to person.

When speaking with scientists, the interviews focused on the experiences they had made in joining the geoengineering knowledge network, their perceptions of the community, and their understanding of the geoengineering concept in relation to other connected forms of it. I also asked questions about their motivations and incentives for working in this particular research area. These interviews typically lasted about 40-50 minutes. They were relatively open-ended and explorative, though they would always begin with the interviewee's memories of their first engagement with the topic and worked on from there. I conducted formal interviews with seven scientists who differed with regard to their background and position within the knowledge network. These include three experts who had been in the field for many years and had witnessed the beginnings of engagement with the object. I also spoke to four experts who had joined the geoengineering network a little more recently. The insights gained were used for the qualitative part of the analysis conducted in **paper I**.

When speaking with government officials, the interviews focused on the way they had first encountered the geoengineering concept, the way in which their perception of it had changed over the years, the manner in which it played a role for their work and decision making, and the actors that they collaborated with in forming their political position. My main aim here was to understand how the geoengineering idea had travelled from the geoengineering community into the realm of policy making and how it was being received there.

As geoengineering only recently began emerging on the climate change policy agenda, it was relatively difficult to find out which officials might be familiar with the issue area. I there-

fore used the conferences I attended to identify and approach policy makers, usually scheduling an interview during the same conference or at a later point in time, in which case the interview would take place over the telephone. These interviews were semi-structured and typically lasted about 30-40 minutes. I spoke with eight governments officials from different countries and different work settings. They include diplomats working for foreign ministries, scientific advisers working for executive government offices, and officials working for environmental agencies or ministries. The countries represented in these interviews are Germany, Sweden, China, the US, the UK, Kenya and Switzerland. The results gathered are used in **paper IV**.

3.3 Reflections

The diversity of methods used in this thesis served as an important way of triangulating data. Whereas each method on its own provided hunches that certain causal mechanisms might be at work, finding evidence of the same mechanism through a different approach enabled a more confident interpretation of the results.

One example is the realisation that certain individuals, or ‘knowledge brokers’, are particularly important in spreading information and inspiration about the geoengineering concept. The initial insights from the social network analysis were corroborated by interviews made with both scientists and policy makers, who regularly mentioned first hearing about the concept in a presentation made by one of the central actors. Another example is the insight that trust and shaming or exclusion serve as mechanisms of discursive control. The observations made at conferences provided important hunches that these processes might play a role, providing the opportunity to ask more about them during interviews.

The combination of methods also revealed the shortcomings of using one method alone. For example, social network analysis is highly sensitive to the assumptions and rules set by the researcher, and needs to be informed by a contextual understand-

ing of the case and the community. Particularly for ‘invisible colleges’, or communities that are not already defined by a given boundary, observations at conferences and conversations with community members served as a way to refine the network assumptions and to properly interpret the resulting graphs. On the other hand, engaging with the network data provided a useful helicopter view of the community, and engaging with the scientific literature provided essential understanding of principle debates and arguments. Both were extremely useful in guiding the interviews, which would have (perhaps) been less informative without this pre-existing knowledge.

The advantages of triangulation and balancing of shortcomings go hand in hand with a loss of depth in each standalone method. This is reflected in the relatively small set of interviews conducted, the purely descriptive use of network analysis and the lack of a more structured approach to the document analysis. Choosing only one method may have resulted in a cleaner presentation of results. However, my impression is that the use of several methods facilitated a reflexive approach to research, enabling the continuous refinement of questions along the way and eventually leading to a more holistic understanding.

4 Conclusion

WHAT DOES THIS THESIS TELL US about the emergence of geoengineering on the global agenda? The format of a compilation thesis makes it hard to immediately see the results of the process tracing exercise, as each paper contributes an alone-standing theoretical framework and set of results. The aim of the conclusion is therefore to summarise the causal mechanisms discussed in each paper, and show how they can be brought together into an overarching explanation of how geoengineering became a global governance object. Section 4.1 provides an overview of the questions and findings of each paper. Section 4.2 discusses the overarching dynamics that are recognisable from the findings, and how they relate to our understanding of the policy and norm cycle. Section 4.3 discusses geoengineering in a wider context of evolving environmental thought, and points out important issues that should to be taken into account as the conversation continues.

4.1 Summary of questions and findings

In this thesis, I first ask how geoengineering became a recognised area of scientific inquiry, and how scientific actors contributed to transforming geoengineering into a governance object. This question is addressed in the first two papers presented.

Paper I asks: Why did researchers start engaging in geoengineering research, although it was long considered a taboo? And how did some technologies come to be perceived as worthy of serious inquiry? The paper argues that the internal dynamics of an identifiable epistemic community led to transforming geoengineering into distinct, salient and malleable governance object. These dynamics can be summarised in the form of three causal mechanisms. Cohesion describes a process by which the desire to belong to a community (for different reasons) leads to the adoption of a common language and subsequently to the creation of a distinct and recognisable object. Brokerage describes the process by which some actors build bridges between differ-

ent communities and, through strategic framing, make the object salient to a wider audience. Diversity describes a process by which the inclusion of alternative views and backgrounds causes contested deliberation and a gradual adaptation of the object, thereby ensuring its malleability. The result of these interdependent and mutually reinforcing processes is an object that is identifiable, interesting and fit for travel across different realms and audiences.

Paper II asks: How do authoritative assessments contribute to shaping the geoengineering research field? The paper argues that geoengineering is not, in fact, an ungoverned field as widely assumed in the literature. Instead, authoritative scientific assessments serve as a source of *de facto* governance that contribute to normalising and institutionalising novel and politically contested environmental and technological fields. By introducing or endorsing certain categories and demarcations, authoritative assessments have contributed to the technicalisation of geoengineering (thereby making it more amenable to scientific research and governmental engagement), and to providing problem framings that act as a source of order and as a source of justification for research funding and research projects. We conclude that such assessments should be recognised for their steering effect on the scientific and political landscape, and for the foundations that they provide in creating more formal, *de jure* governance mechanisms.

I then go on to asking how a governance object, produced amongst non-state actors, can become relevant to the public policy process. This question is addressed in the third and fourth paper presented.

Paper III asks: Why do we observe variations regarding the composition and functions of public and private authority across different sub-areas of climate change? The paper argues that the mix of public and private actors in a given governance architecture, and the functions that these actors take on, is dependent on the the problem structure associated with a governance object. Benign problems, characterised as conflicts over means and absolute goods, have a higher public regime conduciveness

than malign problems, characterised as conflicts over values and relative goods. In benign problem structures, private actors contribute through delegated authority (in the name of public actors), while in malign problem structures, they act with entrepreneurial authority. In comparing three different sub-policy fields of climate change, we find that this relationship applies to distinct and clearly recognisable issue areas, but also that the associated problem structure can shift over time. With increasing normalisation, an issue can become part of the public governance architecture, and private actors who formerly acted with entrepreneurial authority begin acting with delegated authority.

Paper IV asks: How do common problem definitions of geo-engineering governance resonate with the decision-making context of government actors? The paper argues that in order to introduce a new subject to the agenda, decision makers need to take into account the normative expectations shared in their institutional context. When confronting common problem definitions around the geoengineering governance object, they assess these with respect to their national and international political surroundings. Those problem definitions that already reflect common norms and expectations can be easily communicated to superiors and members of the public, facilitating integration into the public decision making process. By contrast, the problem definitions that substantially differ from existing expectations and norms create political uncertainty and risk. They must therefore either be re-defined into a problem that is more familiar, or addressed by a politically legitimate coalition of states.

Taken together, the papers depict a discursive transition in which language around a controversial concept has become streamlined through the social dynamics of creating scientific community, and rendered legitimate through the endorsements of authoritative assessments. Through the activities of knowledge brokers, the concept spreads to different fields of academic inquiry and into the realms of government and civil society. Here, it meets discursive resistance and is subsequently adapted to fit the normative expectations of the new audience, either by re-defining the nature of the problem, or by finding a contextual

authority to support its cause.

4.2 A fractal model of object emergence?

The findings point to a sequential repetition of object introduction, contested deliberation, authoritative intervention, and subsequent discursive order. Repeated over and over, these steps seem to have enabled the normalisation of an originally contested object like geoengineering and aided in its transition from a scientific outcast to a internationally relevant object of governance. The sequence highlights the interaction of leadership and community as well as agency and structure. It emphasises the role of knowledge brokers (or entrepreneurs) in bringing a new subject to the agenda, the role of community in deliberating the new object with respect to its own structural conditions, and the role of a contextual authority to endorse an understanding that also aids in adapting the object towards the needs and expectations of the community.

The repetitive nature of the sequence and its effects across scales suggests that there may be a value in re-thinking the linear or cyclical model of policy or norm emergence. To date, the public policy literature and the international relations literature are separated by their focus on different scales of political action, with the former focusing on national political systems and the latter focusing on international regimes. The thesis shows how this separation hides the fact that the same processes are happening within a single knowledge network, within the national policy process, and within the formation of an international regime. It is therefore plausible that we don't need to work with separate models at each level, but can think in terms of a single model that works across scales.

One way of doing this could be to think in terms of a so-called 'fractal'. In the *Encyclopaedia Britannica*, a fractal is defined as a 'self similar object' whose 'component parts resemble the whole', and in which 'the reiteration of details or patterns occurs at progressively smaller scales'. In nature, fractal patterns can be found in objects like snowflakes, or spatially non-uniform phe-

nomena such as coastlines, river systems and mountain ranges. The concept was coined by the mathematician Benoit Mandelbrot, and is perhaps familiar to the reader in the form of the famous Mandelbrot Set.

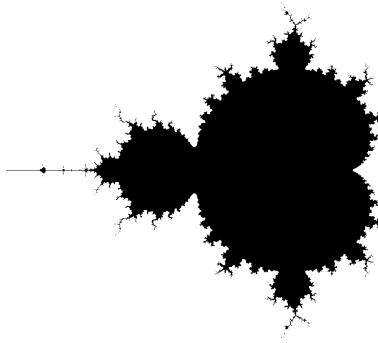


Figure 4:
Mandelbrot set.

The recurring pattern in a fractal model of governance object emergence might be the steps identified above: object introduction, contested deliberation, authoritative intervention and discursive order. This pattern takes place over and over, beginning within a small group of individuals and spreading through knowledge networks up to the highest echelons of international institutions. The pattern might also take place across different fields, and could explain the parallel emergence of other governance objects. Failure in any one part of the pattern may lead to a failure in reproducing the pattern in a different context or level, thereby explaining why a given concept did not turn into a governance object.

A fractal model could accommodate for the repetitive elements of emergence found at different structural levels of the political process while still accounting for agency. Although it is a mathematical concept primarily used to describe phenomena in natural systems, it is not deterministic. In contrast to other models based on natural science metaphors, such as the evolutionary model of norm emergence by Florini (1996) or the organisational ecology model by Abbott et al. (2016), a frac-

tal model of object emergence is always based on the activity of political agents. Every part of the pattern describes a form of interaction between actors and their context, and thus both structure and agency are accounted for throughout the process.

The use of fractals to explain political behaviour has already been suggested by several authors in international relations. Mallard & Foucault (2011) propose a fractal theory to explain European integration, highlighting how political actors enabled integration through the strategic sequencing of negotiation processes around European treaties. Bernstein & Hoffmann (2015) suggest the use of a fractal model to conceptualise the process of decarbonisation, arguing that the same simple patterns must happen across all levels of society. Le Prestre (2017) suggests the use of fractal models in order to better understand the intricacies and complexities of environmental politics more generally. There is thus an emerging literature that would support the use of such a model. Although not further developed in this thesis, the insights found in the different papers indicate that a fractal approach to theorising the emergence of governance objects would be a promising avenue for future research.

4.3 Situating geoengineering

This thesis highlights the social dynamics that have played a role in making geoengineering into a politically relevant governance object. In the process, it argues that the problem narratives associated with this object have been shaped by a relatively small set of actors. It is these actors who are considered experts in their field, and who are regularly invited to advise and contribute to scientific assessments, government hearings or advisory committees. The same narratives and problem definitions therefore continuously reinforce what decision makers and the broader public understand about geoengineering: that it is an imperfect, but necessary element of future climate policy, and that for this reason, research should be supported.

Although this thesis highlights micro-level social dynamics, the increasing traction of geoengineering must also be under-

stood in the context of shifting global norms. Geoengineering technologies are being imagined and designed with the intention to reduce global average temperatures. They arise out of a structural environment in which models of the Earth System are used to predict how changes in the carbon cycle and surface reflectivity induce global warming or cooling. This type of science enjoys immense authority in the context of climate change politics, and is likely to continue doing so.

The authority of Earth System science is closely linked to evolving ideas of global environmental stewardship. It is no coincidence that geoengineering arose in a time where ‘the Anthropocene’ is being used to describe a new geological age. In this new age, environmentalism means thinking at planetary scale, and humanity is perceived as united in both its environmental impact and in its capacity for change. In the Anthropocene mindset, there are no states and no differences in power. We are all inhabitants of the same fragile spaceship that we call Planet Earth. We are all bound by the same fate and by the same planetary boundaries. The logical answer to this perception is that we need to find planetary scale solutions, and geoengineering is one version of them.

While the narrative of spaceship Earth has been a core contribution of the environmentalist movement and an important factor for the establishment of global environmental institutions, it tends to ignore important aspects of social reality. It ignores that there are historical differences in responsibility, that there are differences in political power, and that there are differences in the degree of suffering. The poorer half of the world’s population is responsible for only fourteen percent of global CO₂ emissions, while the richer half is responsible for eighty-six percent. Of this richer half, the highest income group (only sixteen percent of global society) is emitting almost forty percent of global CO₂ (Ritchie 2018). These numbers do not speak of a globally united humanity. They point towards a humanity that is deeply divided.

Just as environmental footprint is not equal, environmental impacts are not uniform. Distinguished environmental schol-

ars like Mike Hulme (2014) remind us that climate change is not about changes in global average temperature. It is about changes in the local environment, about how these changes will affect the values and structures of societies, and whether or not people around the world will be able to survive and live in dignity despite these changes. It is with respect to these variables that geoengineering technologies need to be evaluated. They should be the primary measure in deciding whether to proceed in this direction, and not an add-on to questions of cost-efficiency and effectiveness in average temperature regulation.

This necessity, together with the definition of governance discussed in this thesis, raises questions about the manner in which geoengineering governance is being discussed in the literature. Many contemporary research initiatives focus on *how* geoengineering can be governed in the most effective and legitimate way, conducting legal analyses and proposing new institutions to regulate or encourage technological development. But by assuming that geoengineering will be a part of the world's collective future (either positively or negatively), they are putting the cart before the horse.

As Frank Biermann and I show elsewhere, the discourse around geoengineering is being shaped in the halls of a small number of elite organisations, based primarily in the United States, the United Kingdom and Germany (Biermann & Möller 2019). Meanwhile, those countries who are likely to bear the brunt of both climate change and the potential side effects of geoengineering technologies are excluded from the conversation, and important questions of justice, equity and burden sharing are being sidelined in the geoengineering governance literature (Flegel & Gupta 2018). There is thus a fundamental problem of discursive bias in the way we think and speak about the issue that needs to be addressed first.

The principal challenge of altering the discursive bias around geoengineering is that the topic is perceived to be unique, highly technical, and in need of specialised expertise to make sound conclusions. My thesis challenges this perspective. I argue that geoengineering is what it is because it was *made* to be this way.

The things that are important about it, namely what it will mean for the lives of people on the ground, are amenable to other forms of inquiry.

By providing an example of how we might conceptualise geo-engineering as one instance in a class of many, my thesis shows how we can identify elements with which we are already familiar. Such a re-conceptualisation opens up important avenues towards inquiring what geoengineering means in terms of power imbalances, governability, and environmental or social impact. Exploring avenues like these would help in diversifying the commonly traded narratives that dominate the geoengineering discussion. Only then will it be possible to evaluate whether geo-engineering technologies are really the necessary, or indeed feasible, solutions that they are often presented to be.

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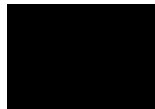
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Scientific Papers

Paper I



Transforming Geoengineering into a Governance Object: What Role for Epistemic Communities?

Ina Möller

Unpublished manuscript

Abstract

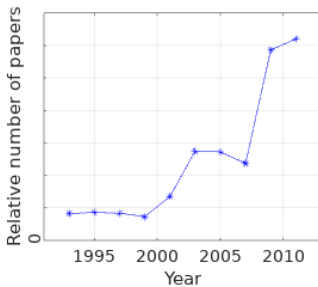
Geoengineering technologies have recently come to be seen as necessary supplements to conventional mitigation and adaptation in the scientific literature on climate change. Yet, for many years, these policy options were highly disputed amongst scientists. Why did scientists start engaging with an idea that was considered taboo, and how did geoengineering become a globally relevant governance object? This study argues that some answers to these questions can be found in the social dynamics of the epistemic community that evolved around the geoengineering concept. It builds on recent theory about the earliest stages of the policy cycle, stating that its first step is the creation of a distinct, salient and malleable governance object. Moving from a purely discursive to an interactive agency-structure perspective, the study sheds light on the social dynamics that take place within epistemic communities, and that enable the creation of globally relevant governance objects. It shows how social cohesion, brokerage and diversity play a part in the causal mechanisms by which an epistemic community produces a governance object, and how it subsequently makes this object relevant to a broader audience.

Introduction

Up until the mid-2000s, suggestions to cool the planet through artificial absorption of carbon dioxide or through the reduction of incoming sunlight occupied a marginal role in the climate change discourse, and scientists who engaged with such ‘geoengineering’ research were treated with suspicion (Cicerone 2006, Lawrence 2006). Today, these technologies are increasingly presented as an inevitable addition to conventional

policies of climate mitigation and adaptation. Efforts to remove carbon dioxide from the atmosphere through large-scale afforestation and the industrial processing of biomass are considered a necessary requirement in all 1.5 degree emissions scenarios described by the Intergovernmental Panel on Climate Change (IPCC 2018). As a response, governmental actors in countries like the United Kingdom and Sweden are beginning to invest in research and development of ‘greenhouse gas removal’ or ‘negative emissions’ technologies. Also planetary cooling through the injection of reflective particles into the atmosphere is prominently discussed as an option to reduce global temperatures (McNutt et al. 2015, Irvine et al. 2019). As a result, governments are increasingly engaging with the topic, recently culminating a (failed) proposal to initiate a global governance process for geoengineering through the United Nations Environment Assembly.

Figure 1: Relative number of publications on geoengineering compared to climate change overall.



than the climate change literature overall. Increase in scientific knowledge about climate change can therefore not be the sole explanatory factor.

What, then, caused this sudden surge in interest? Why did researchers start engaging with options that were long thought to be too preposterous to be spoken about? And how did some geoengineering technologies come to be perceived not only worthy of research funding, but also in need of international governance?

From constituting a scientific and political taboo, geoengineering has transformed into a set of policy options that governments are requested to substantially engage with. This has happened in a much shorter time-span, and at a much faster rate, than the rest of the climate change discussion. When comparing bibliometric analyses of climate change overall (Haunschild et al. 2016) and geoengineering in particular (Oldham et al. 2014), we can see that between 1990 (the year after the Intergovernmental Panel on Climate Change was formed) and 2013, the literature on geoengineering grew six times faster

Understanding this transition means understanding how issues in general are able to arrive on global governance agenda. For this, I draw on recent advances in the theorisation of the global policy cycle that identify the formation of a governable object as the first important phase (Corry 2013, Allen et al. 2018). I then expand the theory on global governance objects with insights from the epistemic communities literature, suggesting a framework of analysis that is based on classical sociological theories about the dynamics of social groups. Using the geo-engineering example, I show how governance objects are constructed in the context of epistemic communities, and that the object's success can be linked to the community's internal social dynamics. In addition to a number of facilitative structural conditions, I show how mechanisms of consensus, brokerage and diversity contributed to transforming geo-engineering from a marginal area of inquiry into a widely discussed and increasingly accepted policy option.

Theorising the Earliest Phase of the Policy Cycle

Recent literature about the global policy cycle highlights the origins of problems as an important part of global governance. Rather than assuming that problems are simply out there and waiting to be put onto a global agenda, it emphasises the discursive processes by which a governance problem must first be created. Corry (2013) and Allan (2017) call this stage the 'constitution of a governance object'. They theorise it as a process in which an object is first designated, or defined, as being separate from other objects (inducing distinctiveness). It then needs to be problematised with respect to globally relevant interests and frames (inducing saliency). Finally, it needs to be translated into a portable, global object that can be used in contexts around the world (inducing malleability). Only after a governance object is thus constituted can it emerge as a policy issue, and be taken up by the agenda setting actors described in other influential models of the global policy cycle (e.g. Finnemore & Sikkink 1998).

Theories like this provide important insights to the characteristics that successful governance objects must conform to, but they are less clear about the on-the-ground mechanisms that guide object creation within a social context. The empirical literature in this field is dom-

inated by a discursive, governmentality perspective that deconstructs objects like ‘the Earth System’, ‘the Anthropocene’, ‘climate refugees’, ‘climate conflict’ or ‘climate risk’ through textual and conceptual analysis (Lövbrand et al. 2009, Hartmann 2010, Oels 2013). In these studies, the focus is often placed on the *political effects* of a given governance object. They ask what the object under study does to our conception of governing, and how it changes the relationships and attributes of different actors. It is thus the governance object itself, in combination with its underlying normative assumptions, that is the main focus of analysis.

The role of agents in constructing these objects and determining their shape and content is less well understood. Not that these scholars don’t recognise their importance; they regularly highlight instances in which certain groups or individuals use an object, or a narrative about that object, for strategic purposes. But how that object develops from being just some concept used by a small group, to an object relevant for global affairs, is not commonly addressed. In short, what is missing from theory on the constitution of governance objects is an understanding of the social mechanisms by which conditions like distinctiveness, saliency and malleability are created.

My aim here is to complement the discursive angle by casting a light on the social dynamics of object constitution. I follow Giddens (1984) approach in acknowledging that structure and agency are mutually constituted, and that both are important in understanding how society functions. Discourses and narratives are central to the constitution of new problems, but there are also agents and social processes through which these discourses become established. By focusing on the agents of knowledge production, I link back to studies like Haas (1992*a*) and Adler (1992) about the role of epistemic communities in shaping global governance efforts.

These studies represent early examples where scholars have tried to pin-point the origins of global governance objects. They, and others who build on their work (e.g. Tannenwald 2005, Carpenter 2007) situate the origin of governance objects within communities of experts or advocates who choose and define novel issue areas, and then export them to the realms of policy making. While acknowledging their oft-cited caveats, notably the problematic separation of different realms like science and politics (Lidskog & Sundqvist 2015), my interest in

this literature is its focus on the agents who constitute globally relevant governance objects. In picking up where they left off, I join the efforts of Antoniadou (2003), Stone (2013) and Davis Cross (2013) in reviving and developing a promising approach that is too easily dismissed in the current literature.

Epistemic communities and global governance objects

Epistemic communities describe professional networks with authoritative and policy-relevant expertise around a given issue area. As Davis Cross (2013) notes, most of the literature on epistemic communities has been unnecessarily narrow in its empirical focus on groups of scientists and their efforts to influence governments. The wider literature on transnational governance networks shows that different types of expert communities exist, that they have an active role in shaping global governance processes, and that they influence the views of both state and non-state actors. Antoniadou (2003) further explains that rather than just communicating knowledge to power, these communities' principal mode of influence is the *construction of social reality*. Because of their authoritative knowledge basis, they have the power to impose discourses about what should be considered a problem. While the communities themselves are not independent of already existing discourses and structures, their position as recognised makers of knowledge gives them preferential access to the language that shapes social reality. This access to language brings us back to the theory described above. Designating a problem, highlighting its relevance, and making sure it is globally transportable is a task tailored to the skills and capacities of epistemic communities.

How do epistemic communities produce global governance objects? Studies in this field identify multiple conditions under which an epistemic community is likely to influence policy making, but still struggle with explaining the mechanisms that might lead to these conditions. Thus, Haas (1992b) has famously highlighted the degree of internal consensus and its access to policy makers in a phase of political uncertainty as principal determinants of an epistemic community's success. Zito (2001) summarises additional scope conditions that are likely to increase an epistemic community's influence, including activity in the early phase of the policy process, weakness of competing knowledge

networks, study of quantitative data and/or natural systems, and compatibility with existing institutional norms. So far, these conditions are mostly treated as exogenous and rarely linked to internal social processes of the community itself. But could it be that they are in fact interdependent outcomes of more fundamental characteristics that define a certain kind of community, namely one that is capable of producing a global governance object? What happens if, instead of thinking of two separate entities, we conceptualise the epistemic community and the governance object as one co-evolving amalgam of network and discourse?

If we re-imagine an epistemic community as the *source* of a global governance object (rather than merely a communicator), then the facilitating conditions of uncertainty and activity in the early phase of the policy process are no longer scope-conditions; they are embedded in the fact that the epistemic community itself is creating a new policy issue. This would also explain why the engagement with quantitative data and/or natural systems is considered a facilitating condition. Knowledge of this realm is limited to the scientists and economists who constitute communities that are found to be influential. Consequently, they are the only ones that can produce and subsequently advise on governance objects based on this kind of knowledge. But in order to be asked for advice, the epistemic community first needs to produce a convincing policy issue: an object that is distinct, salient and malleable.

Is it possible to identify characteristics that might predict a community's capacity to produce such an object? To explore this idea, I propose the use of three basic concepts that link to many of the conditions identified above, and that can be used as an analytical framework to study the social mechanisms within epistemic communities. Drawn from classical theories of social group dynamics, they can be summarised as *social cohesion*, or the willingness of members to conform to the practices of the network; *brokerage*, or the potential of some actors to shape the content of the network's discourse; and *diversity*, a proxy indicator for adaptability through information diffusion and innovation.

Cohesion, brokerage and diversity

Social cohesion can be defined as the individual group members' attitudes and behaviour towards the group, notably their desire to belong

and their degree of participation (Friedkin 2004). Here, social cohesion is used to explain convergence on a distinct governance object. To begin with, the existence of social cohesion can be understood as a prerequisite for an (epistemic) community's existence. Without the members' desire to belong, the network would not exist. In addition, the mere fact that a member wants to belong to the community makes it more likely that this member will conform to the group's practices, as dissidence from commonly accepted behaviour is likely to result in punishment or non-acceptance by the other members of the group. This in turn enables the consensus condition described as important for success in the epistemic community literature. Yet, in the early phases of object emergence, consensus does not immediately necessitate a sharing of the same world view, persuasion or policy goal. More important is the community's convergence on a common practice, notably in the form of a shared social construct that can be debated by an increasing amount of actors (see Hajer 1993). The convergence on such a shared construct ultimately enables a community to produce an object that is clearly distinguishable from other objects.

Brokerage is formally defined as the capacity of individuals to bridge so-called 'structural holes' in a network structure, which results in them being the only (or one of few) channels of information between otherwise unconnected groups (Burt 2004). Here, brokerage is used to explain the evolution of salience in a governance object. The assumption is that an actor who bridges a gap between two groups has preferential access to information from both, as well as the possibility to control information flow and thereby shape the narrative of an idea. Such actors often take on entrepreneurial or opinion-forming roles (Christopoulos & Ingold 2015). The reason for their success becomes understandable when one considers the need for creating compatibility with existing norms and ideas – another condition recognised in the literature as an indicator for the success of an epistemic community (Jordan & Greenaway 1998). In the same way, we can expect that a successful governance object would need to connect to, and resonate with, existing ideas and structures. A broker that understands the normative/institutional context of two different groups can more easily adapt the definition or narrative accompanying a governance object to fit both contexts. This re-shaping of definitions and narratives according to context enables growth of the

network and ensures the salience that is needed for a governance object to become globally relevant.

Diversity is here defined as the variety of societal realms, organisations and disciplines represented in an epistemic community. It is used to indicate the network's potential for producing an object that is malleable. My use of it is inspired by an influential sociological theory about the 'strength of weak ties', which states that information travels quicker and better in a network that contains many acquaintances ('weak ties') than in a network that is full of close friends ('strong ties'), increasing the innovative capacity of the network (Granovetter 1973). The assumption is that diverse networks are characterised by more variety in views and opinions, subsequently leading to a better collective understanding for what kind of object would work in many contexts. In this way, diversity in the network enables the 'contested deliberation' and 'belief polarization' that has been identified as a necessary condition for norm and policy change (Elgström 2000, Leifeld 2013). It may also make the community attractive to a wider range of actors, improving its capacity for growth and reducing the likelihood that a competing community will evolve around a similar issue.

Together, social cohesion, brokerage and diversity provide a set of independent variables that help us conceptualise the causal mechanisms by which epistemic communities can produce globally relevant governance objects. They should be thought of as interdependent and overlapping processes, although the fact that an idea must begin in a smaller group before it can expand suggests that there is some temporal ordering to their prominence. Cohesion seems particularly important in the beginning, when the community establishes itself around a given object and needs to make that object distinct in order to justify the community's existence. Brokerage can be thought of as important in the initial expansion of the community, where targeted framing is needed to make the community and its object attractive (or 'salient') for new members to join. Diversity is the latest step in the process, and can be conceptualised as a self-reinforcing outcome of successful brokerage. A salient object that attracts more people will result in a diverse network, which in turn spreads information and leads to contestation and deliberation. Contestation and deliberation, in turn, is what makes the

object malleable and applicable in many different contexts.

Research Design

The applicability of the analytical framework is evaluated in the geo-engineering case using both quantitative and qualitative data. Process tracing serves as an overarching method to evaluate evidence that shows if indeed, and in which manner, social cohesion, diversity and brokerage played a role in transforming geoengineering from a widespread taboo topic into a global governance object. Evidence is derived from social network analysis based on publicly available attendance lists of geoengineering related events, as well as interviews and observations made in attending geoengineering research events.

Process Tracing

David Collier (2011, 823) defines process tracing as ‘the systematic examination of diagnostic evidence selected and analyzed in the light of research questions and hypotheses posed by the investigator’. The aim of a process tracing exercise is thus to establish the causal relationship between hypothesised independent, dependent and intervening variables. This relationship is established by describing and analysing individual phenomena, or steps in the process, and subsequently judging whether they support the initial hypothesis. The selection of diagnostic evidence is dependent on the researcher’s prior knowledge of the case, including awareness of recurring empirical regularities and the use of an explanatory model. This basis is given through several years of engagement with the geoengineering case and the theory described above.

The hypotheses that inform my analysis are derived from the analytical framework presented earlier:

1. Social cohesion, achieved through incentives that motivate individuals to be part of an epistemic community, incites the community’s members to uphold the language and practices of the network. This contributes to the distinctiveness of the object.
2. Actors who bridge structural holes in the network take on entrepreneurial or opinion-forming roles. Their success depends on

their capacity to understand and adapt to the normative and institutional context of the groups they are bridging. Their activity contributes to the saliency of the object.

3. Diversity in the community is accompanied by a discussion of alternative views and opinions. The resulting deliberation leads to a gradual adaptation of the object so as to better account for different positions represented in the community. This contributes to the malleability of the object.

Each hypothesis is tested using quantitative social network analysis in combination with qualitative insights from interviews and observations. Social network analysis serves to assess the existence of the independent variables, providing quantitative measures for cohesion, brokerage and diversity. Interviews and observations serve as a way to provide evidence about the causal pathways that link the independent variables to the distinctiveness, saliency and malleability of the geoengineering governance object.

Social Network Analysis

Network analysis has proven to be a useful way of studying interdependence and flows of influence between individuals or organisations. Reflecting on its increasing use in political science, Ward et al. (2011) explain how the method can provide insights about power and network character that are otherwise difficult to obtain. These include contours of opportunity or constraint in a social structure, or the importance of certain individuals for organising or maintaining the network. At the basis of the method is the assumption that influence can be measured by mapping the relationships of individuals. The connections ('ties') between individuals ('nodes') in a group are recorded using a matrix of ones and zeros, on the basis of which a network is created. These networks can subsequently be analysed with a view to their structure and with a view to individuals' position within that structure (Borgatti et al. 2013).

Conceptualising the epistemic community around geoengineering as a network has several advantages. Firstly, it provides a way of identifying and setting boundaries around an otherwise diffuse research object. To determine the boundaries of the geoengineering network, I used public

information drawn from the programmes of seventy-four geoengineering workshops and conferences that took place between 2006 and 2018.¹ The nodes are individuals who attended at least two events in the capacity of speakers. Their ties are determined by these speakers' mutual attendance of events, resulting in a two-mode, or 'bipartite' network (Borgatti & Everett 1997). My reasoning here is that those who make the effort to repeatedly attend and speak at such events demonstrate significant dedication to the group. They can be thought of as members of an otherwise unbounded knowledge network, sometimes referred to as an 'invisible college' (see Price 1986, Zuccala 2006). Event data also provides an opportunity to include those members of the network who are not scholars or academics, providing additional insights to publication-based network analyses such as those conducted by Belter & Seidel (2013) and Oldham et al. (2014).

Once the boundaries of the network are set, network analysis provides a way of assessing the structural characteristics of the community. The measures of these characteristics serve as a first step towards establishing the existence of cohesion, brokerage and diversity. To measure cohesion, I report the network's global clustering coefficient. This is a measure used to detect closure amongst groups of individuals. For bipartite networks, the measure is defined as the number of closed 4-paths divided by the total number of 4-paths. It results in a value between 0 and 1, with higher values indicating more cohesion (for further details, see Opsahl 2013).

To measure brokerage, I first projected the two-mode network into a one-mode network depicting only speakers. For purposes of network readability, a tie between two speakers was only kept if they had commonly attended at least two events. Based on this projection, I calculated the betweenness centrality of the network members. This measure gives the total amount of shortest paths between any two nodes that

¹The events were identified through the archives of the 'geoengineering google group', a news server that distributes updates about discussions, blogs, publications and events related to geoengineering. My main criteria for inclusion was the independence of the event (panels within larger conferences were not included), and an explicit reference to geoengineering or its sub-technologies in the title. This included 'geoengineering', 'climate engineering', 'climate intervention', 'climate modification', 'solar radiation management', 'carbon dioxide/greenhouse gas removal', 'direct air capture', 'BECCS' or 'negative (carbon) emissions technology'.

lead through a single individual, providing an indicator for the individuals ability to frame information to new audiences (for further details, see Freeman 1979). To measure diversity, I coded the network members' disciplinary background and organisational realm, presented in the form of a simple bar chart. I also report the so-called 'Rao-Stirling diversity index', which is a function of variety, balance and distance between (in this case) academic disciplines (for further details, see Stirling 2007).² It results in a number between 0 and 1, with higher values indicating more diversity.

Observations and interviews

The qualitative data used to explore the validity of the hypothesised mechanisms is based on observations made in attending several geoengineering events, as well as interviews and informal conversations with members and observers of the network. In terms of observations, my main source of input is the attendance of three large geoengineering events, two located in Berlin (2015 and 2017) and one located in Gothenburg (2018). Each event lasted for three to four days, comprising several hundred attendants who presented in smaller panels and workshops. My main focus of observation were prominent speakers their engagement with the audience, similarities and differences in concepts and narratives used by the conference attendants, overarching and shared narratives or 'no-go' zones that were collectively avoided, and the mode of interaction between individuals, including their ways of engaging in scientific contestation.

I also conducted in-depth interviews with fifteen individuals about their experiences with the geoengineering community. My main focus of inquiry was their first memories of how they had started working with the subject and how they had seen it evolve over the years. I also asked about their relation to the community and their use and understanding of the geoengineering concept. My interview partners came from a range of different backgrounds covering both the natural and the

²For the construction of the necessary distance matrix, I used faculty membership as a means for defining disparity. Disciplines of the same faculty had a distance of 0, disciplines of different faculties had a distance of either 1 (between social sciences and humanities, and between natural sciences and engineering) or 2 (between social sciences/humanities and natural sciences/engineering).

social sciences, and working in both academia and government. Some had been part or aware of the network for many years, others had only joined its activities later on. I used the insights from these qualitative sources to construct a timeline of events and to identify recurring narratives, processes and actors that seemed to play a formative role in the network's development.

The Geoengineering Knowledge Network

On cohesion and distinction

The hypothesis about cohesion leads us to expect that a) there is a community that can be identified based on its regular attendance of events, and b) that there are social mechanisms by which network members are incentivised to adhere to the shared practices of the network.

Figure 2 shows a bipartite graph of the geoengineering community in two phases, depicting events (blue, green and yellow nodes) and attending speakers (red nodes). The network indicates the existence of an epistemic community comprising around 100 active individuals who meet and engage with each other on a regular basis. This resonates with findings in the literature invisible colleges in which 100 scholars has been found to constitute a typical number (Price 1986, 74–76). We can also see that the early network seems to be more cohesive than second, with a global clustering coefficient of 0.33 as opposed to 0.26 in the later network. The colours of the dots indicate the thematic focus of the events at which these members met. In the early phase, the geoengineering community gathered mainly at events on geoengineering in general and solar radiation management in particular. In the later phase, carbon dioxide removal became a much more prevalent thematic focus.

In terms of incentives to adhere to shared practices, several mechanisms can be found when analysing the collected qualitative data. One such mechanism is the building of trust and community through shared narratives of common cause. Several interviewees remember that in times when geoengineering was still very controversial, the topic was often compared to the more accepted policy option of climate adaptation. Members of the geoengineering community would reason that adaptation once used to be the 'poor cousin' of climate mitigation, but

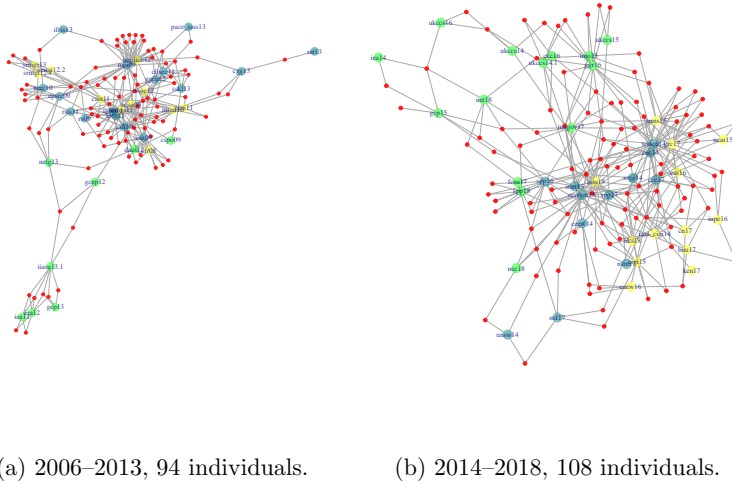


Figure 2: Bipartite graph of the geoengineering epistemic community. Blue (geoengineering), green (CDR) and yellow (SRM) nodes indicate events; red nodes indicate individuals who spoke at more than one event.

was eventually placed on equal footing and is now rightly recognised as an important part of climate policy. In the same way, geoengineering was characterised as the poor cousin of both mitigation and adaptation, and scheduled to find adequate recognition as a third climate strategy within due course. It was therefore worth addressing and advocating for this subject, despite there being scepticism from outside the community. Such narratives created a feeling of togetherness and trust within the network, and incentivised its members to engage in spreading its message.

By contrast, those who openly criticised the community’s cause met considerable resistance. Individuals who questioned the value of engaging with geoengineering research describe the environment as ‘acrimonious’ and ‘hostile’ – much more so than in other experienced research fields. In some cases, the continuous hostility created enough pressure for them to withdraw from the field. This would happen through

dedicated ignoring of fundamental critique, public questioning of their legitimacy, or ultimate exclusion from the community's events and debates. Observations at conferences support accounts given by some of the interviewees in this regard. In plenary sessions, fundamental critique towards the research field tends to be ignored or cut short by moderators. In smaller sessions, critics are sometimes met with open animosity. These forms of control extend to the world of publication, where peer-review ensures that newcomers adhere to the community's language and assumptions. Such a reception makes it unattractive for newcomers to stray too far from the already accepted narrative around geoengineering.

Once the field became established, the increasing availability of funding made it attractive to join the geoengineering research endeavour. Yet influential voices in the community, amplified by authoritative assessment reports, had already channelled research along certain lines.³ One researcher, interested in carbon dioxide removal technologies early on, remembers how 'no-one was interested, no-one was funding it'. She thought that because the influential Royal Society report (Shepherd et al. 2009) had identified stratospheric aerosol injection as a major area of interest, it 'hugely shaped the immediate narrative in terms of what got funded'. She therefore joined a geoengineering research project weighted towards stratospheric aerosol injection instead.

A different researcher had similar reflections about the contemporary setting of carbon dioxide removal research. Being interested in the social aspects of such technologies, he explained how difficult it was to get research funding for projects that differed from the mainstream engineering and modelling-based inquiries. He attributed this difficulty to structural incentives, explaining how natural science funding agencies had 'a ribbon to cut' when new inventions were made or their studies gained high impact, therefore receiving the lions share of public funding. By contrast, social science funding agencies were less competitive and therefore less well endowed. For this reason, research institutions like his own chose to focus on the engineering aspect of the technology.

These mechanisms provide important clues as to how social cohesion works in streamlining the language and practices of a scientific community. Narratives of common cause, control of deviant behaviour and

³For more details on this, see Gupta & Möller (2019).

the structural incentives of research funding have contributed to the maintenance of a distinct object despite increasing engagement of new actors. This object is characterised by a set of basic assumptions and arguments shared amongst geoengineering scientists and increasingly adopted by politicians and civil servants: 1) geoengineering is a sub-optimal solution that, as other climate policy options are failing, will be our only hope to avoid the disastrous consequences of rampant climate change; 2) geoengineering must be divided into two fundamentally different approaches (based on the function of the climate system), namely carbon dioxide removal and solar radiation management; 3) research on geoengineering is necessary in order to prepare for the future and to reduce the unintended consequences of eventual deployment as much as possible; 4) governance for geoengineering research and deployment is necessary to prevent unilateral deployment (of SRM) and to ensure responsible use (mainly of SRM, but increasingly of CDR).

Representing key elements of the dominant discourse on geoengineering today, these tenets are repeated in major geoengineering assessments and have been documented by other scholars of the geoengineering discourse (Sikka 2012, Nerlich & Jaspal 2012, Anshelm & Hansson 2014). They can be therefore considered core definitions and assumptions of geoengineering that contribute to making it a distinct governance object.

On brokerage and salience

The hypothesis about brokerage leads us to expect that there are individuals who bridge gaps between different groups, and that these individuals take on entrepreneurial or opinion leading roles. Their existence and influence is supported by both the network analysis, and the qualitative impressions of interviewees.

Figure 3 shows a projected version of the two-mode geoengineering epistemic community, in which events are removed and individuals share direct ties based on having attended at least two events together. The size of each node is proportional to the node's betweenness centrality measure. We can see that in the early phase of the network (Figure 3a), brokerage potential is highly concentrated amongst a few individuals in the network. David Keith, a physicist and policy expert at Harvard University, is a central figure in bridging research groups in the

UK and US (top-right) and research groups in the EU (bottom-right). Andy Parker, a policy expert affiliated with the Royal Society, Harvard University and the Institute for Advanced Sustainability Studies, also bridges these two groups and additionally provides the principal connection to researchers from non-western countries (top-left). Although other well-known geoengineering scholars also show brokerage potential, these two actors stand out in particular. By contrast, in the later version of the network (Figure 3b), brokerage potential is much more evenly distributed.

The backgrounds and activities of prominent brokers in the early network further confirm expectations about entrepreneurship. David Keith was amongst the first scholars to publish about geoengineering. His early studies on this matter put forth some of the core assumptions that were later adopted by the network more widely, including a differentiation between geoengineering by carbon removal and geoengineering by sunlight reflection (Keith & Dowlatabadi 1992) and a distinctly interdisciplinary perspective on the geoengineering problem, including a strong focus on ethical and societal issues (Keith 2000). He was co-author on the earlier mentioned Royal Society report and now leads a prominent research group at Harvard, currently preparing the first outdoor experiment in stratospheric aerosol injection. Further evidence is delivered by Oldham et al. (2014), who also identify Keith as an influential figure in the solar radiation management literature. The difference between event based data and bibliometric data becomes more clear in the case of Andy Parker. Parker is not identified as a prominent scientist in reviews of the geoengineering literature, but he leads the ‘Solar Radiation Management Governance Initiative’, an NGO that has been very productive in engaging developing countries in the discussion on solar radiation management. Organising over twenty events on solar radiation management in different parts of the Global North and South, he has been a lead figure in introducing the geoengineering concept to a non-western audience.

The reflections of interviewees confirm the pivotal role that brokers have had in introducing the geoengineering idea to new audiences. Several interviewees remembered events at which they had witnessed Keith or Parker speaking about geoengineering, stating that these presentations first introduced them to the topic. As one researcher explained, ‘my increasing interest in [negative emissions] was when I saw David

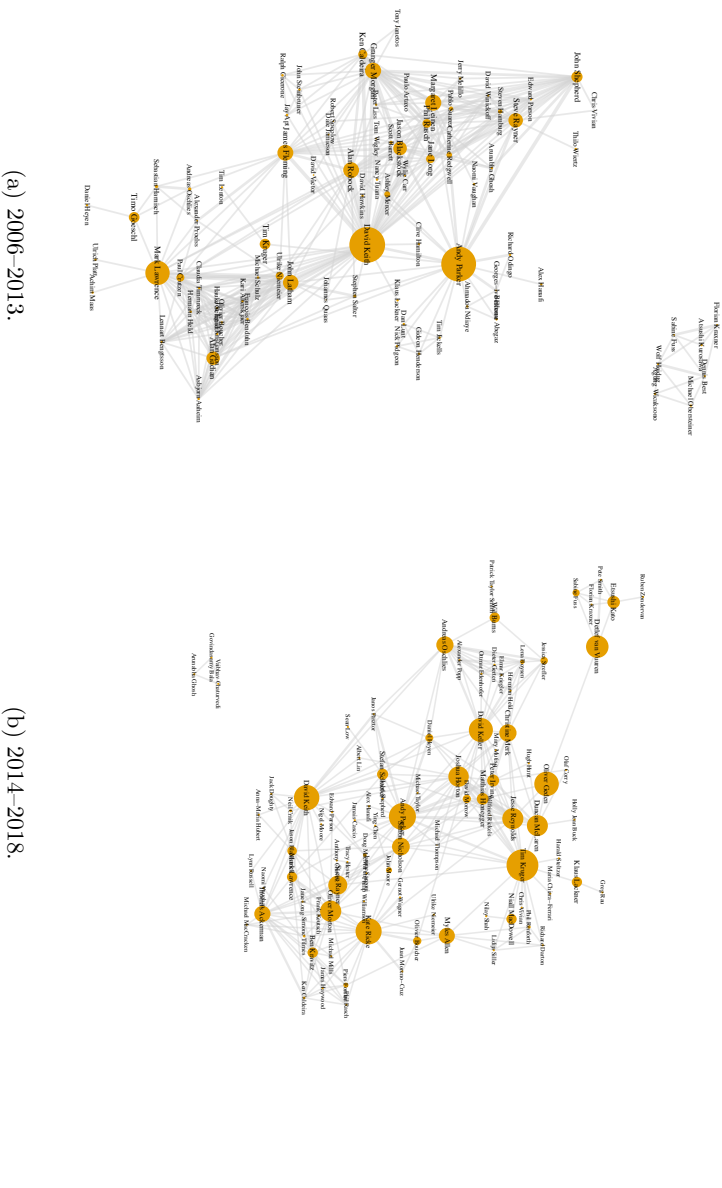


Figure 3: Members of the geoengineering epistemic community. Node size indicates betweenness centrality.

Keith and it became increasingly obvious that mitigation alone is not going to hit the target, and that there were cost-efficiency advantages of employing negative emissions, and it also provided a potential back-stop for carbon price’.

A government official remembered how he had first encountered the idea in a presentation given by Keith and thinking that geoengineering was ‘a bit left-field, a bit non-mainstream, that at the same time was being put forward by scientists who came across as credible in terms of their technical knowledge of the subject’. Those more recently introduced to the field, particularly in the realm of government, mention another broker. Janos Pasztor, a former UN official who leads the ‘Carnegie Geoengineering Governance Initiative’, does not show high values of betweenness centrality in the epistemic community. Nevertheless, he is repeatedly mentioned by government officials from different countries as a person who introduced geoengineering to their work and can be considered a broker between the epistemic community and government actors outside of the community.

Keith, Parker and Pasztor are of course not the only actors who have contributed to opinion shaping in the network, and other central actors (including prominent researchers like Stephen Schneider, Alan Robock, Joeri Rogelj and Detlef van Vuuren) were mentioned by the interviewees.⁴ According to the brokerage hypothesis, the influence of these actors can be attributed to their understanding of the different contexts that they bridge, and the adaptation of narratives to fit these contexts. Examples of how this adaptation has taken place follow.

In the early phase of the epistemic community, adaptation of geoengineering took place mainly with respect to the context of climate scientists. One earth system scientist described the recurring use of a figure that showed how CO₂ emissions were outpacing the IPCC’s worst climate scenarios. This was combined with incoming data about the suspected break-down of the thermohaline circulation, heralding catastrophe for the United Kingdom. Geoengineering, in particular stratospheric aerosol injection, was subsequently presented as the so-

⁴The lack of appearance or centrality of some of these actors in Figure 3 comes down to the data used. My focus has been primarily on a network of scholars engaging with the term ‘geoengineering’. Yet carbon dioxide removal, now commonly termed negative emissions technologies, have also been shaped by a community of integrated assessment modellers that is less well represented in the dataset.

lution. In back-of-the-envelope calculations, knowledge brokers showed it to be cheap, fast and simple: the perfect measure to address an imminent climate emergency. This narrative, although later shown to be faulty, served as a powerful attractor for climate scientists who were initially sceptical of solar radiation management to begin engaging in its research.⁵

In the later phase of the community, the adaptation of geoengineering took place with respect to a political context. Geoengineering technologies – both carbon dioxide removal and solar radiation management – were initially framed as a back-stop measure in the face of failing climate negotiations (Obersteiner et al. 2001, Crutzen 2006). When parties to the United Nations Framework Convention on Climate Change (UNFCCC) adopted the 1.5 degree target in 2015, this narrative was re-written. Now, brokers depicted geoengineering technologies as necessary measures to meet the ambitious political targets set by nation states. The narrative is based on the limited feasibility of ‘deep-mitigation scenarios’ demanded by policy makers, the solution being the addition of carbon dioxide removal technologies (or ‘negative emissions technologies’) to conventional mitigation measures (Rogelj et al. 2016). Proponents of solar radiation management research build on this new narrative, showing how both mitigation and carbon dioxide removal will not be enough to reach the targets. Stratospheric aerosol injection is presented as a solution that can ‘shave the peak’ off of a temperature line that would otherwise transgress 1.5 degrees (MacMartin et al. 2018).

These pieces of evidence provide support for the hypothesis that brokers have played an important role in diffusing the geoengineering concept, and that the adaptation of narratives about an object to a given context are central for ensuring its saliency. Whether the brokers themselves are always explicitly responsible for adapting narratives is less clear, but their multi-disciplinary background and their explicit engagement with the question on how to best communicate a scientific problem to political actors provides additional support for this conclusion (e.g. Keith 1996, C2G2 2018).

⁵According to the interviewee, the method used to calculate the graph had exaggerated the difference between actual emissions and IPCC scenarios, and the changes in thermohaline circulation were found to be a part of natural variability.

On diversity and malleability

The hypothesis about diversity leads us to expect that diversity contributes to the malleability of an object. The causal pathway here is that increase in diversity (and ultimately the expansion of weak ties in the network) incites deliberation and innovation, leading to an adaptation of the object in question. But rather than saliency, this kind of adaptation increases the malleability of an object by creating a better fit with the positions and expectations of a diverse community.

Figure 4 indicates that the geoengineering community is indeed composed of diverse academic disciplines and societal realms. Despite being an object born of earth system science, its epistemic community includes a significant amount of professionals from the social sciences and humanities. Political science, economics, law and philosophy make up approximately twenty-five percent of the total network, while atmospheric science and geoscience make up approximately thirty percent. The Rao-Stirling diversity index, reflecting variety, balance and distance between the represented disciplines, results in values of 0.53 and 0.58 in the early and late network respectively. In terms of organisational diversity, the realm distribution indicates that the network consists primarily of individuals from research institutes and think tanks, but that there are also connections to organisations outside the research sector. These connections are built primarily by individuals who span different realms, most of them having an affiliation in both research and civil society, government or the private sector.

Observations made at geoengineering conferences indicate that disciplinary diversity within the network contributes to enabling the discussion of geoengineering across scientific faculties. This is emphasised by differences in the nature of the conversation within the geoengineering community and the community that has brought forth the term ‘negative emissions technologies’ – a different epistemic community that engages with carbon dioxide removal technologies through land-based methods (Belter & Seidel 2013). In the former network, the attendants and the overarching conversation around geoengineering technologies are highly interdisciplinary. At conferences like the ‘Symposium on Climate Engineering Research’ or the ‘Climate Engineering Conference’ in Berlin (2015 and 2017), engineering aspects, physical effects, questions of ethics and questions of governance were regularly present in the

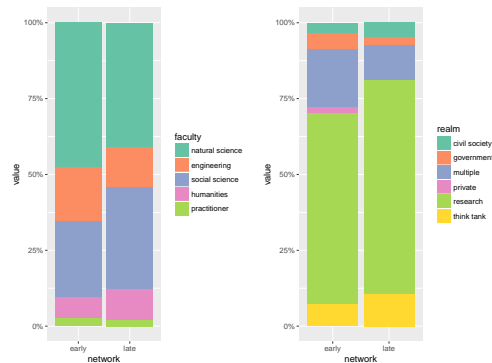


Figure 4: Composition of network members by disciplinary background and organisational realm.

same presentation, discussed by the same person – be they a physicist, a lawyer, or a philosopher. Although not all sessions contained panellists across faculties, the plenaries predominantly did.

By contrast, the ‘Negative Emissions Conference’ in Gothenburg (2018) was dominated by geoscientists and earth system modellers. Although some attendants also came from other disciplinary backgrounds, these crowds did not mix well. One of the scientists interviewed here expressed his exasperation with this division, stating that ‘even here, the communities are in the same building, but they don’t really talk to each other. They talk past each other quite regularly. I don’t think I’ve had one direct question answered’. Although this conference represented a substantive effort to bring together researchers from diverse backgrounds, its overarching conversations remained primarily around technical questions, in some cases expressing the need for policy engagement to facilitate rapid development and deployment of carbon dioxide removal technologies. When fundamental questions about ethics or politics were asked, this seemed to cause discomfort amongst the audience and the presenters.

The deliberation and the adaptation that is sparked when diversity suddenly increases can be seen when people from different communities are brought together. An interviewee from the anglophone geo-engineering research context remembered her engagement with Ger-

man experts to write an assessment report (the separation of these two sub-communities is recognisable in Figure 3a). She described the discussions they had on what terms to use, stating that ‘it felt like endless going around in circles defining stuff’. Although they worked on the same thing, different people had different preferences in terminology. In the end, they went with the German term of ‘climate engineering’ rather than the UK/US term of ‘geoengineering’. In her eyes, this was because climate engineering was less directly associated with solar radiation management and therefore less controversial.

This continuous adaptation of terminology is particularly visible in the case of carbon dioxide removal technologies. After the IPCC’s fifth assessment report in 2013/2014, the earlier mentioned community around land-based carbon dioxide removal began engaging with members of the geoengineering community. (Their ‘merger’ is visible in Figure 2b and Figure 3b, with the increase of CDR related events and the decrease in cohesion). This happened because the integrated assessment models in the IPCC report were relying heavily on a land-based technology called bioenergy with carbon capture and storage (BECCS) to absorb carbon dioxide from the atmosphere and thereby stay below 2 degrees average warming. Once the resource implications of relying on such huge amounts of BECCS were voiced by studies like Fuss et al. (2014) or Anderson & Peters (2016), carbon dioxide removal started playing a more pronounced role in science and politics. The community’s answer to this critique has been to expand the portfolio of technologies by incorporating methods that were traditionally discussed in the geoengineering network (see Minx et al. 2018).

The merging of these communities has led a redefinition of carbon dioxide removal. The BECCS community traditionally saw their technology as a form of mitigation and did not want to be associated with solar radiation management in any way. An interviewee from this community explained that they had worked hard, since the publication of the Royal Society report, to make clear that BECCS and negative emissions were *not* geoengineering.

The result of this effort becomes visible when comparing the IPCC’s fifth assessment report (IPCC 2013) and its report on 1.5 degrees (Allen et al. 2018). The former follows the geoengineering community’s understanding, defining it as ‘methods that aim to deliberately alter the climate system to counter climate change’ and stating that ‘[l]imited

evidence precludes a comprehensive quantitative assessment of both Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR) and their impact on the climate system' (29). The latter takes a different approach, distinguishing between mitigation, carbon dioxide removal, adaptation and 'remedial measures' (equated with SRM), explicitly excluding the term 'geo-engineering' (70). The result is a creation of two entirely new climate change policy options that are no longer mentioned somewhere in a last paragraph, but side-by-side with the traditional categories of mitigation and adaptation.

The contents of all these terms have not changed. The technologies subsumed under carbon dioxide removal and 'remedial measures' are more or less the same large scale interventions discussed by the 1992 National Academy of Sciences report and the 2009 Royal Society report under the term 'geoengineering'. But the encounter of different epistemic communities has led to making large parts of the concept seem a lot more acceptable in the eyes of a wider public. Ironically, this is a development that one of the most important knowledge brokers, David Keith, already anticipated early on. In a 2000 article, he expressed the concern that greenhouse gas removal through biological sinks was being divorced from more 'objectionable' technologies, indicating a move towards the acceptance of geoengineering-like proposals without first conducting a proper debate about ethics. Despite efforts to address this problem by including CDR as a sub-set of geoengineering technologies, the conversation seems to have fallen back into its original state.

Accounting for additional factors

In addition to the activities of agents, important structures that shape the behaviour of epistemic communities, knowledge brokers, and their audiences, need to be taken into account. The first of these is the legacy of climate science. Allan (2017) shows how climate change itself is an object of governance that has been constructed in terms of a geophysical problem rather than a bioecological one. Climate science is conducted using geophysical models of the Earth system, leading it to be seen as a problem of radiation balance based on reflectivity and sources and sinks of greenhouse gases. This definition of the problem has fundamentally contributed to seeing the alteration of reflectivity

and/or the enhancement of carbon dioxide sinks as an obvious solution. If climate change itself had been defined in a different manner, it is unlikely that geoengineering could have become so prominent.

The second important structure is the mutual dependency of climate science and climate politics. Studies about this co-dependency are plentiful, explaining how science and politics mutually reinforce each other (see Jasanoff 2004, Beck & Mahony 2017). Yet the problem is perhaps best summarised in the observation of an interviewee:

The modelling community serves the decision community and the policy community very very well. Whether we like it or not, there is a co-dependency. After all, what are modeller's careers? Their livelihoods, their reputation, their professorships, everything is dependent on their ability to perform to the requests of a client such as the IPCC. [A prominent climate modeller] is never going to say no you can't do it, because they're going to find someone else. You know, it's really dangerous, its completely obvious. And you know, it's been so hard-baked into the process that they don't even realise it's happening.

What is captured by this quote is that the institutional structure of climate change politics is built to be dependent on the assessments of climate science. Policy makers rely on climate scientists to tell them that it is possible to reach ambitious goals, and they need the models to show how 2 degrees or 1.5 degrees are still feasible in order to keep spirits high and negotiations going (also see Lövbrand 2011). But because the dominant climate science of the day is based on geophysical variables, and because it is very difficult to model alternative solutions – such as behavioural or political change –, the only way for scientists to accommodate this demand is by adding ever larger technologies to the equation.

Conclusion

What lessons can we draw from this case? Some of the findings discussed here match insights from similar studies on the origins of networks. Hajer and Versteeg (2005, 343) argue that a shared discourse is essential for the success of a network, describing how policy networks made up of very different actors gradually adopt not only a common language,

but also a shared identification of core problems and potential solutions. According to them, ‘it is the discourse that keeps the governance network together and explains the actions that the various participants see as appropriate’. The geoengineering case adds further insight to how this common discourse can be upheld, namely by creating feelings of trust amongst the community’s members and dis-incentivising new members from using alternative practices. Community internal ordering mechanisms like this add to other forms of *de facto* governance that are exerted, for example, by authoritative assessments and the funding structures that they shape (Gupta & Möller 2019).

The importance of brokers in spreading the geoengineering idea supports findings about so-called ‘seed actors’ in shaping the content of a community’s activity. In their study of the evolution of advocacy networks, Lake & Wong (2009) argue that certain individuals serve as seeds around which a network clusters, and that these individuals shape the ends towards which the network collectively moves. The geoengineering case adds an important extension to this finding, namely that successful seed actors are required to continuously engage in expanding the network by introducing the idea to new audiences, and that they need to use salient narratives to do this. Effective knowledge brokering is thus important for the creation and expansion of epistemic communities, and for enabling a governance object to become globally relevant.

The importance of diversity supports findings about mechanisms of innovation, diffusion and success. Keck and Sikkink (1999, 89) reflect that transnational advocacy networks ‘build new links among actors in civil society, states and international organisations’, thereby multiplying opportunities for dialogue and exchange. Witte et al. (2000) similarly posit that the distinctive flavour of what they call ‘global public policy networks’ is their ability to bring together actors from diverse backgrounds. More detailed process studies like Leifeld (2013) point out the importance of polarisation in advocacy coalitions to explain change. Successful epistemic communities appear to be no different from these other types of networks. This similarity points to the fact that theoretical development in this area should combine insights from different bodies of network-based literature.

All in all, this study has described how the geoengineering concept came to be shared by an epistemic community that, through mechanisms of cohesion, brokerage and diversity, helped transform the idea

into a globally relevant governance object. But it also reflects on the structures that were necessary for this transformation to happen. The geophysical understanding of the climate change problem, combined with a co-dependency between climate science and politics, have laid the foundations upon which geoengineering could grow. These foundations need to be closely evaluated if the increasingly techno-centric trajectory of climate change science and policy should change.

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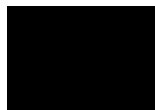
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Paper II



De facto governance: how authoritative assessments construct climate engineering as an object of governance

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ABSTRACT

Analyses of climate engineering (CE) governance have accelerated in the last decade. A key claim is that CE remains a largely ungoverned space, with shared norms, institutional arrangements, and formal rules to regulate CE not yet present. In contrast, here it is argued that de facto governance of CE is underway, discernible in an ordering of this nascent field of inquiry by unacknowledged sources of steering. One key source of de facto governance is analyzed: high-level ‘authoritative assessments’ of CE. The focus is on how these assessments are constructing CE as an object of governance through demarcating and categorizing this emerging field of inquiry, and how this contributes to normalizing and institutionalizing CE research (and CE research communities). Scrutinizing the distinct nature and political implications of de facto governance, particularly of novel and speculative technological trajectories not yet subject to formal steering, remains a key task for governance scholars.

KEYWORDS De facto governance; climate engineering; geoengineering; scientific assessments; carbon dioxide removal; solar radiation management

Introduction

One of the most pressing and intractable societal challenges of our times is how to imagine, anticipate and govern our collective climate future(s). Such challenges come into even sharper focus in the context of debates, now raging, around whether a set of technological interventions collectively categorized as ‘climate engineering’ can provide a way forward to prevent the worst consequences of climate change. Climate engineering had been defined as the ‘deliberate, large-scale manipulation of the planetary environment in order to counter anthropogenic climate change’ (Shepherd *et al.* 2009, p. ix). It is a quintessential anticipatory governance challenge (Gupta 2011), wherein the perils and promises

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associated with a suite of CE options remain uncertain, contested and to large extent unknowable (Foley *et al.* 2015).

Notwithstanding this, climate engineering (henceforth CE) is the subject of growing scientific and academic scrutiny, including in the social sciences. In particular, governance analyses of CE have accelerated in the last decade. A central tenet of such analyses is that CE remains a largely ungoverned space, usually understood to mean that shared norms, institutional arrangements and formal rules to regulate CE-related research and potential deployment are largely non-existent. The vast majority of CE governance analyses focus on debating what such norms, institutional arrangements and rules could or should be, usually accompanied by description of the few formal governance arrangements that do exist (Pasztor *et al.* 2017).

In contrast to existing analyses, our point of departure is that CE is *already* a governed space. Despite the relative absence of formal governance arrangements, we advance the proposition that an emerging *de facto* governance of CE is discernible, by which we understand, following Rip (2010), sources of governance that are *unacknowledged and unrecognized* as seeking to govern, even as they exercise governance effects. Understood as such, *de facto* governance is distinct both from formal, state-led, legally binding *de jure* forms of steering, as well as informal, non-state sources of steering, which share the characteristic of intentionally seeking to steer the behavior of certain actors or institutions, in order to realize specific, openly stated goals. If so, scrutinizing the nature and implications of *de facto* governance remains all the more necessary, given that it is not subject to the political oversight that accompanies, to greater or lesser extent, more intentional/acknowledged sources of governance.

Our interest here is to explore the workings of what we see as one key source of *de facto* governance: authoritative assessments. By this, we mean expert-led, multi-author assessments produced by eminent scientific bodies advancing state-of-the-art understandings of novel and politically contested environmental and technological fields. We see these as ‘authoritative’ insofar as they leverage and reflect the scientific eminence associated with the institutional context from which they emerge, which serves to endow them with epistemic authority and legitimacy, but also a steering capacity.¹ The dominant view of such assessments is that they survey an emerging field in order to advance knowledge, outline gaps in governance and/or identify appropriate principles to underpin (future) governance arrangements. In contrast, we discuss how such authoritative assessments constitute a source of *de facto* governance themselves, and consequently shape the context for *de jure* types of governance.

We proceed as follows: in the subsequent section, we flesh out the concept of *de facto* governance, and advance an analytical framework to specify interventions and effects expected from such governance. Next, we

analyze how two CE-focused authoritative assessments have helped to construct CE as an object of governance, and thereby steered research trajectories (and communities) in specific directions. These are the 2009 Royal Society report on 'Geoengineering the Climate: Science, Governance and Uncertainty' (Shepherd *et al.* 2009) and the 2015 National Academy of Sciences report on 'Climate Intervention: Reflecting Sunlight to Cool Earth' (McNutt *et al.* 2015b). We conclude with the implications of our findings for further research into de facto governance, including its nature, effects and political implications.

Conceptualizing de facto governance: interventions and effects

Our use of the term 'de facto governance' draws on analyses of this phenomenon in the context of nanotechnology (Rip 2010). According to Rip, de facto governance refers to scattered 'actions and interactions and how these add up to outcomes at the collective level that function as governance arrangements' (Rip 2010, p. 287). It is important to note that in such an understanding, neither governor nor governed is necessarily identified or recognizable in these terms, even as actions and interactions generate specific outcomes at a collective level that constitute governance. This understanding resonates closely with early ideas on governance advanced by global governance scholar James Rosenau. Conceptualizing governance as an emergent system of rules, Rosenau (1995, p. 13) pointed out the need to search for 'order in disorder', specifying 'authorities that are obscure' and 'boundaries that are in flux' as important elements in the study of global governance. He also described how patterns of order at the collective level evolve out of myriad interactions between individuals who are not explicitly understood to be, or acknowledged as, rule-makers themselves (Rosenau 1990).

Drawing on these two sources, we use de facto governance to capture the idea that unacknowledged steering is discernible from the effects generated, and that these effects are neither mandated nor openly pursued as governance goals by de facto governors. Such an understanding is aligned with the Oxford dictionary's definition of de facto to mean 'unacknowledged, unrecognized, but actual, manifesting in reality'. The steering entailed in de facto governance is not explicitly recognized as an act of governing by others, even as it steers a field of inquiry in specific directions, thereby also shaping the context for *de jure* governance.

Operating with such an understanding of de facto governance, specific sources of such governance become important to identify and analyze. We view 'authoritative assessments' as one key source of such unacknowledged steering. While much recent CE scholarship has emphasized the need to develop appropriate mechanisms to govern scientific research, a de facto

governance perspective emphasizes that some scientific activities (including assessments) themselves generate governance effects. Owen (2014) for example has explored in detail the role of expert reports and expert-generated principles as sources of *de facto* CE governance. With a slightly different focus, Oldham and colleagues document how the evolution of research funding, author networks and patenting patterns within CE research from 1971 through 2013 ‘can *de facto* shape the development of the field’ (2014, p. 1, italics added).

Our analysis builds on this important earlier work by bringing *de facto* governance more front and center within mainstream CE governance analyses. In particular, we see a need to draw greater attention to this phenomenon within political science and international relations analyses of politically contested and novel technological trajectories, where the contours of an emerging field of inquiry are neither agreed nor wholly knowable. In such instances, a crucial, first-order intervention is delineation of the object of governance, i.e. specifying ‘what is to be governed’, often through demarcating and categorizing an emerging field of inquiry. Writings within science and technology studies have long noted how categorization is a political act of steering and control that constructs objects (or subjects) of governance through processes of inclusion and exclusion (e.g. Bowker and Star 1999). Equally, scientific assessment processes that serve to demarcate, categorize and thereby frame and construct an object of governance are political acts that shape a field of inquiry and the context for formal (*de jure*) governance (Jasanoff and Long-Martello 2004, Gupta 2006, Dooley and Gupta 2017). As such, we posit here that demarcation and categorization, as incorporated within authoritative assessments, are likely to be powerful acts of *de facto* steering.

With regard to the effects that such acts of *de facto* governance might generate, Rip suggests examining consequences for ‘...legitimacy, governability and the directions that are pushed’ (2010, p. 6). In line with this, we specify an overarching potential effect of *de facto* governance that is likely to flow from acts of demarcation and categorization: the *ordering* of a nascent and highly contested field of inquiry. Such an ordering, we further posit, occurs through normalizing and institutionalizing specific research and governance directions, and thereby also shaping the context for *de jure* governance.

We capture these interventions and potential effects in Figure 1, which serves as our analytical lens. Our aim is not to posit linear causal relationships, but rather to depict what we see as key elements that help to delineate and systematically analyze the phenomenon of *de facto* governance.

Figure 1 captures how, in our view, a *de facto* governance intervention, consisting of an act of demarcation and/or categorization of a contested

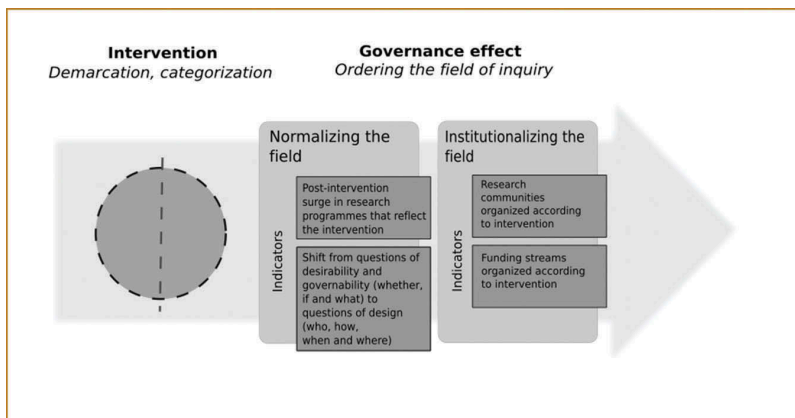


Figure 1. De facto governance by authoritative assessments: interventions and effects.

field of inquiry, may help to order research and governance directions in specific ways. In particular, we identify two sequential components of such a process of ordering: normalization and institutionalization of research and governance directions, with establishment of research programs, delineation of research communities, creation of funding streams and a shift in the nature and direction of the governance conversation serving as indicators through which to ascertain such ordering effects.

De facto governance of CE: steering through assessment

We turn here to our analysis of authoritative assessments as a key source of de facto CE governance. Our aim is to be illustrative rather than comprehensive, hence we identify one core act of demarcation contained within each of these two assessments. We then discuss how this has constructed CE as an object of governance, and contributed to normalizing and institutionalizing CE research directions, thereby also shaping the context for (future) *de jure* governance.

Authoritative assessment I: the Royal Society report

In 2009, the UK Royal Society published a report entitled 'Geoengineering the Climate: Science, Governance and Uncertainty' (Shepherd *et al.* 2009). Written by 12 scientists, the report was a considerable endorsement of the scientific worthiness of what was, until then, a nascent and largely speculative and controversial field of inquiry. We consider this report to be an 'authoritative

assessment' because of the eminence associated with the UK Royal Society, and the prolific subsequent references to this report throughout the CE literature.

The report identified CE as a topic of urgency for the international research agenda on climate change. As earlier insightful analyses have shown, the report served, first and foremost, to legitimize CE as an object of research (Owen 2014). We assess here how this assessment has de facto governed the CE space. In particular, we focus on a key act of demarcation contained herein: the categorizing of CE into two groups of techniques, carbon dioxide removal (CDR) and solar radiation management (SRM). We explain below the context in which this demarcation was introduced, and steering effects flowing from it.

The intervention: categorizing CE techniques as CDR and SRM

In the early 1990s, suggestions to engineer the Earth's climate were met mostly with suspicion, and there were few attempts to develop typologies or classify CE technologies. The most common denominator in this emerging field was that CE connoted the large-scale, intentional manipulation of the climate system to combat global warming. Scale and intent thus underpinned early renditions of the 'what' question around CE. As Jamieson (1996, p. 325) put it, '[w]hat makes geoengineering suspect in the eyes of many is lack of familiarity with the technologies, and the scale and magnitude of the proposals'. Schelling (1996, p. 303) described CE as 'something global, intentional, and unnatural'. There was no widely shared reference point for what CE was or how it should be conceptualized, beyond scale, magnitude and intentionality.

Many argue that wider discussion of CE technologies was made both scientifically and socially acceptable after Nobel Prize winner Paul Crutzen published an article advocating for more research on using sunlight deflection to moderate global warming (Crutzen 2006), one of the key approaches within CE debates today. Drawing attention to a climate altering technique that had been suggested several decades earlier, Crutzen's proposition to inject sulfate particles into the stratosphere as a means to deflect incoming solar radiation resulted in an exponential increase of publications on what came to be referred to as stratospheric aerosol injection (SAI) (Oldham *et al.* 2014). While some took the publication as a cue to research SAI and CE more generally, Crutzen's promotional language was not well received by all and caused heated discussion on the feasibility and desirability of SAI and other CE techniques in the research community (e.g. Robock 2008).

It is in this context that the Royal Society report and its act of demarcation appeared. In a stated effort to provide a neutral and balanced assessment on a subject 'bedeviled with much doubt and confusion' (Shepherd *et al.* 2009, p. v), the report included a demarcation and categorization act relating to CE, consisting of two important dimensions. The first dimension

was to categorize CE technologies along the lines of earth system parameters (in particular, types of radiative forcing) and underlying physical processes, namely whether specific techniques removed carbon dioxide from the atmosphere (CDR) or reflected incoming sunlight back into space (SRM). The reasoning underlying this distinction was that CDR techniques (including land-use management, bioenergy with carbon capture and sequestration (BECCS), mineral weathering, direct air capture and ocean iron fertilization) addressed 'the root cause of climate change by removing greenhouse gases from the atmosphere', while SRM techniques (altering surface or marine cloud reflectivity, SAI and space mirrors) focused on altering solar reflectivity as a way to 'offset' the effects of greenhouse gas concentrations in the short run (Shepherd *et al.* 2009, p. ix). The difference in physical earth system processes, or 'mode of action', was considered so fundamental that the report proposed a division between CDR and SRM techniques, with correspondingly distinct governance considerations.

A second dimension of this categorization was that the report attributed different levels of risks and societal desirability to the two groups of CE technologies. It went on to state that '[i]n most respects Carbon Dioxide Removal methods would be preferable to Solar Radiation Management methods because they effectively return the climate system to closer to its natural state, and so involve fewer uncertainties and risks' (*sic*, Shepherd *et al.* 2009, p. x). SRM was asserted to be more problematic overall, with the report noting that 'Solar Radiation Management methods should not be applied unless there is a need to rapidly limit or reduce global average temperatures' (Shepherd *et al.* 2009, p. xi).

Although widely used today, this was not the only categorization option available or even necessarily dominant at the time of the Royal Society's endorsement of it. Alternative ways to carve up the spectrum of CE technologies were available. These included, for example, distinguishing between interventions deployed in the global commons versus within national territories. SRM technologies like SAI, space mirrors and marine cloud brightening, and CDR technologies such as ocean iron fertilization are all deployed in the global commons, raising legal challenges that are distinct from technologies deployed within national boundaries. Land-intensive approaches like afforestation and BECCS, deployed within national-borders, raise issues of exploitation and justice that are distinct from space or ocean-based technologies (whether carbon or solar radiation focused) deployed in the global commons, given the lower potential to infringe on the land-use rights of vulnerable populations. Another possible categorization was to distinguish between contained versus open ecosystem techniques, which also cuts across the SRM/CDR spectrum. Thus, contained technologies (the CDR technique

of direct air capture or the SRM technique of space mirrors) could ostensibly be seen to pose lower risks to biodiversity, for example, than techniques designed to alter ecosystems (such as the SRM technique of SAI, or the CDR techniques of ocean iron fertilization and BECCS).²

These alternatives notwithstanding, the report's opting for a categorization based on physical (earth system) parameters was seen by many as justifiable, also considering the scientific history of the field³ and the disciplinary make-up of the authors on the Royal Society report writing team (mainly natural scientists). Our aim here is not to suggest that specific alternative typologies could or should have been put forward by the report, but rather to analyze how this chosen demarcation has served as an act of de facto governance in constructing CE as an object of governance, and shaping CE research and governance directions. We turn next to exploring such effects.

Governance effects: ordering the field of inquiry

We draw on our analytical lens to consider how specific CE research and governance directions have been normalized and institutionalized as a result of the Royal Society's CDR/SRM demarcation act. In terms of normalizing research directions, similar to the surge in academic publications documented by Oldham *et al.* (2014) after Paul Crutzen's call for research on SAI, the Royal Society report was followed by multiple CE research programs being established, many of which referred directly to the Royal Society report in motivating their purpose, and most of which adhere to the CDR/SRM demarcation.

Figure 2 below shows the release of the Royal Society report in 2009 and the wave of government inquiries on CE by the UK, US and German parliamentary bodies that followed in its wake, all of which prominently refer to the report. In the same period, some of the first coordinated CE research projects were established. Most of these were UK-based and drew their legitimacy and purpose directly from the report's recommendations. This legitimizing function of the report lasted until the Intergovernmental Panel on Climate Change (IPCC) included the topic of CE prominently in its 2014 Assessment Report (AR5), after which many CE research projects referred to the international scientific body for legitimacy.

Nevertheless, the Royal Society report left its mark in terms of language and categorization. Regardless of whether the report is referred to at the outset or not, almost all research projects listed in Figure 2 categorize CE in terms of CDR and SRM. Furthermore, the report's emphasis on SRM as the most controversial group of CE technologies is reflected in the exclusive focus on this sub-set of CE techniques in six coordinated research projects.

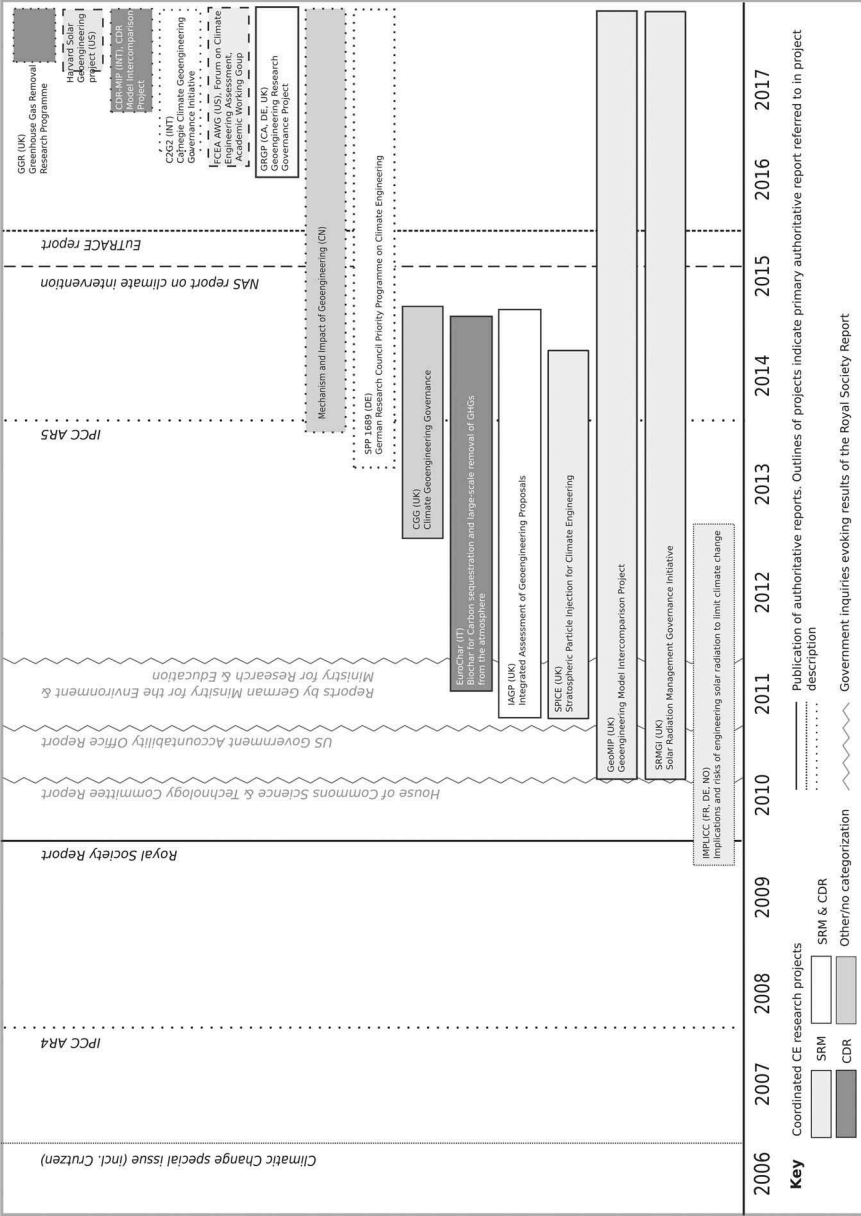


Figure 2. Ordering the field of inquiry: timeline and focus of research projects on CE.

Even those projects that examine CE writ large use the categorization in their project descriptions.

An interesting example of divergence from this categorization is the recently initiated Chinese ‘mechanism and impacts of geoengineering project’, which describes CE in terms of the CDR/SRM categorization for definitional purposes, but then explicitly opts for a different categorization – one that distinguishes between land/surface processes, atmospheric processes and ocean processes – for the conduct of actual CE research (Cao *et al.* 2015). This illustrates both the pervasiveness of the Royal Society’s demarcation act and the utility of alternative categorizations to guide research, even that with a predominantly physical science orientation.

Equally striking is that emerging social science CE research initiatives and networks, most of which focus on governance (and hence could have chosen to work with a different framing and categorization) also uphold the CDR/SRM demarcation. Examples include the recently initiated Geoengineering Research Governance Project, which aims to create a code of conduct for CE research and deploys the CDR/SRM distinction. Similarly, the Carnegie Climate Geoengineering Governance Initiative, aiming to move CE governance debates into the political and policy realm, also differentiates between CDR and SRM. We see the widespread reference to this demarcation as a clear indicator of a normalization process.

Another indicator of how the Royal Society categorization serves as an act of de facto steering is its uptake by public or intergovernmental authoritative bodies, like the Convention on Biological Diversity (CBD 2012) or the Intergovernmental Panel on Climate Change (IPCC 2014). The replication of the demarcation in authoritative assessments directed at policymakers ensures that public research funding is increasingly allocated on the basis of this categorization. Just recently, the UK’s Natural Environment Research Council allocated £8.3m for research on methods to remove carbon dioxide from the atmosphere at a climatically relevant scale, and members of the US Congress explicitly suggested allocating funds to research albedo modification (NERC 2016, US Congress 2017). The separate allocation of research funding as per this demarcation has had (and will likely continue to have) discernible impacts on the CE research community in terms of structuring associated research networks and institutionalizing the divide between those who research CDR and those who research SRM.

Why does it matter that the Royal Society’s de facto governance act has contributed to normalizing and institutionalizing CE research according to the CDR/SRM categorization? We posit a number of potential consequences for CE research and governance directions.

First, the CDR/SRM demarcation has arguably aided in directing discussion away from philosophical and ethical concerns relating to intentionality and scale that dominated earlier CE debates, toward questions of a more technocratic nature. This includes measuring and assessing specific climate and earth system parameters, such as units of greenhouse gas emissions stored or released or sunlight reflected, and the need to reduce associated uncertainties (Flegal and Gupta 2017). Such a technicalization of the field of inquiry can have the effect of depoliticizing the object of governance, and reducing the hubris label earlier associated with CE, thus helping to render CE a more researchable and 'governable' object.

Second, the demarcation between SRM and CDR, and the suggestion that one set of techniques requires more scrutiny than the other, has been accompanied by a proliferation of governance-related research on SRM, in comparison to minimal engagement (until recently) with ethical and legal aspects of CDR. As just one example, the American University-based Forum for Climate Engineering Assessment set up an Academic Working Group consisting of 15 international governance experts in 2016 to explore pressing concerns relating to CE governance, but elected to focus exclusively on SRM. The Royal Society report's demarcation act was accompanied, in general, by a perception that CDR was a less controversial and more acceptable element of a climate policy portfolio, and it was extensively included in the IPCC AR5 report (2014). It was only after the IPCC's inclusion of CDR options, such as BECCS, that critical discussions concerning social justice and governance came to the fore. Initially very much under the radar, various post-AR5 publications now point out the immense social and ecological challenges associated with land-based CDR (Fuss *et al.* 2014).

Within SRM research, the governance conversation increasingly focuses on *design* questions (who should govern, how to govern), with a predominant concern with ensuring 'responsible' research and/or addressing the problem of unilateral deployment. Much attention is also devoted to mapping public perception and encouraging public deliberation, or debating institutional arrangements and principles for governance (e.g. Lloyd and Oppenheimer 2014). Research on more overtly 'political' aspects such as justice, power or responsibility is not necessarily at the front and center in CE and SRM governance debates. A rough indicator of this can be found in the program of the most recent international conference on CE in Berlin that brought together key academics and practitioners engaged with CE debates. Descriptions of panel sessions in the conference program reveal that 'power' and 'justice' appear only once and twice respectively, while 'governance' is a theme in 11 out of 39 sessions (CEC 2017).

In sum, we have argued that the Royal Society report's CDR/SRM demarcation act has influenced the ways in which the CE research community is organized, as evident from the foci of established research programs and funding streams, and has influenced the nature and direction of the CE governance conversation. Conceptualizing the Royal Society's categorization as an authoritative intervention, rather than an assessment of the state of knowledge based on self-evident technical criteria, provides in our view a new perspective on how de facto sources of steering construct an object of governance, and serve to order an emerging and politically contested field, thereby also shaping the context for more formal *de jure* governance.

Authoritative assessment II: the National Academy of Sciences report

Six years after the publication of the Royal Society report, the US NAS followed suit and released a detailed assessment of CE technologies, their potential and their pitfalls (McNutt *et al.* 2015a, 2015b).⁴ Adopting the now widely held position that CDR and SRM are fundamentally different CE approaches, the report consisted of a separate publication on each. It also echoed the Royal Society's judgment on the risks associated with each, describing CDR as relatively well-understood and largely unproblematic, and SRM as a set of techniques with unknown challenges and risks. The 2015 NAS report was 400 pages long, providing the most extensive assessment on the subject to date. As the NAS constitutes a principal source of scientific information for the US government, we consider the report's recommendations to be a potentially important source of de facto steering that may shape the trajectory of CE research and policy in the US.

As with the Royal Society report, we explore here the nature and effects of one key intervention embodied in the SRM ('albedo modification') section of the NAS report. This entails, at its core, an endorsement to take SRM research outside the lab by demarcating small-scale from large-scale outdoor SRM research. One justification for this provided by the report is a concern with unilateral deployment of SRM by other states or private actors as a key governance challenge, meriting both an acceleration in US research and the construction of a global SRM research and deployment monitoring system. We explain below the context for and implications of this demarcation act.

The intervention: demarcating small-scale from large-scale outdoor SRM research

While computer modeling and the use of data from 'natural experiments' (i.e. volcanic eruptions), has become a standard approach within SRM research, moving outside the laboratory to conduct research on the effects

of aerosols in the stratosphere and potential deployment strategies remains controversial. Although some advocates of CE research have emphasized the need for outdoor experimentation (e.g. Keith *et al.* 2010), those opposed to outdoor research note that governance is inadequate, that there is no urgent need to explore the feasibility of SRM now, and that proponents have failed to provide convincing evidence of its necessity (Schäfer *et al.* 2013).

Crucial to this debate is the uncertainty and contestation around the distinction between outdoor experiments in need of specific governance measures, versus those considered part of normal scientific inquiry. This is evident from lengthy discussions about what constitutes outdoor research, and possible distinctions with regard to impact and associated governance imperatives (Hubert and Reichwein 2015). Because of this uncertainty, major CE research projects like Germany's coordinated SPP 1689 CE research program or the EU's FP7 project on the implications and risks of engineering solar radiation to limit climate change explicitly refrain from endorsing or conducting any outdoor experiments. The much analyzed UK research program on stratospheric particle injection for climate engineering (SPICE) included cancellation of an originally planned experiment to test a stratospheric aerosol delivery mechanism. Although the immediate cause of cancellation was a conflict of interest over patenting, this brought to the fore key issues relating to governance of research and outdoor experimentation (Stilgoe *et al.* 2013).

The NAS report and its demarcation act thus takes on a contested aspect of CE research and governance, wading into the conflict around what constitutes acceptable SRM research practice by taking a clearly positive stance on the need for outdoor experimentation. In particular, small-scale experimentation is demarcated from large-scale field trials and framed as a necessary mechanism through which to verify results of SRM modeling (McNutt *et al.* 2015b, p. 9). The report also states that governance is not a synonym for regulation, and that existing scientific research norms are sufficient to govern some types of outdoor SRM experiments (McNutt *et al.* 2015b, p. 10). Ethical and sociopolitical issues are framed as being more relevant in the context of large-scale field trials and 'responsible deployment' (McNutt *et al.* 2015b, p. 135). Thus, the NAS report rejects the position that any small-scale, outdoor experimentation would need to be regulated, and that societal concerns associated with this technology make self-governance by the scientific community inadequate.

Furthermore, the recommendation to engage in outdoor research on SRM goes hand in hand with a recommendation to enhance US capacity to measure changes in radiative forcing, therefore enhancing the ability to detect large-scale activities by unilateral or uncoordinated actors (McNutt *et al.* 2015b, p. 9). This recommendation increases the political relevance of

SRM, but in a rather unconventional manner. By highlighting the problem of rogue action within a recommendation explicitly directed at the US government, it sets up the context wherein infrastructure investments for monitoring and control of SRM activities can be justified on grounds of detecting a potential foreign threat, thereby framing SRM as an issue relevant to national security.

Although the NAS report repeatedly points out various risks associated with potential future use of SRM and the importance of prioritizing emissions reductions and adaptation, the emphasis is on creating conditions for 'responsible' SRM deployment, based on the assumption that policymakers will contemplate its use to avoid catastrophic climate change in the future, and thus need to improve their knowledge base before that moment comes. The inherent governability of SRM is therefore implicitly assumed, and fundamental political questions of governance capacity to steer and manage the safe, equitable and effective use of such technologies collectively is hardly considered. This simultaneous focus on technical knowledge needs and a national security justification for expansion of SRM research, including giving a nod to the need for outdoor experimentation, results in a further ordering of the CE field of inquiry in specific directions, to which we turn next.

Governance effects: ordering a field of inquiry

In contrast to the Royal Society report, the publication of the NAS report remains relatively recent. Thus, we can only posit some first signs of the ways in which its demarcation act may serve to normalize and institutionalize specific research and governance directions.

One effect of the NAS report's intervention is greater engagement with the idea and prospects of SRM outdoor experimentation. In March 2017, 2 years after publication of the NAS report, Harvard University announced a project to begin outdoor experimentation relating to 'solar geoengineering' (Harvard University 2017). Although plans for this experiment were already publicly known prior to publication of the NAS report (Dykema *et al.* 2014), the report's approval of outdoor experimentation provided an important source of legitimacy for the project. Thus, Gernot Wagner, co-leader of the Harvard Solar Geoengineering Research Program, explicitly mentions the NAS as an authoritative source that encourages research on solar geoengineering (Harvard University 2017). In a related *Guardian* article, David Keith and Gernot Wagner again refer to the Royal Society, NAS and IPCC as authoritative sources legitimizing their outdoor experimentation project (Keith and Wagner 2017). The experiment has not yet been conducted, but its successful execution may trigger a wave of small-scale outdoor experiments and normalize a type of research that was previously contested.

In addition, the NAS report continues a trend, traceable back to the Royal Society report, of normalizing the notion of CE governability. It does so by relying on powerful metaphors that depict the existing CE demarcation of CDR and SRM in ways that simplify the climate system and reinforce the idea that humans have the power to control it. Most strikingly, the report explains CE as follows:

The climate system can be compared to a heating system with two knobs, either of which can be used to set the global mean temperature. The first knob is the concentration of greenhouse gases such as CO₂ in the atmosphere that affects the infrared side of the energy balance (...). The other knob is the reflectance of the planet, which controls the amount of sunlight that the Earth absorbs. (McNutt *et al.* 2015b, p. 27)

Although ‘only’ a metaphor, the image of humankind being able to manipulate the global climate like a domestic heating system is powerful. Conjuring up the very concrete experience of a hand on a temperature knob (and using an associated metaphor of ‘pulling down the window shades a bit’) is bound to stay present in a reader’s mind, especially in the context of a long and rather technical report. Squarely placed at the beginning of the introduction, the hand-on-knob metaphor sets the scene of CE as a controllable, governable system. No amount of cautioning in the aftermath about risks and uncertainties can easily erase that impression.

In terms of institutionalization, it is too early to detect substantial changes in terms of funding streams for outdoor research, or further consolidation of research communities, but first indications of these effects can be found in relatively recent activities of US government institutions. The US Global Change Research Program, which was designed under the Obama administration to directly inform the national research priorities of the US President and Congress, cited the NAS report in its recommendation to take action on CE research. Amongst other things, it echoed the NAS report’s rogue actor theme, stating that:

[t]he need to understand the possibilities, limitations, and potential side effects of climate intervention becomes all the more apparent with the recognition that other countries or the private sector may decide to conduct intervention experiments independently from the US Government. (GCRP 2017, p. 37)

The rogue actor theme also provides justification to develop national monitoring and surveillance systems relating to CE. One indicator pointing in this direction is the interest in, and concern about, SAI expressed by John O. Brennan in his function as director of the US Central Intelligence Agency (Brennan 2016).

In an important recent development, on 8 November 2017, the science committee of the US Congress held a hearing on ‘geoengineering

innovation, research and technology', in which members questioned four witnesses about the potential and possibilities associated with CE (US Congress 2017). Witnesses as well as members of Congress repeatedly referred to the NAS report as justification in supporting the need for further research. Furthermore, the concern that other countries or private individuals might develop CE technology was voiced several times. Five members of Congress asked questions about other countries, with China and Russia standing out as potential rivals in terms of technology development and field tests, as well as reference points in considering the merits or not of regulating SRM research. The hearing revealed that two members of Congress were in the process of putting forward legislation that would facilitate further research, one encouraging development of CDR research capacities within the Department of Energy, and the other requesting the NAS to develop a research agenda for SRM, further underscoring the NAS report's de facto steering capacity.

De facto governance by authoritative assessments: ordering a field of inquiry

Here we briefly synthesize and compare our analyses of the de facto governance acts contained within the Royal Society and NAS authoritative assessments, and their effects in shaping this field of inquiry (see Table 1). As can be seen from Table 1, the reports are similar in how they attempt to bring order to an emerging, contested field, with the NAS report building in important ways on the Royal Society report. In both cases, certain research directions are encouraged by acts of demarcation contained within the reports. While the Royal Society report categorized CE in terms of physical processes in need of further research, and thereby helped construct CE as an object of governance, the NAS report frames SRM as a question of security and demarcates small-scale outdoor experimentation from responsible deployment as a necessary means to 'verify' the 'theory' of SRM models.

In terms of shaping the governance conversation, both acts of demarcation have had the effect of recasting the original hubristic framing of CE techniques. Both depict controversial CE issues as manageable (or 'governable'), hence settling the 'whether to govern' question, even as they authoritatively intervene to shape the 'what' question. In so doing, these framings and acts of demarcation have contributed to shifting the focus of governance debates from first-order 'what, if, and whether' questions to 'how, when, and who', i.e. to questions of (technical) design.

Table 1. De facto governance by authoritative assessment: ordering the CE field of inquiry.

Intervention: the act of demarcation/ categorization	Governance effect: ordering the field of inquiry	
	Normalizing the field	Institutionalizing the field
<p>Royal Society distinction between CDR and SRM</p> <p>Predominant categorization of CE in terms of earth system parameters (rather than scale, political jurisdiction, familiarity or other criteria)</p> <p>CDR categorized as slow and less cost effective (but safer); SRM as quick, affordable and effective (but less safe)</p>	<ul style="list-style-type: none"> Establishment of CE research programs reflecting the demarcation (CDR and SRM) Shift away from association of hubris, and political and ethical debates over scale, safety (and contingencies), to scientific debates over measurable units; cost-benefit analysis; reduction of uncertainties Governance focus now more on design aspects (<i>who, how, when, where</i>) rather than first-order, politically contested issues of desirability or governability (<i>if, whether, and what</i>) 	<ul style="list-style-type: none"> Separation and increasing institutionalization of research communities, according to the demarcation (CDR and SRM) Establishment of funding streams for CE research according to demarcation
<p>NAS distinction between acceptable outdoor experimentation and responsible deployment</p> <p>Demarcation between 'acceptable' outdoor experimentation (without needing new governance arrangements) versus responsible deployment</p> <p>Justifying need for outdoor experimentation by framing SRM as an issue of national security</p>	<ul style="list-style-type: none"> Directs focus away from debates on desirability of outdoor experimentation and towards technical research needs, such as monitoring systems to detect changes in radiative forcing Normalizing questions of governance through metaphor of 'hand on the thermostat' Depicts SRM as a question of national security, directing governance questions in a certain direction (preventing rogue deployment, unilateral action) 	<ul style="list-style-type: none"> SRM experimentation and research programs encouraged by members of Congress, based on NAS recommendations Planned first SRM outdoor experimentation scheduled to take place in US, using NAS to justify

Conclusion: de facto governance – what’s new under the sun?

We have highlighted how sources of de facto governance, such as authoritative assessments, have normalized and institutionalized CE research, thereby contributing to ordering an emerging, contested field of inquiry characterized by multiple uncertainties and unknowns. We examined this process of ordering by identifying specific acts of demarcation and categorization incorporated within authoritative CE assessments. We argued that these interventions have served as a way to normalize and institutionalize specific strands of inquiry as per the demarcation, even as they have arguably helped to direct a number of politically contested debates into the realm of the technical by privileging that which is amenable to expert assessment and measurement.

Our analysis has shown that demarcations and categorizations contained within authoritative assessments play an important role in constructing CE as an object of governance. Thus, the continuous redefinition and framing of ‘what is to be governed’ is shaped by authoritative actors who render contested and hitherto largely imagined entities graspable and governable. Demarcation becomes a crucial political move in a highly contested area.

It is important to note that all governance (whether de facto or *de jure*) serves to order a field of inquiry. The difference lies in the fact that de facto ordering of a field is not subject to the political oversight that would (to greater or lesser extent) accompany state-led or private, mandatory or voluntary, attempts to bring order to a previously unordered or nascent field. As such, we argue that politically salient de facto acts of demarcation and their effects require continued attention, including within mainstream CE governance analyses.

This suggests a research agenda to further explore similarities and differences between de facto and *de jure* governance, and how these may influence each other. We need to better understand who is empowered by specific acts of de facto governance, and what the geopolitical implications of such governance might be. Most broadly, our analysis opens up the notion of what constitutes governance in the first place, and draws attention to the need for political oversight of de facto sources of steering in emerging and contested global environmental governance domains.

Notes

1. The most well-known ‘authoritative assessment’ in the global environmental realm, the IPCC, has been extensively analyzed for its role and influence in climate governance and politics from a variety of theoretical perspectives. By bringing a de facto governance lens to assessing the steering capacity and governance effects flowing from authoritative assessments, we complement such existing analyses.

2. For more elaborate discussions of alternative categorizations, see e.g. Boucher *et al.* (2014) and McLaren (2015).
3. The distinction between technologies that affected the CO₂ cycle and those that represented ‘countervailing modifications’ can be found in a number of earlier publications (e.g. MacCracken 1991), although there was no widespread consensus that CE should be categorized in this way.
4. The NAS reports were released in the same year as another major report by the European Transdisciplinary Assessment of Climate Engineering (EuTRACE), (Schäfer *et al.* 2015). The reason we choose to analyze the NAS report (and not EuTRACE) is because the NAS represents an older, more established scientific body, and because it makes explicit recommendations for CE-related investment and political action. The EuTRACE report adopts a more neutral tone in assessing scientific developments, and listing pros, cons and questions for further research. It offers no explicit opinions on where or how the EU should develop CE research.

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Paper III



Institutional complexity and private authority in global climate governance: the cases of climate engineering, REDD+ and short-lived climate pollutants

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ABSTRACT

How and why do institutional architectures, and the roles of private institutions therein, differ across separate areas of climate governance? Here, institutional complexity is explained in terms of the problem-structural characteristics of an issue area and the associated demand for, and supply of, private authority. These characteristics can help explain the degree of centrality of intergovernmental institutions, as well as the distribution of governance functions between these and private governance institutions. This framework is applied to three emerging areas of climate governance: reducing emissions from deforestation and forest degradation (REDD+), short-lived climate pollutants (SLCPs) and climate engineering. Conflicts over means and values, as well as over relatively and absolutely assessed goods, lead to considerable variations in the emergence and roles of private institutions across these three cases.

KEYWORDS Regime complex; institutional complexity; institutional fragmentation; private authority; non-state actors; climate change; climate engineering; geoengineering; REDD+; short-lived climate pollutants

Introduction

In the run-up to the 2015 UN climate summit in Paris, non-state actors helped provide a new impetus to multilateral climate negotiations. After Paris, this functional differentiation and interplay between multilateral diplomacy and transnational climate action keeps evolving. Public, private and hybrid governance arrangements are experiencing further institutionalisation, but with considerable variation among subfields of international climate politics.

Here, we seek to both assess and explain the different shapes of institutional complexity or ‘hybrid multilateralism’ (Bäckstrand and Kuyper 2017) that characterise selected sub-areas of global climate governance. This objective implies two uncommon, but much needed perspectives for the study of institutional

complexity. First, we bridge the divide between studies that mainly examine international regimes and studies focusing on transnational approaches (cf. Betsill *et al.* 2015). Second, we zoom in on global climate governance, addressing the institutional complexity of specific issues *within* this domain.

We understand institutional complexity as a diversity of international institutions that legally or functionally overlap in addressing a given issue area of global governance. They do so while potentially differing ‘in their character (organisations, regimes, and implicit norms), their constituencies (public and private), their spatial scope (from bilateral to global), and their subject matter (from specific policy fields to universal concerns)’ (Biermann *et al.* 2009, p. 16).

We analyse three distinct sub-areas of high policy relevance: reducing emissions from deforestation and forest degradation (REDD+), short-lived climate pollutants (SLCPs) and climate engineering (CE). We selected these cases, because all are dynamic areas of international climate policy that have recently experienced significant institutional development; they are relatively new and still represent major gaps in institutional analysis; they vary significantly in their degree of complexity, in the number of major public institutions involved in their regulation and in the distribution of functions across public, private and hybrid institutions.

For each of these issue areas, we address two questions. First, what is the shape of institutional complexity? Here, we are interested in identifying the functions that private or hybrid arrangements have come to carry out and how these relate to the roles of intergovernmental institutions.

Second, what are the underlying causes of this complexity? Here, we are interested in exploring why we observe a certain type of hybrid multi-lateralism or public–private mix, and why there are variations across areas. We specifically focus on the role of problem structure as an explanatory variable. We build it into a falsifiable research design, acknowledging that there would be other variables (e.g. constellations of power, norms, knowledge) that equally merit examination.

The following section sketches our analytical framework to address both research questions. The subsequent sections provide an explorative application of this framework to the three issue areas. The conclusion delivers crosscutting findings.

Analytical framework

Public and private authority

Following Bäckstrand and Kuyper (2017) in their understanding of ‘non-state’ as the broader class of actors, with ‘private’, we refer to a subgroup thereof: actors and institutions that are not exclusively public. This includes business, civil society, experts or media actors and also extends to hybrid

arrangements set up by both private and public actors.¹ It excludes inter-governmental bureaucracies and organisations, and public actors operating at sub-national levels such as municipalities. This distinction between intergovernmental and private is instrumental for the theoretical approach we develop here. Our framework consists of different, albeit connected, assumptions about the emergence of international public (i.e. intergovernmental) institutions and international private (i.e. transnational) institutions.

Second, we focus on ‘authority’, defined as the institutionalised forms of power exerted by public and private actors in an issue area of global governance (Hall and Biersteker 2002, Büthe 2004). The authority of a public entity refers to a recognised institutional competence to make decisions or interpretations in the name of the collective interest (Raz 2009). For private authority, institutionalisation and legitimacy are equally important (Cutler *et al.* 1999, Hall and Biersteker (2002). It is often much harder, however, to delineate a clear audience or set of principals for private institutions, and to assess the legitimacy-related aspect of private authority. For our explorative case studies, we therefore follow Green’s (2014, p. 6) pragmatic definition that focuses on institutionalisation and ‘restricts private authority to the creation of actual rules, standards, guidelines, or practices that other actors adopt’. We thus use the terms private authority, transnational institutions and private institutions interchangeably, referring to the institutions that private actors establish in a given area of global governance.

Institutional complexity, mixed governance architectures and the role of private institutions

If institutional complexity is a matter of degree (Biermann *et al.* 2009), what are useful criteria for characterising and comparing the respective mix between private and public institutions across issue areas? We distinguish centrality of one or several core public institutions, sources of private authority and the functional division of labour between public and private institutions.

With regard to the *centrality* of public institutions, we differentiate between architectures with one core institution, two or a few identifiable cores and multiple or no cores with no clear hierarchy or division of labour. We build our assessment on taxonomies by Biermann *et al.* (2009) and Keohane and Victor (2011). However, their taxonomies do not address the specific mix of private and public institutions and the respective functions that each ‘camp’ performs for a given architecture of global climate governance. For this, we draw on a second strand of literature.

A first approach to analysing functions of private institutions in global climate governance is to ask *how* private institutions play a role, either duplicating or replacing public institutions for these functions or filling the governance gaps they leave. Building on some of the leading studies on private authority (Cutler *et al.* 1999, Abbott 2012), we distinguish the following *functions*: agenda-setting (with a particular focus on sharing information and networking), policy formulation (setting standards, rules and guidelines), financing, implementation and evaluation. These functions roughly correspond to the policy cycle model (cf. Howlett *et al.* 2009), with the difference that we collapse policy formulation and decision-making, and add financing, which represents a particular channel of influence for private authority.

A different question is *why* they have taken on a governing role. Green (2014, pp. 33–36) distinguishes two *sources* of private authority, delegated and entrepreneurial. Either a private institution has been instructed to create rules, set standards or perform other governance functions on behalf of the governed or a public institution; or a private institution has taken entrepreneurial initiative on its own to set rules or standards. By ‘the governed’, Green refers to ‘those who obey’ authority, meaning here those who adopt the rules of private institutions (Green 2014, p. 29).

This distinction is connected to the centrality of a public institution in the issue area. If there is a dominant intergovernmental institution, or but a few with a clear division of labour, we can expect this core to leave only limited functional space to private institutions and, potentially, to play a role in the assignment of respective functions through delegation. On the other hand, where there is no dominant institution or no clear division of labour, private institutions might have more space to fill governance gaps on their own initiative. Table 1 summarises the criteria through which we will assess the institutional complexity of the three selected governance architectures.

Table 1. Dimensions and values of institutional complexity in mixed architectures.

Dimensions	Values
Centrality of public authority	<ul style="list-style-type: none"> – One core institution – Two or a few identifiable cores (with hierarchy or division of labour) – Multiple cores (without hierarchy or division of labour) – No identifiable core
Sources of private authority	<ul style="list-style-type: none"> – Delegated – Entrepreneurial
Distribution of functions among public and private institutions	<ul style="list-style-type: none"> – Agenda-setting – Policy formulation – Financing – Implementation – Evaluation

The above dimensions cover aspects of institutional complexity that a problem-structural approach may help explain, including the emerging opportunities or functional spaces for private institutions. They do not specify which private institutions will fill these functional gaps. Moreover, our dimensions do not differentiate between the levels at which institutions operate. Finally, we avoided adding a relational dimension that would characterise interactions within and across the public and private institutional camps.

Explaining different degrees of complexity and architecture mixes

We distinguish two types of theory-guided assumptions: those derived from the problem-structural strand of institutionalism, to explain the degree of centrality of public institutions as well as potential sources of private authority; and those derived from private authority theory, to explain the functional mix between public and private institutions.

We chose the first set of theories because the considerable variation of institutional complexity across issue areas suggests that the definition and nature of issue areas may have a causal impact. Rittberger and Zürn (1990) distinguish different types of conflicts among actors according to the object of contention. Conflicts over means and values are both classified as dissensual conflicts, as actors disagree on the collective subject of the conflict. Whereas in conflicts over means, actors share a common goal but disagree on the means to pursue it, conflicts over values are based on 'incompatible principled beliefs regarding the legitimacy of a given action or practice' (Hasenclever *et al.* 1997, p. 63). Conflicts of interest, on the other hand, are consensual, as actors value the same scarce good, but compete for it. If the good in question is assessed absolutely, such as clean air or an intact ozone layer, actors tend to consider only their own shares and gains in these goods: 'how much do I get?' For relatively assessed goods, such as fisheries or plant genetic resources, relative shares and gains matter: 'how much more or less than the others do I get?' Rittberger and Zürn (1990) expect different degrees of regime-conduciveness for each of these four types. They assume that actors will more easily cooperate in conflicts over means and absolutely assessed goods, as these situations imply a less asymmetrical constellation of preferences.

Underdal adds situation-structural elements to this approach. He distinguishes between benign and malign problems, understanding the political malignancy of a problem as 'a function of the configuration of actor interests and preferences that it generates' (Underdal 2002, p. 15), with constellations of preferences corresponding to certain types of contested objects. *Malign problems* are characterised by competition among actors and incompatibility of values. They likely entail manipulation or coercion in the course of negotiations and are marked by persisting incentives for unilateral defection after an agreement is struck. In light of these features,

the notion of malign problems incorporates conflicts over values and conflicts over relatively assessed goods (problem-structural approach) as well as collaboration and suasion situations (situation-structural approach).

Benign problems are characterised mainly by imperfect information, with no incentives for unilateral defection from an agreed solution. By stressing symmetrical interests and values, the benign problem-type covers Rittberger and Zürn's conflicts over means and conflicts over absolutely assessed goods. Furthermore, with their relatively high potential for efficient cooperation, benign problems comprise major elements of the situation-structural types of assurance and coordination situations (Underdal 2002). [Figure 1](#) summarises Underdal's integrated approach.

Based on the theory explained above, we derive a first set of hypotheses on the relation between problem structure and emergence of intergovernmental institutions:

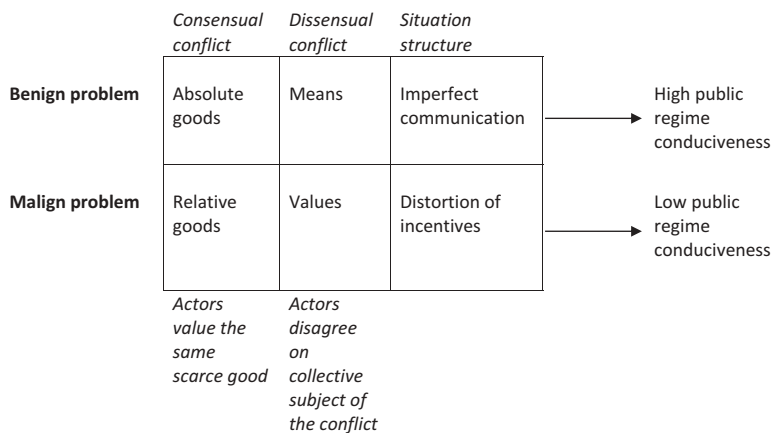


Figure 1. Integration of problem-structural and situation-structural explanations for regime-conduciveness.

H1a. Benign problems tend to feature a centrality of one (near-universal) or a few public institutions, with a legal or functional hierarchy or division of labour among them. This identifiable core takes over the key functions for regulating the issue area. It will leave less functional space for private institutions and rely on delegated authority.

H1b. Malign problems tend to feature no public institutional cores, or multiple ones that likely conflict on major subjects or lack a clear hierarchy or division of labour. The resulting functional governance gaps are (partly) filled

by other types of institutions (smaller public ones, private and hybrid ones) through entrepreneurial authority.

These hypotheses help predict the first dimension of public centrality and also tendencies towards sources of private authority (delegated or entrepreneurial), but they do not give concrete indications about the particular functions that are taken over by private institutions. For this, we refer to the literature on private authority. Green (2014) names both the demand for private authority and the supply of private authority as main explanatory factors for its emergence. Adapting Green's distinctions, we introduce two further sets of hypotheses to explain the functional mix in complex governance architectures.

H2a. Private institutions tend to perform specific functions *when there is a demand of the governed for*

- lowering transaction costs: through agenda-setting (here particularly information-sharing), policy formulation (soft rule/standard-setting) and financing;
- enhancing credibility of commitments: through implementation and evaluation;
- providing first-mover advantage to early adopters on a policy problem: through agenda-setting and policy formulation;
- enhancing reputation: through implementation and evaluation.

H2b. Private institutions tend to perform specific functions *when they supply:*

- expert opinions, practical experience or legal/moral authority: for agenda-setting, policy formulation, implementation and evaluation;
- financial capacities and economic experience: for implementation and financing.

Unlike the first set of assumptions, these hypotheses cover relatively short causal chains, with the dependent variable (distribution of functions among private and public institutions) explained by functional gaps (demand side) and functional qualities (supply side).² What is more, demand and supply can be (partly) seen as functions of the nature of the problem to be regulated. Green (2014, p. 47) makes clear that private institutions will only be chosen 'when [international organisations] cannot supply the equivalent benefits' – in other words, when significant public governance gaps exist. Green and Auld (2016) further argue that different game-theoretic situations may call for different types of private rule-setting. Thus, the factors of demand and

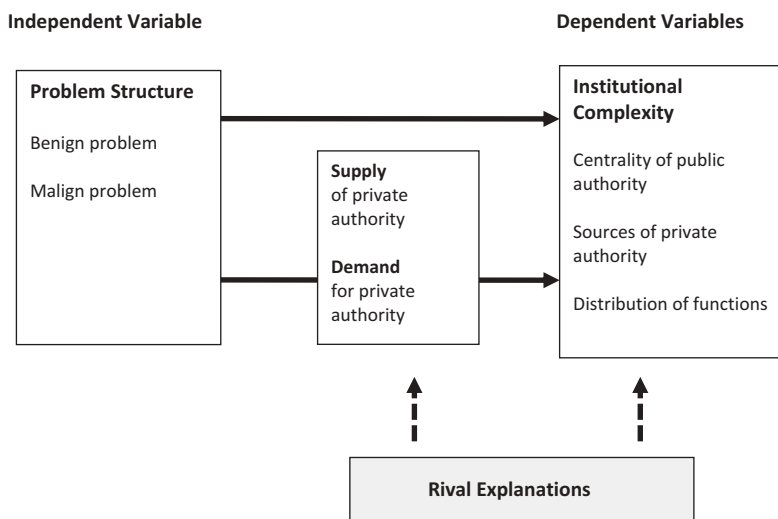


Figure 2. Overview of the analytical framework.

supply rather play the role of intervening variables in our framework (Figure 2).

Finally, there are rival factors that may influence the shape of an institutional architecture and the roles of private authority therein. Jordan *et al.* (2015, p. 979) summarise some of these factors: ‘moral concerns, fear of new regulation (or the opportunity to secure first-mover advantages by shaping it), the pursuit of direct financial rewards, indirect or “non-climate” benefits (for example, reputational enhancement), and the satisfaction of consumer expectations’. Beyond these, the constellations of norms, knowledge or different forms of power may enable specific types of private actors more than others to build and entertain effective institutions. Our falsifiable, parsimonious approach hence comes at a price, since it cannot explain the dominance of specific actors, nor particular relations between public and private institutions.

To probe this framework, the following sections present an explorative qualitative analysis for each of three cases.

REDD+ governance

An incentive mechanism to avoid emissions from deforestation

REDD+ seeks to create financial value for carbon stored in forests. Proponents of REDD+ intend to provide economic incentives for the sustainable use and conservation of forests while also reducing the drivers of

deforestation and forest degradation. However, opponents have expressed scepticism about putting a price on nature through economic incentives (Corbera and Schroeder 2011) and cautioned against negative impacts on indigenous and local communities as well as biodiversity (Peskett and Todd 2013).

These concerns entailed debates on social and environmental safeguards that should be provided by public and private actors. In addition, several other key aspects of REDD+ need further specification, for instance, conditions for the allocation of funds and approaches to measurement, reporting and verification (MRV).

Institutional complexity in REDD+: which role for private authority?

The global REDD+ architecture is fragmented, with a diverse mix of global public institutions, bilateral arrangements and non-governmental approaches (Gupta *et al.* 2016). This patchwork notwithstanding, a relatively high degree of public institutional centrality can be identified, with the United Nations Framework Convention on Climate Change (UNFCCC) at the core.

Negotiations under the UNFCCC represent the decision-making hub. At the 2005 Conference of the Parties (COP), REDD+ was proposed by an alliance of rainforest nations. In 2008, the definition of REDD+ was expanded to account for non-carbon benefits of forests and sustainable forest management. At COP 16 in Cancún in 2010, parties adopted a list of social and environmental safeguards to be respected when implementing REDD+ activities. COP 19 (2013) agreed on the Warsaw Framework for REDD+. To be eligible for performance-based financing, governments must in every 2 years provide a summary of how they are complying with REDD+ safeguards. The Paris Agreement did not add substantially to this framework and confirmed the non-binding character of REDD+.

In addition to, but closely related to, UNFCCC negotiations, three multilateral financing institutions are central in the REDD+ governance architecture: the Forest Carbon Partnership Facility, a World Bank programme launched in 2007; the Forest Investment Programme, a multi-trust fund under the World Bank's Strategic Climate Fund created by several regional developing banks and several bilateral donors; and UN-REDD (UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation), launched in 2008 by the Food and Agricultural Organization, the UN Environment Programme and the UN Development Programme.

All three institutions assist developing countries in their preparation and implementation of REDD+ projects, support respective capacity-building and, ultimately, provide payments for verified emissions reductions. With nearly US\$ 2 billion as of October 2016,³ the three funds provide the bulk of currently pledged REDD+ financing. Moreover, they exert key policy

formulation and implementation functions. The UNFCCC might be nominally tasked with providing overarching guidance, but, in practice, funds have fewer problems defining enforceable safeguards since they can make financing contingent on them (McDermott *et al.* 2012).

Next to these four central bodies, several other public initiatives contribute to REDD+ financing, including multilateral mechanisms (Global Environment Facility) and regional banks that administer their own funding mechanisms (the Amazon Fund and the Congo Basin Forest Fund). Norway, Germany and Japan are major donors of bilateral funding. Nearly all these institutions provide suggestions or even regulations on particular sub-issues, such as allocation criteria for funds, social and environmental safeguards, and MRV.

Against the backdrop of this strong public institutional involvement on REDD+ policy formulation and financing, private institutions perform largely agenda-setting functions (mostly information-sharing), implementation and evaluation services. Key actors are domestic or foreign companies and conservationist NGOs that serve as project developers and lobby or advise public forest authorities. The impact of vulnerable groups such as indigenous communities or smallholder associations, by contrast, is generally much lower.

One outcome of the engagement of NGOs and companies is the growing number of private REDD+ environmental and social safeguard certification schemes (Gupta *et al.* 2016). The specific mix of actors and the relevance of their schemes vary from country to country, as do the sources of their authority. While private institutions often proactively occupy and shape the functional spaces they find for project development, many collaborate with funding institutions, thus representing delegated rather than entrepreneurial forms of private authority.

This is not to say that policy formulation, especially the setting of soft standards on safeguards, and financing through private authority, do not play a role at all. Voluntary carbon markets, for instance, may provide funding for REDD+ pilot projects (Hamilton *et al.* 2010). Here, a whole array of private actors is involved, starting with project developers (NGOs or companies), that hire private auditors to verify their emission reductions, which are then registered as carbon offsets and traded by private brokers or re-sellers. While only a fraction of the sums raised by such markets is associated with REDD+ projects and the future weight of REDD+ financing is hard to predict, other market-based approaches, and linking of domestic and subnational markets, may increase these figures in future.

Explaining institutional complexity

Why does the governance architecture on REDD+ exhibit the observed degree of complexity – with not just the UNFCCC as a single core, but several public financing institutions with considerable functional leeway, while private

authority engagement largely happens in implementation and evaluation? This institutional setting covers some middle ground between the expectations for benign and malign problem structures. One answer is that REDD+ has eventually changed from a conflict over values to one over means. Early REDD+ debates concerned the compatibility of climate goals and market mechanisms. This debate reflected an overarching value conflict in global forest governance: there is no consensus about the core forest values and services that should be promoted, with key fault lines between social and cultural dimensions (livelihoods, spiritual values, recreation), economic dimensions (wood, non-wood products) and ecological dimensions (biodiversity conservation). REDD+ added the dimension of forests as carbon sinks. This constellation of multiple values may explain why, notwithstanding several high-profile deliberations, no agreement could be reached on establishing a central global forest institution (Dimitrov *et al.* 2007).

In REDD+ governance, the value conflict between carbon and non-carbon dimensions eventually turned into a conflict over means when the importance of social and environmental co-benefits became widely recognised. The debate on safeguards today is one about the scope and intensity of this recognition. Many stakeholder groups moved away from outright rejection towards active participation in implementation; indigenous associations such as the Coordinator of Indigenous Organizations of the Amazon Basin now seek to implement an indigenous version of REDD+ (Zelli *et al.* 2014).

This said, REDD+ is not a clear-cut benign problem. It also implies conflict over relative goods: the generation and distribution of considerable financial volumes. In this competitive setting, donor countries tend to avoid the one-country-one-vote structure under the UNFCCC and rather choose arenas that grant them more leeway over the allocation of their donations. The emergence of major bilateral or World Bank-related funds can be seen as a consequence of this relative goods conflict.

Regarding demand for, and supply of, private authority, the considerable volume of public funding has so far dampened requirements for financing from other sources. Instead, there is clear demand for private support in implementation and evaluation activities. At the early stages of REDD+, domestic and local authorities in developing countries had no or limited knowledge and capacities for establishing and administering payment schemes and projects. At the same time, the UNFCCC and most of the major funding institutions lacked on-the-ground capacities. This gap and the associated need for lowering transaction costs have been quickly addressed by experienced conservation NGOs and private investors. Providing a first-mover advantage, they collaborated with local stakeholders to develop REDD+ pilot projects. Similarly, the Climate, Community and Biodiversity Alliance and other NGO alliances use their expertise to design and assess standards to fill implementation and evaluation gaps on social and environmental safeguards (Zelli *et al.* 2014).

SLCP governance

SLCPs as a complementary mitigation strategy

SLCPs, which include black carbon, methane, tropospheric ozone and hydro-fluorocarbons (HFCs), have relatively short lifespans but high global warming potential. Measures to address SLCPs can help slow climate change, if combined with aggressive CO₂ emission reductions (Ramanathan and Xu 2010).

SLCPs vary. Black carbon (soot) only stays in the atmosphere a few days but is an important driver of global warming: it absorbs sunlight and generates heat, reduces the ability of snow and ice to reflect sunlight and affects cloud formation. Reducing black carbon emissions is expected to bring near-term climate benefits (Shindell *et al.* 2012), deliver significant health benefits (by reducing exposure to local air pollutants) and improve food security (by reducing crop yield losses) (UNEP & WMO 2011).

Methane is a greenhouse gas 34 times more potent than CO₂, with an atmospheric lifetime of 9.1 years (Myhre *et al.* 2013). Methane emissions are also responsible for another SLCP, tropospheric ozone. Measures to reduce methane emissions are estimated to avoid warming of 0.28°C by 2050 (Shindell *et al.* 2012). Longer term methane mitigation is considered essential for staying below 2°C (Rogelj *et al.* 2014).

HFCs are chemicals whose global warming potential outstrips that of CO₂ significantly, sometimes by a factor of thousands. While used in only a limited set of products, their use is increasing, mainly as a result of phasing out ozone-depleting substances. HFCs could contribute to annual greenhouse gas emissions of between 3.5 and 8.8 Gt CO₂ equivalent (UNEP 2011).

Institutional complexity in SLCPs: which role for private authority?

Several global public institutions are concerned with the governance of SLCPs, albeit without a clearly identifiable core institution. Depending on the specific SLCP, different institutions come into play.

Black carbon is addressed in the context of the Convention on Long-Range Transboundary Air Pollution (LRTAP) and the International Maritime Organization (IMO). In 2012, the Gothenburg Protocol to the LRTAP Convention, whose parties include the European Union and the United States, was amended to encourage voluntary black carbon emission reductions. To facilitate this, the LRTAP regime issued guidance to assist parties to identify control techniques for, and report on, black carbon emissions. As several parties have submitted voluntary emissions inventories, the regime helps to improve transparency. Since international shipping is a source of black carbon, it also falls within the IMO's remit. In 2010, Norway, Sweden and the United States proposed to discuss black carbon emission reductions from shipping in the Arctic, focusing on the

definition of black carbon, measurement methods and possible control measures, but discussions have not yet moved beyond agreement on a definition.

Methane is a greenhouse gas covered by the UNFCCC, and parties can achieve their climate targets by reducing methane emissions. In addition, methane emissions are regularly reported by UNFCCC parties through greenhouse gas inventories. Methane and other SLCPs are increasingly discussed in the context of the UNFCCC, including through the incorporation of SLCPs in some parties' intended nationally determined contributions submitted ahead of the Paris Agreement.⁴

HFCs, whose use was initially promoted under the Montreal Protocol on ozone-depleting substances, will be phased down under the same treaty following the adoption of the Kigali amendment in October 2016. For developing countries, the Protocol's Multilateral Fund can help finance the transition towards climate-friendly alternatives to HFCs.

SLCPs are also addressed by several hybrid governance institutions involving governmental and non-governmental actors. The Climate and Clean Air Coalition (CCAC) was created in 2012 to raise awareness, enhance and develop actions at various levels, promote best practice, improve scientific understanding on SLCPs and mobilise resources. Although the CCAC is government driven, private actors, including business, civil society and research organisations, play an important part by implementing projects, financing activities and providing scientific advice (CCAC 2014). Supported by a Scientific Advisory Panel, the coalition has launched several projects involving the private sector as an implementing partner, such as the Oil & Gas Methane Partnership⁵ and the Global Green Freight Project.⁶

Another hybrid institution, the Global Methane Initiative, is, like the CCAC, country driven, although it also involves the private sector and NGOs in implementation. The Arctic Council, a high-level forum bringing together eight Arctic states and six indigenous peoples' organisations, is another hybrid institution addressing SLCPs. Drawing on scientific assessments by its Arctic Monitoring and Assessment Programme and efforts by its Task Force for Action on Black Carbon and Methane, the Council agreed a voluntary framework for action on SLCPs in 2015 (Arctic Council 2015).

In addition to these government-driven institutions, there are examples of private sector-driven initiatives, such as 'Refrigerants, Naturally!', a collaboration between companies in the food and drinks sectors (including Coca Cola and Unilever), UNEP and Greenpeace, through which companies commit to reduce HFC consumption,⁷ creating a market for climate-friendly substitutes for HFCs.

Several public institutions thus play an increasingly important role in governing SLCPs, including policy formulation, aimed at enhancing transparency about SLCPs, but also leading to commitments (e.g. the Kigali amendment). These institutions are also instrumental in financing SLCP reductions (e.g. through the Montreal Protocol's Multilateral Fund or the UNFCCC's Green Climate Fund). As with REDD+, the role of private institutions is mainly confined to agenda-setting, by providing scientific advice and implementation. Multi-stakeholder partnerships such as the CCAC and the Global Methane Initiative play a key role in the implementation of various activities – from sharing practical experiences to development of climate-friendly products.

Explaining institutional complexity

SLCPs exhibit a consensual problem structure dealing with absolutely assessed goods (notably clean air). If there is a conflict, it is mainly over means: what kind of measures should be implemented, when should they be implemented, and who will pay? The measures themselves are rather clear. For instance: to mitigate black carbon, traditional cookstoves could be replaced by modern ones; for HFCs, substitutes with limited or no global warming potential are available; for methane, measures could minimise leakage from pipelines (UNEP & WMO 2011). This availability of options to abate SLCPs, combined with co-benefits, has arguably made SLCPs 'the climate threat we can beat' (Victor *et al.* 2012). The problem can thus be characterised as benign.

But why do we see *multiple* institutions? One possible explanation is that while SLCPs are often discussed as a group of substances that are short lived but nonetheless have a climate impact, they are also very different. For instance, the problem structure of HFCs is different from that of black carbon. Abatement of the latter is often in a country's own interest, as it will also help reduce local air pollution and promote public health. Phasing out HFCs, by contrast, does not yield such co-benefits. Moreover, as HFC emissions are primarily expected to increase in the global South, the problem of HFCs becomes more dissensual. This was clear in Kigali amendment negotiations, with India and Saudi Arabia insisting on financial and technological support from the North.

Concerning the role of private authority in SLCP governance, it is notable that the main hybrid governance institutions – the CCAC and the Global Methane Initiative – still have governments in the driver's seat. Nonetheless, the role of private actors in these institutions, in agenda-setting and implementation, is important. Arguably, these activities are carried out because they help lower transaction costs, complementing the

efforts by public governance institutions, which are still in the process of gathering information and formulating policies. Activities under the CCAC and the Global Methane Initiative, as well as private initiatives such as 'Refrigerants, Naturally!', can be considered as important first-mover actions on SLCPs, important if the near-term climate benefits of SLCP mitigation are to be achieved. At the same time, the role of private authority can be explained by the fact that they have something unique to offer: whether scientific advice (CCAC's Scientific Advisory Panel), economic power (companies involved in 'Refrigerants, Naturally!') or practical experience (NGOs involved in the CCAC).

Climate Engineering Governance

Technologies to engineer the climate

CE entails intentionally altering the Earth's atmosphere with the aim of reducing climate impacts. CE is often subdivided into solar radiation management (SRM) and carbon dioxide removal (CDR) (National Academy of Sciences 2015). However, technologies within each group are very different. For example, land-based CDR techniques such as afforestation and bioenergy with carbon capture and storage (BECCS) face other governance challenges than marine-based techniques such as ocean fertilisation.

For our purpose, we scrutinise the problem as identified by key communities, which leads to a duality. On the one hand, CE is an amalgam of large-impact technologies that are difficult to compare with one another. On the other hand, the dominant discourse continues to group these technologies into the subcategories of CDR and SRM. Analysing this discourse, we address the problem-structural connotation associated with each subcategory and the implications for the respective formation of governance institutions for both CDR and SRM.

CE has experienced dramatic changes within only a few years. Initially a marginal idea in climate science, the term 'geoengineering' arose in the 1990s. It described a diverse set of ideas to intentionally combat impacts of rising greenhouse gas concentrations and was considered 'unmentionable' and deeply disturbing (Schelling 1996). The breakthrough for geoengineering is often associated with a publication by Nobel Prize winner Paul Crutzen (2006), who advocated research on stratospheric aerosol injection. Subsequently, several popular science books brought the idea to a broader audience, whence national governments started showing interest and commissioned scientific inquiries. From that period onwards, scientific publications on geoengineering increased exponentially, in the wake of which

geoengineering was renamed ‘climate engineering’ and was further divided into subcategories (Oldham *et al.* 2014).

The widely cited differentiation between CDR and SRM suggested by the UK Royal Society (Shepherd *et al.* 2009) created a split in the pathways of the two technology groups. Consequently, CDR is now often called negative emissions technologies (NET) and widely described as a necessary strategy for addressing climate change. In recent years, the connotation shifted from controversial marine-based techniques to large-scale afforestation and BECCS, which are now included in the Intergovernmental Panel on Climate Change (IPCC) scenarios of the Intergovernmental Panel on Climate Change (IPCC) and considered a central component of climate policy (Fuss *et al.* 2014). Meanwhile, SRM, including equally different types of techniques, continues to be seen as less desirable and more problematic, although acceptance here is also rising gradually (Burns and Nicholson 2016). Some argue that the Paris Agreement has contributed to justifying CE techniques to achieve the treaty’s 1.5°C goal (Horton *et al.* 2016).

Institutional complexity in CE: which role for private authority?

Unlike for REDD+ and SLCs, international public governance of CE is considered more absent than present. There are currently three international institutions with direct relevance to CDR: the Convention on Biological Diversity (CBD), the London Convention and London Protocol on the Prevention of Marine Pollution (LC/LP) and the UNFCCC (Schäfer *et al.* 2015).

As the CBD encourages its own members to adhere to the LC/LP’s strict regulations on ocean iron fertilisation and suboceanic CO₂ storage (CBD 2012), these two institutions can be regarded as cooperative and coupled on the issue. By contrast, although mentioned by the CBD as potentially relevant for regulation, the UNFCCC only implicitly addresses CE. Nonetheless, as the IPCC relies on NET for its emissions pathways, and the Paris Agreement now includes carbon removal as a form of mitigation, it seems that the UNFCCC plays a key role in justifying development and use of land-based CDR. Together, the three public institutions provide some degree of agenda-setting and policy formulation for CDR technologies.

Private authority, apart from agenda-setting for the recognition of CDR by the epistemic community, is increasingly visible in technology development, financing and implementation. Examples are public–private venture companies such as Carbon Engineering (connected to the University of Calgary) or Skytree (a spinoff company of the European Space Agency) that develop direct air capture technologies, and several philanthropic foundations supporting them. Private for-profit companies are becoming

increasingly involved with BECCS and biochar, with the first industrial-scale BECCS plant having been set up in Decatur, Illinois in a public-private partnership between the US Department of Energy and the agribusiness Archer Daniels Midland (Yeo and Pearce 2016).

The Paris Agreement, with its acknowledgement of carbon removal, has provided a formalised legitimacy that could characterise these activities as examples of delegated authority. However, the fact that many such initiatives started before Paris shows that the lines between public and private authority, as well as between entrepreneurial and delegated, may not be as clear-cut as our framework suggests. Entrepreneurial authority may change into delegated authority if a public institution starts regulating a given policy issue.

While the institutional landscape for CDR can be tentatively described as an emerging regime with two cores (land-based and ocean-based CDR techniques, respectively) and an increasing number of private actors involved in implementation, the landscape for SRM displays no identifiable public regulation or pronounced engagement of private actors beyond the epistemic community. Although knowledge about the opportunities and dangers of SRM is relatively established, no international public institution has started regulating it. Explicit public interest in, and reference to, these technologies exist only at national and subnational levels in the United States, United Kingdom, Germany, Russia and China, but without legal regulation (Huttunen *et al.* 2015).

In the absence of public governance, some private actors within academia have spurred institutionalisation, making suggestions on how to govern research, in the hope that their efforts will be adopted by public actors. NGOs linked to academia, such as the Solar Radiation Management Governance Initiative and the Forum for Climate Engineering Assessment, seek to increase transparency, inclusiveness and public participation in discussion on SRM. Simultaneously, several research institutes working on CE have proposed frameworks for self-regulation, including the Oxford principles (Rayner *et al.* 2013) and a 'Draft Code of Conduct' on responsible CE research (Hubert and Reichwein 2015). While NGOs focus explicitly on networking and information-sharing, and thereby agenda-setting, the self-regulation frameworks suggest policy formulation. Private authority here exists mainly in the form of scientific authority, with some more prominent members of the epistemic community informing government positions on SRM. As they lack political experience or legal/moral authority, resulting initiatives focus mainly on knowledge-brokering or suggestions for self-regulation that are not (yet) endorsed by a wider community.

Explaining institutional complexity

Why is the governance structure for CE in general so underdeveloped? One explanation lies in the problem structures around CE. Until recently, CE

was characterised by an ideological battle between belief in social change and belief in technological power. Core debates circled around: the hubristic nature of CE versus the urgency for climate action, a ‘slippery slope’ towards deployment versus the control of an already opened Pandora’s box and concern for moral hazard (threatening efforts to decarbonise society) versus embracing of climate change as a pollution control issue (Anshelm and Hansson 2014).

In recent years, the exclusive conflict over values shifted increasingly towards a conflict over means. Catalysed by slow progress on emissions reductions, continuous investment in fossil fuels and the normalisation of CE research, the core question is no longer *whether* research should be done but rather *how* research should be regulated and *which kind* of research should be funded. This development has facilitated some governance activity by public actors, including the elementary regulations on CDR described above. But while CDR is now at least recognised and addressed by public institutional cores that regulate and/or encourage research and development of carbon removal technologies, SRM still remains conspicuously absent from international governance realms.

Meanwhile, the composition and functional distribution of private actors and their institutionalisation attempts differ in each area. Many private actors in CDR exist at the nexus of research and business and are mainly involved in technology financing and implementation. Private actors in SRM are only visible within the epistemic community, advocating research, suggesting governance options, creating space for public deliberation and providing advice to governments. It seems that in the absence of public regulation, not even university-based research (beyond modelling) is possible, and the general lack of public authority is requiring private actors to engage with questions of governance before any further advances can be made.

Why are the institutional landscapes for CDR and SRM so different? With the increasing emphasis on separating CDR from SRM, the two groups of technologies have experienced changes in perceived problem structures independently from one another. Whereas SRM still exhibits a significant conflict over values, CDR has evolved towards a conflict mainly over means. The general perception of CDR⁸ is shifting from a malign to an increasingly benign problem structure, while SRM remains characterised as largely malign. The assessment of the US National Academy of Sciences is illustrative:

Carbon dioxide removal (CDR) approaches generally share some characteristics with respect to how they are perceived by society. Some methods, such as direct air capture and sequestration (DACS) and reforestation, result in far less of a perturbation to the Earth system than that associated with albedo modification (...). Deployment of such methods is more likely to be viewed as an “undoing” of what has been done and, thus, may be perceived as more benign. (National Academy of Sciences 2015, p. 97)

Discussion and conclusions

We started from the assumption that the understanding and delineation of a given global governance issue is connected to the roles of intergovernmental and private institutions, leading us to approach the phenomenon of institutional complexity in two novel ways. Empirically, we focused on three subfields of climate governance. We showed that these subfields differ in their institutional complexity from global climate governance as a whole. The latter exhibits an identifiable institutional core in the UNFCCC, while this centrality is considerably qualified, albeit in different ways, for the global governance architectures for REDD+, SLCPs and CE. The three subfields also vary considerably concerning key sources of private authority and predominant functions taken over by public and private institutions.

Theoretically, we sought to break new ground by bridging problem-structural approaches of institutionalism and private authority theory. Our main expectation was that 'benign' problems are more likely to be regulated through central public institutions, with one or few cores and relatively clear hierarchy among them, while private institutions will largely exert authority on behalf of public ones ('delegated authority'). 'Malign' problems are less likely to be addressed by public institutions. We expected them to exhibit either no intergovernmental core or multiple cores that likely conflict on major subjects and/or lack a clear legal or functional hierarchy. Most institutional activities of private actors in such settings will rely on 'entrepreneurial' authority.

While we only provided an explorative application of our framework, the overview of dependent, independent and intervening variables in [Table 2](#) supports some of our assumptions. The benign (CDR) and malign cases (SRM) exhibit the expected shapes of public cores (i.e. two complementary ones and none, respectively), while the ambiguity of REDD+ and SLCPs is reflected in intergovernmental diversity at the centre. These different public constellations, in turn, open up different spaces for private authority.

The increasingly benign case of REDD+ features one core public institutional complex where the leadership of the UNFCCC is challenged by the functional impact of multilateral funding institutions. Private institutions are taking on functions qualified by delegated authority, mainly in implementation and evaluation.

In CE, private institutions take different roles for CDR and SRM. Private actor networks are engaging in financing and implementation of land-based CDR, relying on public authority for legitimacy. Meanwhile, the complete lack of public authority in SRM inhibits any private action beyond agenda-setting and policy formulation.

On the other hand, the 'benign' case of SLCPs exhibits multiple institutional cores, while still showing delegated authority amongst private



Table 2. Institutional complexity and problem structure across cases.

	CE				SRM
	REDD+	SLCPs	CDR		
<i>Centrality of public authority</i>	One core, flanked and partly challenged by further central institutions	Several cores with division of labour	Two cores with division of labour	No core	
<i>Predominant source of private authority</i>	Delegated	Delegated	Entrepreneurial, moving towards delegated (?)	Entrepreneurial	
<i>Predominant functions of public and private institutions</i>	<i>Public</i> – Policy formulation – Financing	<i>Public</i> – Policy formulation – Financing	<i>Public</i> – Agenda-setting – Policy formulation – Financing	<i>Public</i> – None	
	<i>Private</i> – Implementation – Evaluation – Agenda-setting	<i>Private</i> – Implementation – Agenda-setting	<i>Private</i> – Implementation – Financing	<i>Private</i> – Policy formulation – Agenda-setting	
<i>Problem structure</i>	<i>Benign</i> – Shifting from values to means	<i>Benign</i> – Absolutely assessed good; means (e.g. black carbon)	<i>Benign</i> – Shifting from values to means – Absolutely assessed good		
	<i>Malign</i> – Relatively assessed good	<i>Malign</i> – Relatively assessed good (e.g. HFCs)		<i>Malign</i> – Values – Relatively assessed good	
<i>Demand for/supply of private authority</i>	<i>Demand</i> – Providing first mover advantage – Lowering transaction costs	<i>Demand</i> – Providing first mover advantage – Lowering transaction costs	<i>Demand</i>	<i>Demand</i> – Enhancing credibility – Enhancing reputation	
	<i>Supply</i> – Expert opinions – Political experience	<i>Supply</i> – Expert opinions – Finance	<i>Supply</i> – Expert opinions, practical experience – Finance	<i>Supply</i> – Expert opinions	

institutions, perhaps because of the framing of the policy area. SLCPs represent a synthetic group of non-carbon climate pollutants that exhibit different qualities and problems. Similar issues arise with CE technologies. A breakdown according to single pollutants and technologies may yield additional corroboration for our framework. This is not a limitation but rather a confirmation for the need to zoom in on sub-issues to better understand underlying mechanisms of institutional complexity – as, following dominant perceptions, we have done for the CE case.

The case studies show that problem structure is not static, but subject to changes in framing and public perception. Problems initially perceived as malign have experienced changes in discourse, association and framing, making them more accessible to public authority and governance. This said, in our analyses we only addressed the changing nature of core conflicts but could not detail the associated situation structures or constellations of preferences. A more thorough application to a larger sample of cases is needed to probe the plausibility of this framework. Here, the interests of both public and private actors could provide additional explanations for the institutional and functional constellations we observed. Moreover, the analysis of problem structures should ideally rely on conflict perceptions of key stakeholders and not only on deductive assessments.

The preliminary nature of our analysis notwithstanding, it shows the importance of explaining institutional complexity and the roles of public and private authority in complex settings. Deeper causal insights can help us make more informed decisions about whether and how such complexities need to be addressed. While there is a rich theoretical basis that can be drawn upon to close this research gap, problem-structural approaches suggest that there may be no right or wrong degree of complexity, but rather different institutional fits – and respective roles of private authority – for different governance problems.

Notes

1. While we use ‘private’ as a generic term that also includes such arrangements, we will explicitly refer to the hybrid nature of specific institutions.
2. Demand may be directly voiced by certain groups of the governed or be identified indirectly, for example, via high transaction costs or lacking legitimacy. But this is different from ascertaining the very delegation of authority to private actors and their institutions. There may be potential for such delegation, but it does not need to be exploited (Tosun et al. 2016, p.5).
3. <http://www.climatefundsupdate.org/data> (Accessed 9 April 2017).
4. See http://www.ccacoalition.org/sites/default/files/resources/SAP-MAR2016-04_CurrentStatusofSLCPsintheINDCs.pdf (Accessed 9 April 2017).
5. <http://www.ccacoalition.org/en/content/ccac-oil-gas-methane-partnership>
6. <http://www.globalgreenfreight.org/>

7. <http://www.refrigerantsnaturally.com/>
8. A possible exception is the still very controversial case of marine-based CDR, although international regulation does allow scientifically informed outdoor experimentation (Dixon et al. 2014).

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Paper IV



Political Perspectives on Geoengineering: Navigating Problem Definition and Institutional Fit

Ina Möller
Under review

Abstract

As the visibility and saliency of geoengineering grows, scientists and NGOs see a need for political decision making about how to proceed in terms of research, development and international regulation. This study examines how calls for geoengineering governance are reaching the realms of political decision making. It argues that in the deliberation of this problem, policy makers must take into account the institutional context in which they operate. Drawing insights from policy documents, conference observations and interviews with government practitioners, this study analyses the geoengineering problem definitions that policy makers are confronted with, and the institutional context they take into account when contemplating governance options. In combining the two, the study identifies three areas where 'institutional fit' is lacking. These include a mismatch between the silo-division of geoengineering technologies and the multi-level structure of international legal architecture; concerns regarding reputation, trust and the position of major powers; and the dissonance of large-scale, transboundary interventions with the precautionary norms of environmental governance. Based on these insights, the article argues that in order to govern novel technologies like those subsumed under geoengineering, decision makers need problem definitions that connect with existing normative and institutional structures.

Introduction

In recent years, the increasing visibility and presence of geoengineering technologies in global climate science has evoked concerns that un-governed research or deployment will result in serious negative ecological and social side-effects (Wetter & Zundel 2017, Adelman 2017). The

reaction comes from a prominent scientific discussion in which atmospheric particles to reflect sunlight, machines to filter carbon dioxide from the air or bioenergy with carbon capture and storage are suggested as approaches to meet the 1.5 degree target. At the same time, there are still few incentives for any of these technologies to be developed and deployed within the time-frame that advocates are suggesting will be needed (McNutt et al. 2015, Nemet et al. 2018). Because of these concerns, calls for governance of climate geoengineering – be it in the form of strict research regulation or in the form of incentives to accelerate development and adoption – have become increasingly audible in the realm of climate change policy-making.

To date, much of the geoengineering literature has advocated for creating governance mechanisms based on problem definitions put forward by the research community itself. These include a consensus to differentiate between technologies according to their radiative forcing effect (i.e. to distinguish carbon dioxide removal from solar radiation management), an expression of urgency in the need for establishing governance, and a need for research despite potential risks, based on the risk of climate change itself (e.g. Pasztor 2017, Chhetri et al. 2018).

Yet, little is known about how these problem definitions resonate with the decision-making context of policy makers. In fact, little overall is known about the perspectives of policy makers on this topic. Those who have made progress here include Huttunen et al. (2014), who used policy documents to provide a first insight to frames and perceptions of geoengineering in policy-making contexts, and Himmelsbach (2018), who interviewed scientific advisers of the European Union. Building on their work, I expand and update our understanding of policy makers perspectives by conducting a deliberative policy analysis of the geoengineering governance problem.

In this study, I examine the deliberative process by which policy makers confront the problem of geoengineering governance. As an interpretative framework, I use the concepts ‘problem definition’ and ‘institutional fit’.¹ As Rochefort & Cobb (1994) explain in their theory of the policy process, policy makers first make sense of novel or ambiguous

¹The contextualist definition of institutional fit that I use here differs from the problem structural definition put forth by Oran Young (2002), who uses the term to emphasise that institutional arrangements should match ‘the defining features of the problems that they address’ [p.20].

issues by defining the problem. This part of the process is influenced by agenda-setting actors who vie for influence amongst decision makers.

What the problem is defined as consequently influences the types of institutions that are designed to regulate it. Problem definition, however, does not take place in a vacuum. March & Olsen (2011) explain that decision makers need to account for the institutional and normative structures in which they work. Navigating these structures means that decision makers cannot merely pick-and-choose the problem definition that suits their interests. Instead, norms, institutions and expectations determine which problem definitions work and which ones fail.

The negotiation of problem definition in relation to institutional fit captures a deliberative process in which policy makers decide what geoengineering should be understood as, and how it can be governed given existing structures. My hypothesis is that the problem definitions delivered by geoengineering governance advocates (mostly academic actors or NGOs) are not enough to determine what the problem is and to consequently govern it. Instead, policy makers need to judge and contextualise the sometimes contradictory discourses presented to them by governance advocates. They need to evaluate the various problem definitions of geoengineering with respect to diplomatic relations, national reputation, the expectations of peers and constituencies, and the normative surroundings in which they work.

Structures like these are not usually taken into account by geoengineering governance assessments, where widespread scientific problem definitions are used as a starting point. Although the need for research and the urgency of governance are widely published about, political progress on these fronts is still minimal. Identifying dissonances between what is generally considered to be the problem and what is a politically workable problem definition may help in understanding why the conversation is still treading water.

My analysis is based on the study of policy documents, observations made at scientific and political conferences, and interviews conducted with government officials from seven different countries. Based on recurring dissonances across the data-sources, I present three areas where a mismatch between scientific problem definition and the institutional context pose challenges for the initiation of *de jure*, i.e. formal and

intentional, geoengineering governance.²

I find that the wide-spread demarcation of geoengineering into carbon dioxide removal (CDR) and solar radiation management (SRM) presents a problem when deliberating regulatory options.³ The existing legal architecture for environmental regulation uses categories like jurisdiction and transboundary effect, making it difficult to allocate CDR or SRM to existing legislative structures. It also seems like the urgency expressed by governance advocates regarding stratospheric aerosol injection (SAI), in particular, presents serious challenges in terms of scientific and political uncertainty.⁴ Here, the deliberation resembles a chicken-and-egg problem in which decision makers hesitate to propose governance without having more knowledge, while advocates argue that governance is needed before more knowledge is formed. More importantly, decision makers are unsure about the expectations and positions of other countries, resulting in hesitancy to be the first to bring up the subject. Finally, the risk-risk definition of geoengineering vs. rampant climate change conflicts with the precautionary norms that characterise global environmental governance. To address geoengineering technologies, policy makers need to ensure that risk is minimised and precaution is emphasised, requiring a different kind of argumentation than often provided by the academic literature.

Problem Definition and Institutional Fit

Problem definition and institutional fit are concepts that I use to summarise key processes in the deliberative process of policy-making. The concept ‘problem definition’, discussed by Rochefort & Cobb (1994), describes any kind of problem understanding that informs the shape and content of a policy or institutional set-up. Their theory proposes that the shape of a policy depends on the manner in which a problem

²I use the term *de jure* governance to distinguish from the informal and unrecognised types of *de facto* governance mechanisms that are also at play (Gupta & Möller 2019).

³These two categories are commonly used to differentiate technologies according to whether they cool the earth by absorbing carbon dioxide or by reflecting incoming sunlight.

⁴SAI is a technology proposed to cool the planet by injecting particulate matter into the atmosphere, imitating the effect of volcanic eruptions (Crutzen 2006).

is defined. Actors who attempt to steer the course of a political development use problem definitions as a way to further their interests and strengthen their position. In this way, problem definitions can be used strategically to gain political ground.

Analysing the use and development of problem definitions, also called ‘frames’, can therefore be a good way to understand why some policy debates are so contentious. Schön & Rein (1994), the founding fathers of framing theory, explain that policy relevant actors may use different frames to understand an issue, depending on existing values and world-views. Seemingly intractable policy controversies are often based on differences in problem definitions, and it can be worth examining these more closely if political progress is to be made.

Evidence of the practical relevance of problem definitions for international climate politics is offered by Bentley Allan (2017). He describes how state agencies, particularly those linked to the US military, accelerated the development of geophysical sciences and set the framework in which climate science was conducted. The type of framing used, namely that climate change is a problem of carbon emissions and carbon sinks, profoundly shaped the carbon measurement and accounting institutions that stand at the core of international climate politics today.

Geoengineering itself is arguably a consequence of the geophysical narrative of climate change. In the process of defining climate change as a problem of radiation balance, geoengineering emerged as a ‘solution’ to the geophysical problem of climate change, and was originally presented as such by advocates of SAI (Crutzen 2006) and bioenergy with carbon capture and storage (BECCS) (Azar et al. 2006). Evidently, however, this solution narrative does not quite match the expectations of many and has come to be seen as a problem in itself. How this problem is defined – controlling rogue actors, encouraging technological development, preventing moral hazard, prohibiting field experiments or including a wide variety of stakeholders – could eventually define what its governing institutions look like.

But what, or who, determines which problem definition is successful? To answer this question, we need to look at the institutional context. Framing theory and problem definition only address half of the picture, namely the interpretation that happens between the individual policy maker and the problem. Yet we know that social actors make decisions within a pre-structured environment. To account for context, I rely on

insights from normative institutionalism. March & Olsen (2011) argue that political actions are determined by a logic of contextual appropriateness. Policy makers work in an environment that is structured by laws, agreements, bureaucratic procedures, expectations and values. Effective decision making is continuously aware of its context and needs to link to it. To describe this necessity, I borrow the term ‘institutional fit’ from Lejano & Shankar (2013), who use it to put forward a theory of institutional contextualism. According to this perspective, institutions are constituted by a ‘constant dialectic’ between the blueprint of a problem and the particular context in which this blueprint needs to be applied. In order for it to be effective, the problem definition needs to be adapted to the existing institutional context.

Logic of appropriateness and institutional contextualism are theories that highlight the importance of structure for individual action. Including such a perspective is necessary to go beyond identifying discourses and frames of geoengineering, as successfully done by the likes of Anshelm & Hansson (2014*a,b*). If we want to know what these discourses mean for politics, the next step is to understand a problem definition’s performance and effect in its institutional surrounding.

Acharya (2004) provides a classic example of how this works in his discussion of international norm diffusion. He argues that legal norms adopted at the international level (which are, essentially, some form of problem and solution definition) are integrated in local settings only if they can be re-framed to match the local actors’ ideas and identities. The extent to which decision makers are able to ensure a ‘fit’ between the international legal norm and local institutional context explains the variation in its acceptance. Though geoengineering is not an international norm, it does represent a set of problem definitions shared and advocated by an international epistemic community. Policy makers asked to initiate public governance mechanisms based on these problem definitions need to consider them with respect to their national and international context.

The combination of problem definition and institutional fit essentially covers three elements of the policy-making process: a given problem definition (put forward by agenda-setting actors), the policy makers’ engagement with the problem definition, and the institutional context in which this engagement takes place. It is an agent-based framework that explicitly examines the role of structure, both in the discursive sense

(available or negotiated problem definitions) and in the institutional sense (bureaucratic, legal or normative structures). It assumes that the policy maker can reflect upon and navigate these structures to negotiate new governance mechanisms. In the process, problem definitions and institutional structures can be used reflectively and strategically to influence what kind of governance framework will come out at the end. The ways in which government officials and advisers do this in the case of geoengineering is examined more closely in the analysis.

Deliberative Policy Analysis

To study the perspectives of policy makers on the geoengineering governance problem, I used a form of deliberative policy analysis as discussed by Frank Fischer in Hajer & Wagenaar (2003). This kind of interpretive approach emphasises the assessment of a problem in its particular context. Methodologically, it brings together a comparatively wide range of evidence, establishing interconnections between empirical data, the assumptions that shape the interpretive framework, and the particular circumstances of a given context. It does this by studying deliberations in the concrete, every-day practices and activities of political decision makers. This includes analysing the way in which actors make meanings, accounting for the practical realities in which they do so, and identifying moments of conflict and contestation. Deliberative policy analysis aims to ‘tease out’ the normative conflicts that underlie different interpretations of the same goal. It moves beyond assessing the technical efficiency of governing institutions, seeking to assist practitioners in identifying their own interests and enabling constructive action based on given circumstances.

To inform my analysis, I looked at deliberations within international fora, as well as deliberations at the national level. My selection of countries covers those that have demonstrated some interest or engagement with geoengineering science, albeit at different levels of intensity. The United States, the United Kingdom and Germany are obvious candidates here, as they are powerful actors with substantial amounts of ongoing research projects across the geoengineering technology board. China is included as another powerful actor who has recently shown interest by providing substantial funding for geoengineering research.

Switzerland and Sweden are included as more neutral countries that have funded smaller geoengineering research projects, and Kenya is included because it is one of the few developing countries with an active role in attending and hosting geoengineering research events through the African Academy of Sciences and several universities. While not perfect or complete, this selection covers different roles and positions that might be taken in international negotiations, while ensuring that at least some policy makers are aware of the issue area.

In terms of data, I relied on records of political proceedings and government documents, observations at conferences, and interviews with government officials. The proceedings I analysed focused on events in which some sort of political engagement with geoengineering took place. Internationally, these are first and foremost the negotiation of marine geoengineering regulation under the London Protocol and the decision on geoengineering made in the Convention on Biological Diversity. Here, the reports of the Earth Negotiations Bulletin were particularly helpful, but also broader analyses like those provided by Dixon et al. (2014) and Fuentes-George (2017). Nationally, I analysed publicly available proceedings and documents in which governments made inquiries into the subject area. These included a hearing on geoengineering held in the United States congress (US Congress 2017) and documents in which governments or governmental departments explicitly position themselves towards geoengineering in reaction to inquiries from parliament or from the public. I also compared the most recent national climate policies of the examined countries for their reference to geoengineering technologies.

Observations of deliberations took place at conferences and events in which government actors engaged with the geoengineering topic. These include two major scientific conferences (one on climate engineering in Berlin, 2017 and one on negative emissions in Gothenburg, 2018); observations made at the United Nations Framework Convention on Climate Change (UNFCCC) COP23; and observations made in attending an internal workshop of the German Agency for the Environment. By ‘observations’, I mean in-the-corridor conversations with government actors who attended these events, speeches or presentations given by government representatives or advisers, and observations of how government actors engaged with or questioned the geoengineering-related science that was being presented.

For each country, I conducted at least one semi-structured expert interview with a government official who was familiar with the problem. Although low in quantity, the interviews provided valuable insights into the types of mechanisms at play in the national and international deliberation process. Five interviewees worked within their national ministry for the environment and/or energy, two within their national ministry for foreign affairs, and one within a sub-national government office. Some worked primarily towards informing their government's policy on environment or climate change, while others were directly involved in the negotiations of international environmental agreements. No matter what level they were engaged in, all interviewees had a good understanding of their government's procedures and positions at both national and international level. My questions revolved around the ways in which the interviewees had become aware of the geoengineering issue, how they perceived it, how they dealt with it, and the obstacles that they encountered in doing so.

Challenges to Initiating *de jure* Geoengineering Governance

The results presented here depict areas of dissonance that emerged out of the deliberative analysis. By analysing the data according to the interpretive framework of problem definition and institutional fit, I identified issues where a pervasive geoengineering problem definition seems to be at odds with the institutional context. To be clear, these results do not intend to cover all political processes that are relevant to the deliberations. Instead, they highlight areas of dissonance that are likely to play a pronounced role as political discussions unfold.

Scientific Demarcations and the Global Legal Architecture

One recurring theme of dissonance indicates a mismatch between the scientific demarcation of geoengineering (SRM and CDR) and the global legal architecture. Popularised by the Royal Society report on the governance of geoengineering (Shepherd et al. 2009), the categorisation of geoengineering technologies into carbon dioxide removal and solar radiation management has shaped the scientific and popular understanding of what geoengineering is. Because of its wide dispersion, policy makers share this definition and use it consistently in their deliberations about

the issue. Yet when it comes to governing these technologies, other demarcations, notably scale, risk and jurisdiction, seem to play a more important role.

An early example of this dissonance can be found in the negotiations of the London Protocol amendment on ocean geoengineering. In 2013, parties to the London Convention and London Protocol adopted an amendment which restricts the use of ocean fertilisation to well-controlled scientific experiments. The process around this amendment was first initiated in 2007, in reaction to a private company's announcement that they would carry out ocean fertilisation experiments off of the coast of Galapagos (IMO 2018). Although negotiations were initiated in response a single technology, the advocates who brought the topic to the international agenda explicitly categorised the procedure as a form of 'geoengineering', thereby raising concerns amongst the international community (Fuentes-George 2017).

This term caused some difficulty in the negotiations, as it wasn't clear how geoengineering as a group of technologies would fit the London Protocol's mandate. A former Swedish negotiator explained that 'the concern was firstly not to overstep the mandate of the cooperation globally, and secondly to bring about a generic formulation. That means of course that the way [that geoengineering is] formulated in the London Protocol is not necessarily how someone would define it more broadly'. Eventually, negotiators agreed that only technologies which added substances to the marine environment could be included in the amendment, due to the Protocol's mandate being about marine dumping. This formulation was quite different from the SRM/CDR demarcation, in that it had to focus on the process of deployment, rather than the effect of the technology.

Another mismatch became visible during one of the geoengineering workshops I attended, where German government officials deliberated a political position on the issue area. Here, participants expressed substantial concern regarding the CDR category used in the Intergovernmental Panel on Climate Change (IPCC) 1.5 degree report. At stake were the differences between *re*-forestation and the restoration of natural ecosystems on the one hand, and *a*forestation or large-scale industrial systems like BECCS on the other. Placing these approaches in one category made it necessary to differentiate between approaches that support ecosystem services, and those that endanger them.

It was also seen as relevant with respect to regulation of geoengineering under the Convention on Biological Diversity (CBD). In 2010, the CBD's parties had adopted decision X/33, in which they restricted the use of geoengineering to small-scale scientific experiments in controlled settings. Counter-intuitively, the Convention's decision to discourage the deployment of geoengineering in combination with the IPCC's decision to include reforestation and restoration as a form of CDR (and therefore geoengineering), could make ecosystem restoration relevant to the CBD's decision. The decision itself asks governments to ensure that 'no climate-related geo-engineering activities** that may affect biodiversity take place' – a formulation that does not by default exclude restoration attempts. Conversely, the IPCC's definition makes it difficult to use the CBD's decision to regulate those types of CDR that are seen as problematic.

Interviews with policy makers further clarified the dissonance between scientific demarcation and legal architecture. CDR and SRM are categories that include both local and familiar techniques easily deployed within national territory, as well as large-scale interventions that could have serious transboundary effects. Yet for many government officials, the question of scale, impact and familiarity were considered much more relevant in determining if, how and where regulation should take place. They mentioned different techniques that were already in use, but because of their categorisation, would fall under the current definition of geoengineering (some forms of cloud seeding, and the enhancement of natural carbon sinks). The question arose how to draw a distinction between technologies that were perceived as ethically and ecologically problematic, and those that were considered conventional activities.

The mismatch between scientific distinction according to physical mechanism and the political distinction according to familiarity and scale resonates with what has been found in comparable studies. In his analysis of interviews with experts advising the European Union, Himmelsbach (2018) writes that 'this discrimination between CE proposals according to the degree of control, or, as one might argue, ontological complexity, cuts against the conventional distinction between the technological families of carbon management and solar radiation management. [...] It does, however, align with concerns about which technologies might be governable on a national level and which ones

would require multilateral cooperation' [128].

Urgency in the Face of Uncertainty

A second theme of dissonance links to the urgency narrative often invoked to press for geoengineering governance. In a recurring problem definition, SRM (*de facto* equated with stratospheric aerosol injection) is presented as a free-driver problem in which the low cost might lead to rogue actors who deploy the technology without global consent (Weitzman 2015). It is therefore imperative that countries form a global institution to prevent this (C2G2 2018). But the urgency with which SRM governance is advocated for finds its barriers in scientific and political uncertainty. Lack of scientific consensus, concerns for reputation, and insecurity about other actors intentions or expectations make it difficult to formulate a political position. Yet a political position is needed to bring geoengineering to the international negotiation table.

Scientific uncertainty plays an important role for position-building towards internal constituencies. Informative here are similarities in the German and UK government responses to inquiries made by parliamentarians or members of the public. Expressed in different degrees of detail, the lack of scientific consensus is named as the main reason why the government finds it difficult to judge (Bundestag 2018), or engage in a 'rational debate on' (BEIS 2018*a*) the merits or risks of geoengineering technologies. This kind of reasoning is also reflected in interviews with government officials from countries as different as Kenya, Switzerland and China. As a Swiss diplomat put it, 'if we try to start influencing the atmosphere, then I get the impression that not even the scientists know what will happen exactly. And that makes it even more difficult to explain. With so much uncertainty, it is very difficult to define a clear path of how one should deal with it.'

Similarly, a Chinese diplomat stated that any decision making on this subject would be premature, commenting that the scientific conferences themselves still included 'a lot of different views on every perspective of this issue'. The same opinion was voiced by a Kenyan climate negotiator, who thought that the science needed to be sound and the options needed to be clear before a country like Kenya would engage. Many of the interviewees attended scientific conferences precisely because they were looking to better understand the status of contemporary research,

and concluded that the scientific discussion were still very confused.

Political uncertainty associated with SRM represents another barrier to decision making – including the decision to initiate a coordinated research program that might improve the overall knowledge basis. Officials from European countries like Germany, the UK and Switzerland seemed particularly cautious of how their government might be perceived if they showed too much enthusiasm for technologies like SRM. The Swiss diplomat summarised this concern in the following way:

If we could create clarity and decide, as a world community, what kinds of field experiments we want to allow, that wouldn't be bad. But it will certainly be very difficult. Immediately, there would be countries that say this is a cheap exit, that you want to neglect your mitigation obligations, and solar radiation management is an easy way to do that.

Because of such reputation concerns, all interviewees thought that a coordinated research program could only be initiated by an actor with substantial climate legitimacy. Officials from the German agency for the environment thought it would take a collective like the EU, or a diverse coalition of states from around the world, to bring the issue to the table. A scientific advisor from the UK suggested that such legitimacy might lie with the small island states or the least developed countries, who were very serious about climate change.

Uncertainty regarding the political positions of other countries constituted another important point of concern. For example, the diplomat from China indicated that his government would be reluctant to bring the issue forward without knowing the stance of other major powers. 'If other governments show their interest and have some proposal, we have to consider what's the benefit or the challenge of the proposal. So that's going to be an interactive process. [...] So far the United States, the UK, Germany, although they have done some research in this respect, their government does not take position. So it's going to be hard to initiate a process in the General Assembly.'

Uncertainty concerning the positions of other major powers also played a role in a US congressional hearing on SRM in 2017. During the hearing, Republican members of Congress expressed concern about the advancement of SRM research in other countries traditionally conceived of as competitors, mentioning China, the EU and Russia in particu-

lar. Here, the concern was less relevant to how the US should act internationally and instead referred to whether or not the US should strengthen its support for SRM research in order to stay at the head of international developments (US Congress 2017).

Uncertainty also played a role for those considered most legitimate in bringing forth SRM to the global agenda. The Kenyan climate negotiator that I spoke to explained that the novelty of SRM and its ideational origins in the Global North were likely to make developing countries suspicious. Because of negative experiences with promises made and broken in the past, developing countries lacked the trust that would be needed to bring the issue forward of their own accord. If a country like Kenya were to take up SRM as an agenda item, this recommendation would need to come from an internationally authoritative body like the UNFCCC. Comparable concerns were expressed by a policy maker representing the Small Island Developing States at one of the geoengineering conferences. In a speech, she explained how the 1.5 degree target had been advocated for by SIDS in the midst of destructive hurricanes threatening her country's existence. SRM however had never been part of the debate, and was unlikely to be supported in her cultural context, where such a technology would be seen as blasphemy. In addition, both officials stated that the lack of capacity in developing countries to deal even with the most immediate threats of climate change made it questionable whether they could substantially engage with SRM in the first place.

While the challenges of uncertainty only become clear through deliberative analysis, the content of the problem definition – namely that international governance of SRM is urgently needed – is pervasive amongst officials engaged with the subject. This highlights an important tension in the geoengineering governance debate. On the one hand, policy makers buy into the urgency narrative, expressing the need for early international governance of SRM research. On the other hand, they state that the scientific knowledge is too preliminary and contested to qualify for political discussion. The outcome of this chicken-and-egg problem is likely to depend on how much influence policy entrepreneurs like the 'Carnegie Climate Geoengineering Initiative' (C2G2) or the 'Solar Radiation Management Governance Initiative' (SRMGI) will have

in convincing governments to take action.⁵

Political uncertainties add another layer of complexity. Environmentally concerned and technologically advanced countries fear costs in terms of reputation if they seem too positive about the technology. Major powers are uncertain how to proceed without knowing the stance of other major powers. Developing countries vulnerable to climate change lack scientific capacity, and show little trust in a planetary-scale technological approach promoted by western scientists. As one country passes the buck to another, it is difficult to imagine a constellation in which actors with enough legitimacy, enough capacity *and* enough interest in the technology would put forward a suggestion to encourage international research on a technology like SRM.

Risk-risk and the Precautionary Norms of Environmental Governance

A third theme of dissonance relates to how the risk-risk definition of geoengineering matches with existing norms of global environmental governance. A problem definition that has accompanied the geoengineering concept from the very beginning states that although large-scale interventions might have significant side-effects, the world may need to use these interventions in order to stop the worst effects of global warming (National Academy of Sciences 1992). Yet, endorsing one type of risk in order to mitigate another is a difficult sell amidst existing ideals and principles of environmental protection. Norms like preventive action, precaution, polluter pays and the responsibility to avoid transboundary harm constitute an influential, albeit amorphous, institutional infrastructure that decision makers must navigate. In this institutional environment, a risk-risk problem definition does not find much political traction.

The most effective strategy for supporting geoengineering technologies seems to be to separate individual approaches from the geoengineering concept and its risk-risk definition entirely. More concretely, governments are careful to avoid these terms in their climate strategies,

⁵Both initiatives explicitly aim to introduce the issue of SRM governance into new contexts, with SRMGI involving actors from developing countries and C2G2 involving government actors around the world. The urgency narrative of SRM governance seems to be primarily conveyed through organisations like these, and all the policy makers that I spoke to had been in contact with one of these initiatives.

and those technologies with a high-risk profile (stratospheric aerosol injection or ocean iron fertilisation) are excluded from national government activity. A clear example of this can be found in the UK governments policy towards CDR technologies. In a prestigious investment programme financed by the UK natural environment research council, CDR is re-named ‘Greenhouse Gas Removal’ (GGR) and largely divorced from the geoengineering label. In this form and with reference to the Paris Agreement, GGR has become an official part of the UK’s clean growth strategy (BEIS 2018*b*). While the technologies subsumed under GGR remain exactly the same as under CDR (afforestation, BECCS, direct air capture, enhanced weathering and ocean liming), the term ‘geoengineering’ or ‘climate engineering’ is omitted. As an interviewed official explained, the only reason why the UK government has a public statement on geoengineering is because citizens and NGOs sometimes write letters to their politicians, expressing concerns about the topic (see BEIS 2018*a*).

Individualisation of technologies and separation from the geoengineering concept is also visible in the Swedish government’s emerging policy towards CDR. In its climate strategy, the government emphasises a need for achieving net zero emissions under the Paris Agreement and includes support for carbon sequestration in forests and soils and BECCS, without making any reference to the risk-risk problem definition or the general idea of geoengineering (Miljö-och energidepartementet 2018). Whether or not this move was intentional is unclear, but it is certainly politically advantageous.

While the separation approach works for technologies that are not (yet) considered overly risky, technologies with a high-risk profile need to be addressed differently. As discussed earlier, most governments do not have a position on the governance of ‘ontologically complex’ technologies yet. But when encouraged to give an opinion on how governance might take place, officials usually react by emphasising widespread participation. The reasons they give for this are mostly of normative nature. Some highlight ethics, stating that those affected by the intervention should have a voice in the governance procedure. Other express concerns that interventions should be sustainable, and therefore adhere to collectively determined standards. Still others emphasise the need for authority, making a multilateral forum like the United Nations General Assembly an attractive option.

It is interesting to note that rather than highlighting effectiveness and efficiency, which would call for a minilateral option (Victor 2009, Parson 2014), the policy makers that I spoke to express a preference for multilateral solutions. Perhaps this is due to the amorphous normative landscape of global environmental governance mentioned earlier. Environmental governance is largely defined by vague concepts and principles that nevertheless point towards prevention and precaution (Beyerlin 2008). With something like stratospheric aerosol injection, a more pro-active and explicitly transboundary approach would be required. Because these principles are not reflected in the international normative architecture, any decision making on the development or deployment of stratospheric aerosol injection stands to be rejected by the international community if not collectively and inclusively negotiated.

Where negotiation should take place is a different question, and depends on the individual decision makers' inclination towards geoengineering (i.e. whether they see it as overall dangerous or whether they deem it worthy of investigation). This could be because they are aware of variations in the normative underpinnings of different international fora, and know where their own positions are likely to be supported. For example, negotiators in the CBD can take a more sceptical stance than negotiators in the UNFCCC, as the foundational norms of these institutions differ with respect to what is considered appropriate. Desirée McGraw (2002) notes some of the main differences between the CBD and the UNFCCC. Whereas the former prioritises national sovereignty and an ecosystem based approach, the latter prioritises global cooperation and a science based approach. Because of these differences, the CBD is more likely to restrict and regulate geoengineering research, while the UNFCCC is more likely to encourage and support geoengineering research.

Decision makers with a strong opinion on geoengineering tend to legitimise those fora that provide a favourable normative environment, playing down the importance of alternatives. The clearest example can be found in the proceedings of the CBD's COP10, where negotiators discussed a possible geoengineering moratorium. Attending members of the Earth Negotiations Bulletin noted that while some participants took the issue very seriously, muttering that 'there are real issues at stake here', others downplayed the process and argued that 'the *real* decisions will be taken in other fora, most notably the UNFCCC' (IISD 2010). Le-

gitimation and de-legitimation of these fora can be observed again and again at various geoengineering events and conferences. While sceptics triumphantly uphold the CBD's decision X/33 as an already existing *de facto* moratorium, supporters consistently deny its significance on the basis that it is not legally binding.

Existing norms of global environmental governance obviously constitute important structures in the practical assessment of geoengineering. It is surprising that they are not more front and centre in the corresponding academic literature. With some notable exceptions (Brent et al. 2015, Talberg et al. 2018), norms are mostly addressed as something that still needs to be developed in order to properly govern emerging technologies. Yet the work that existing norms do in steering governments' behaviour clearly determines which debates and discussions can be initiated in the first place. Instead of assuming a blank slate, geoengineering governance assessments could profit from taking into account the power of existing values and principles.

Conclusion

Why are we not seeing more governance on geoengineering, despite a decade of scientific advocacy for regulation? In this study, I argue that there are dissonances between the problem definitions put forward by governance advocates, and the problem definitions that have traction in environmental politics. In order to initiate *de jure* governance, policy makers need to find a problem definition that links to the existing institutional structure of global environmental governance. This negotiation of institutional fit requires an understanding of the problem definitions that are out there, evaluating how they relate to existing structures, and discarding or re-defining those that do not match existing values or expectations. In this process of reflection and deliberation, some policy makers are further than others. Those who have already spent many years following the subject are aware of the different angles and debates put forward by governance advocates. Others are only just starting to engage with the topic and heavily dependent on the framing provided by experts.

My analysis indicates that there are at least three areas where lack of institutional fit presents challenges to the development of *de jure* gov-

ernance. The ubiquitous demarcation between technologies according to their radiative effect (CDR and SRM) has helped geoengineering become a conceptual object of governance (Gupta & Möller 2019). But as it stands, this conceptual object is difficult to match with the existing legal architecture.

More useful in the political deliberation process is the focus on individual technologies that can be evaluated according to politically relevant criteria, including economic co-benefits and social, political and environmental compatibility. The individual technologies can then be addressed through different venues and levels as required. This is particularly important for the category of CDR, or ‘negative emissions technologies’ (NETs), which is reaching political agendas through the conclusions and models of the IPCC. Treated as CDR or NETs, a range of very different approaches are presented as exchangeable ways of absorbing greenhouse gases. An individualised approach would enable better integration with other types of climate solutions and facilitate governance under existing regulatory structures.

The urgency with which governance is advocated for, particularly in the case of stratospheric aerosol injection, presents a second challenge. Governance advocates are actively pushing the agenda here, but the substantial scientific and political uncertainties around this subject make it difficult for policy makers to know what other actors’ expectations are. It is therefore challenging to form a political position for negotiation. If governance advocates do convince one country or another to raise the subject in an international forum, this would force all other states to react. Most know next to nothing about SRM, and so the next logical step would be to commission a special report. While a conventional literature review is likely to re-produce the same problem definitions that already shape the geoengineering discourse, a more productive path might be for policy makers to pose specific questions. Although not necessarily a solution to the governance problem, this approach could steer scientific inquiry to answer questions specifically relevant from a policy makers perspective – questions that scientists themselves might not yet be aware of.

Finally, the risk-risk trade off that geoengineering is understood as is not compatible with the normative foundations and expectations of global environmental governance. While the environmental regime complex does not have many legally binding rules, it is characterised by

principles of precaution and prevention that seek to stop environmental harm from happening, rather than risking one kind of harm in order to avoid another. Although all climate and energy policies pose some kind of risk, these are usually amenable to environmental impact assessments – another norm of governance that serves to minimise risk as far as possible (Beyerlin 2008). To find political support, individual technologies currently subsumed under the geoengineering umbrella must be amenable to such impact assessments and conform to widespread norms like precaution and prevention, sustainable development, the avoidance of transboundary harm, and the polluter-pays principle. In the meantime, the risk-risk definition that always accompanies large-scale, ‘ontologically complex’ types of geoengineering makes it easier to regulate these restrictively (as in the case of ocean iron fertilisation), than to regulate them supportively.

The conclusions made here assume that geoengineering will be addressed in the context of global environmental governance. This picture could change if the problem definition were brought into a different institutional context, an obvious alternative (at least for stratospheric aerosol injection) being international security (Corry 2017). The main argument however, namely that decision makers need to create institutional fit in order to initiate *de jure* governance, should hold for any situation. If scholars want to help politics catch up with novel technologies, the answer is not to design perfect hypothetical institutions. Instead, the key is to find bridges through which existing structures can become relevant and functional.

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The Emergent Politics of Geoengineering



This thesis is about how a thought experiment, at first subject to a scientific taboo, became relevant to the global politics of climate change. It explains how the activities of a scientific community helped spread ideas about large-scale interventions into the Earth's natural systems in order to stop global warming. It draws on theories of social dynamics and political culture, providing a sociological institutionalist perspective on the role of science in creating new objects of governance.

Ina has a background in political science and in environmental studies. As the only social scientist in a family of natural scientists and engineers, she feels equally comfortable around ecologists and physicists as she does around scholars of international relations and public policy. Throughout her studies, her motivation has been to understand why humans act the way they do, and how their actions contribute to driving environmental change. Though the answer is complex, her approach is simple: empathize with the individual, and work on from there.



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