Rock, Paper, Scissors:

Uncertainty, Innovation, and the Evolving Ecology of Climate Change Discourse

Gary Bowden
University of New Brunswick
glb@unb.ca

Through an examination of the past 25 years of developments in both climate science and the attempts to develop a policy response, I will argue the following: 1) there has been a significant decrease in the level of scientific uncertainty about climate science over the 25 years and 2) over that period of time there has been a correspondingly significant loss of consensus about the broad outlines of the appropriate structure for an international policy response. Thus, the past 25 years have seen a shift from a period of high scientific uncertainty and high consensus on the structure for international cooperation to a period of comparatively low scientific uncertainty and low consensus about a structure for international policy cooperation. The dynamics of these trends will be examined in terms of the relationships among three discursive realms: a) science, b) public policy, and c) the rise, fall, and resurrection of geoengineering as a proposed solution to the climate change problem.

Climate change has several features which separate it from the majority of environmental problems. First, the complexity of the problem means that there is more uncertainty about the science, even with the massive investments of research dollars that have occurred over the past decades, than is the case for similarly studied problems. Second, the scale of the problem requires institutional innovation in order to implement successful mitigation policies. Where most developed countries have institutional mechanisms that do a reasonable job of addressing local, regional, and national scale environmental problems, climate change requires a global response and, hence, the creation of an policy vehicle capable of facilitating global cooperation. Thus, aside from the significance of climate change as a problem with implications for the fate of the planet, it also provides a strategic research site for examining the relationship between uncertainty and innovation.

Specifically, this article focuses on discourse surrounding one particular type of innovation: geoengineering, defined by the National Academy of Science (1992) as "options that would involve large-scale engineering of our environment in order to combat or counteract the effects of changes in atmospheric chemistry." The first section describes the various realms of climate change discourse. The second section traces the historical trajectory of geoengineering discourse and argues that it has passed through three distinct phases: rise, fall, and resurrection. The third and fourth sections trace the historical trajectory of two other discursive realms: climate science and international climate policy. The fifth and final section develops an ecological model of climate change discourse. Most previous accounts focus on the causal impact of one discursive realm on another. Thus, for example, corporate funding of climate deniers in the US is seen as resulting in disproportionate media coverage to the uncertainties in climate science, leading to a

public that is unconvinced of the severity of the problem and, hence, an unwillingness of politicians to expend political capital on the issue. In contrast to such traditional accounts, which focus on unidirectional causes (e.g., the impact of media on public opinion or public opinion on policy), I argue that changes in climate change discourse are better conceptualized as a game of rock, paper, scissors.

Realms of Climate Change Discourse

There is no satisfactory way to talk about climate change discourse as a unified whole. Rather, climate change discourse takes place in a number of distinct, but interconnected, discursive realms. Each realm has a distinctive institutional structure and, typically though not necessarily, discursive agents that are specific to that institutional realm. For example, while climate scientists will occasionally write op-ed pieces about climate science or policy, the bulk of climate change discourse present in the media is the product of journalists, bloggers, or other individuals whose main focus is in the media realm. As such, the analysis must both a) specify the different institutional realms of discourse and the institutional norms that structure participation in that discursive space and b) articulate the nature of the interaction and interconnection between discursive realms.

For the purpose of this article, climate change discourse is conceptualized in terms of a variety of different realms defined both in terms of institution and scale. While it is important to note that the different institutional realms are characterized by different normative structures, the detailed examination of these structures goes beyond the parameters of this article. For clarity of the argument, research describing the institutional norms of two institutions is briefly discussed, but no attempt will be made to explore these differences systematically.

Merton (1942) identified the following norms that define the institution of science and orient the behaviour of scientists: communalism (scientific results are the common property of the entire scientific community), universalism (contributions to science are evaluated on merit rather than on the basis of the scientist's race, nationality, culture, or gender), disinterestedness (scientists should not conflate their findings with their personal beliefs or activism for a cause), and organised scepticism (scientific claims must be exposed to critical scrutiny before being accepted). The key point is that the primary audience for scientists is other scientists and, hence, their discourse is typically articulated in the context of that institution and those normative expectations. By way of contrast, the traditional media—as described by Tuchman (1980), Ericson, et. al. (1987), and others—use a different set of institutional norms to determine the newsworthiness of a story. Among these are thematic coherence (i.e., the ability to connect the story or event to other stories or events) and the existence of conflict (which increases the likelihood of a larger audience for the story). In short, the audience for news (the general public) is different than the audience for technical science (other scientists). As a result, each institution has evolved different norms and reward structures which act to differentially orient the actions of individuals participating in the two realms. This same idea, that the institutional realm in which discourse takes place is more important to understanding the nature of the discourse in that realm than is the topic itself, can be generalized to other discursive realms. Thus, rather than talk about climate change discourse as an undifferentiated whole, it is necessary to specify the different discursive realms.

Internationally, there exist two dominant discursive realms, those of climate science and international climate policy. Science, as noted above, is a universalist institution with a global span. In contrast, as also noted above, environmental policy in most areas is dealt with at the na-

tional, regional, or local level. International climate policy, as discussed below, involves the integration of various national policy positions within the attempt to create a new international institution. At the national level, climate change discourse occurs in the media (both traditional and new), as a national public policy discussion (which, in democracies, revolves around the politics of the elected representatives), and at the level of public opinion. The organizational manifestations of these national discursive realms (i.e., media outlets, governing institutions, publics) also occur at the sub-national and local levels, but the institutional norms and reward structures governing participation largely parallel those of the national institutions. The remainder of this article focuses on the two international discursive realms and the rise, fall, and revitalization of geoengineering.

The Rise, Fall, and Revitalization of Geoengineering Discourse

Geoengineering, or climate engineering, refers to proposals aimed at intentionally manipulating the earth's climate in order to counteract the effects of global warming. Over the years a number of such proposals have been advanced. Broadly speaking, the major proposals involve either the management of solar radiation or the remediation of greenhouse gases. Solar radiation management projects counteract temperature rise by limiting the amount of sunlight that reaches the earth. Proposed ideas include mimicking the actions of volcanic ash through stratospheric sulphur aerosols; increasing the earth's albedo (amount of reflected light) by painting roofs and highways light colors or spraying water on the arctic ice cap in order to thicken the ice and reduce the rate at which it melts; enhancing the amount of cloud cover or its reflectivity through cloud seeding or using fine sea water spray to whiten the clouds; or building space-based mirrors or other structures designed to shade the earth. Greenhouse gas remediation projects aim to reduce the level of greenhouse gases in the atmosphere. Proposed ideas include various schemes for carbon capture and storage as well as proposals to fertilize the oceans with iron in order to stimulate a phytoplankton bloom and, hence, remove additional carbon dioxide from the atmosphere.

These options, as is evident from the fact that the National Academy of Science had a term for them back in 1992, have been advanced since the early days of concern about climate change. Indeed, most of the basic ideas date from the late 1960s-80s. However, with few exceptions (such as the 1997 Wall Street Journal op-ed "Why not do that?" by physicist Edward Teller, the father of the hydrogen bomb), the proposals were marginalized in the scientific community and ignored by the general public. There were three basic reasons for this. First, the ideas were perceived as speculative and as a distraction from attempts to gain international cooperation to slash emissions (Morton, 2007). Second, many of the techniques were not well understood and there were concerns about the uncertainties and/or potential side effects. Thus, for example, the notion of pumping sulphur into the atmosphere to mimic the effects of a volcano has been criticized on the grounds that much of the sulphur will precipitate into the ocean and change the ocean's chemical balance. Third, a number of prominent scientists had moral or philosophical reservations. As Hans Fichter, a climate modeller at the Max Planck Institute for Meteorology, noted "the role of a geoscientist is to understand nature, not to change it."

In the mid 2000s, however, a series of changes occurred. The idea of geoengineering began to gain traction in the scientific community following its endorsement by two Nobel laureates, Paul Crutzen and Ralph Cicerone (Morton, 2007). Broad (2006) provides a concise description of the change. Prior to 2006,

> their proposals were relegated to the fringes of climate science. Few journals would publish them. Few government agencies would pay for feasibility studies. Environmentalists and mainstream scientists said the focus should be on reducing greenhouse gases and preventing global warming in the first place. But now, in a major reversal, some of the world's most prominent scientists say the proposals deserve a serious look because of growing concerns about global warming. Worried about a potential planetary crisis, these leaders are calling on governments and scientific groups to study exotic ways to reduce global warming, seeing them as possible fallback positions if the planet eventually needs a dose of emergency cooling.

In contrast to the earlier phases, where discussion of geoengineering both rose and fell within the confines of the scientific community, the recent discussion has migrated from the scientific to other domains. This migration has involved a series of stages. In stage one, as noted above, several high-profile scientists embraced the idea, leading to coverage of the idea in the news sections of prominent scientific journals like *Nature* (Morton, 2007) and major newspapers like the *New York Times* (Broad, 2006). In the second stage, the idea was embraced by a number of public intellectuals. Thus, for example, Homer-Dixon and Keith (2008) argue against the all or nothing approach (either we do it full scale or we don't do it at all) and advocate limited small-scale testing to find out what works best in the event that such approaches must be used. The need for practical knowledge about the techniques also follows from Dyer's (2008) suggestion that small-island nations or other countries facing existential threats might unilaterally implement such measures. In the third and most current phase, the idea has become a mainstay of policy debate and, as evidenced by a spate of recent books aimed at the literate public (Kintisch, 2010; Fleming, 2010; Parkinson, 2010; Pielke, 2010), a topic of public interest.

To summarize, geoengineering emerged in the 1980s as a scientific/technological silver bullet for climate change which was quickly marginalized within the scientific community because of issues, among others, of cost, feasibility, uncertainty, and risk, as well as philosophical objections to the attempt to play "God." Despite the fact that little has changed to ameliorate these concerns, a substantial portion of the scientific community has recently embraced the idea of geoengineering and introduced it into both public and policy discourse. To understand this shift in discourse about geoengineering, we need to examine discourse on both climate science and international climate policy.

Climate Science

Climate change became a major topic of scientific investigation in the late 1980s. The general trajectory of scientific understanding of the phenomenon from that point to the present can be characterized as involving the reduction of scientific uncertainty about a) whether or not the climate was changing and b) whether or not humans were responsible for the change and, as a result, the emergence of a broad consensus within the international scientific community about the reality of anthropogenically caused climate change. Three distinct lines of evidence support this characterization.

First, this trajectory is evident in the selected quotes from the series of Intergovernmental Panel on Climate Change reports summarizing the current state of climate change science (Table 1).

IPCC Report	Key Conclusions / Quotations
1st Assessment (1990-92)	There is a natural greenhouse effect, humans are contributing to more greenhouse gases, the implications of this are unclear.
2nd Assessment (1995)	Climate has changed over the past century and is expected to continue changing. "The balance of evidence suggests a discernible human influence on global climate."
3rd Assessment (2001)	"An increasing body of observations gives a collective picture of a warming world and other changes in the climate system." "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."
4th Assessment (2007)	"Warming of the climate system is unequivocal." "Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."

Table 1. Selected quotes from Intergovernmental Panel on Climate Change

Second, during the 1980s and 90s, when the level of scientific uncertainty was higher, scientific associations did not take official positions. However, in the past few years a number of scientific associations issued statements concluding that the evidence for human modification of climate is compelling (American Meteorological Society, 2003; American Geophysical Union, 2003; American Association for the Advancement of Science). Third, Oreskes (2004) examined 928 papers about climate change published in refereed scientific journals between 1993 and 2003:

> The 928 papers were divided into six categories: explicit endorsement of the consensus position, evaluation of impacts, mitigation proposals, methods, paleoclimate analysis, and rejection of the consensus position. Of all the papers, 75 percent fell into the first three categories, either explicitly or implicitly accepting the consensus view; 25 percent dealt with methods or paleoclimate, taking no position on current anthropogenic climate change. Remarkably, none of the papers disagreed with the consensus position.

As scientific knowledge has increased, uncertainties have remained, but they are tied to increasingly more specific questions. Thus, in the early years of the global warming debate (1980s-early 1990s) attention focused on the broadest question: Is the global climate changing? By the mid-1990s, that question had been largely answered in the affirmative, but there were still significant doubts about the cause and, hence, the focal uncertainty was whether or not human activities were responsible. At the present time, the existence and anthropogenic origin of climate change are not seriously questioned within the scientific community. The bulk of current scientific debate surrounds a much narrower question: How extensive will the change be and how rapidly will it occur? In particular, the past 10-15 years have seen a substantial focus on the possibility of "tipping points," i.e., possible positive feedback loops that could lead to comparatively quick changes in climate; e.g., rising Arctic temperatures leading to thaws that release methane into the atmosphere, thus increasing the greenhouse effect and starting the cycle over again (NSF, 2010).

International Climate Policy

Climate change, as a global problem, necessitates a global response. However, in the late 1980s, when climate change was initially identified as a potential problem, the institutional structure for such a response did not exist. This section briefly recounts the history of attempts to forge such a structure and argues that the consensus on how to proceed that characterized most of the period from the late-1980s on has recently fallen apart.

Broadly speaking, the structure for addressing global environmental problems can be traced to the World Commission on Environment and Development (WCED), which was commissioned by the UN in 1983 to discuss the environment and development as a single issue or, in other words, to facilitate a rapprochement between the global north (whose high levels of consumption were blamed for environmental degradation by the global south) and the global south (whose high levels of population growth were rendered as the primary problem by the north). The most significant legacy of the group's work was the publication of Our Common Future (1987) and the popularization of the term "sustainable development." In an attempt to reconcile the differences between the north and the south, the report made two major points. First, development was still desirable, but unlimited development for all was recognized as biophysically impossible and, hence, future development should be sustainable development. Second, the countries of the developed north have already received significant economic benefits from the exploitation of natural resources and, hence, they should take the first steps in addressing global environmental problems while the less developed countries of the global south would be given more leeway in the pursuit of economic development. Stated another way, there was recognition both of the need for restrictions on growth and an ethical consensus on how to achieve those restrictions.

The development of an institutional structure specific to climate change can be traced to the UN Framework Convention on Climate Change (UNFCCC) produced at the Rio Earth Summit of June, 1992. The objective of the convention was to stabilize greenhouse gas emissions at a level that would prevent human-induced climate change. While the agreement lacked any strict limits or enforcement mechanisms, it is notable for three major reasons: 1) it established internationally agreed upon methods for collecting and distributing data on greenhouse gas emissions (leading to the IPCC reports quoted in the previous section), 2) the treaty called for updates (known as Protocols) aimed at setting mandatory emissions limits and providing enforcement mechanisms, and 3) it divided the signatory countries into three groups with differing responsibilities: 23 industrialized countries, 17 "countries in transition," and developing countries (the remainder of the signatories). This division reflects the ethical consensus reached by the WCED: the developed countries were required to accept limitations while developing countries were not, though developing countries could become subject to emissions limits when they were sufficiently developed.

The Kyoto Protocol, negotiated in December 1997, updated and extended the UNFCCC. In it most industrialized nations and some central European economies in transition agreed to legally binding reductions in greenhouse gas emissions of an average of six to eight percent below 1990 levels between the years 2008-2012, defined as the first emissions budget period. Three points merit specific attention. First, the Protocol followed the UNFCCC structure: countries classified as industrialized or in transition agreed to binding reductions, while developing countries were not expected to make such commitments. Second, the Protocol, following the model of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, adopted a "cap-and-trade" strategy for achieving the stated emission targets. Third, the specific reduction

targets agreed to by the various countries were reached following Vice President Al Gore's arrival in Kyoto with a US proposal to reduce its total emissions an average of seven percent below 1990 levels, a proposal that significantly went beyond what other countries expected the US to agree to and which broke a negotiating impasse that had existed to that time. However, neither the Clinton administration nor the Bush administration sent the Protocol to Congress for ratification. The Bush administration explicitly rejected the Protocol in 2001.

The 15th Conference of the UNFCCC Parties (COP 15) took place in December 2009 in Copenhagen. This conference was expected to be the follow-up to Kyoto, where a treaty extending beyond the 2012 end date of Kyoto (i.e., the second emissions budget period) would be agreed upon. Instead, the conference ended in chaos as a result of the confrontation between the US and China—the two largest contributors to global emissions, neither of which is bound by the provisions of the Kyoto Protocol. On December 17, Secretary of State Hillary Clinton outlined the details of a US proposal aimed at "breaking the impasse" in the existing negotiations. That proposal had two key provisions: 1) support for an initiative to mobilize $100 billion per year by 2020 for developing countries to help them mitigate the impacts of climate change and 2) pressuring developing countries to agree to emissions cuts along with the industrialized world for the first time. The Chinese adamantly opposed the US proposal.

In short, the negotiations broke down over a dispute between the two largest emitters on the nature of the path forward. While not part of the formal Kyoto agreement, the general expectation was that a) the developed countries would fulfill their commitment and b) the next major agreement (i.e., the Copenhagen agreement) would broaden the number of countries accepting emissions limits to include some of the developing countries that were not covered by Kyoto. Viewed in the context of this history, the US proposal aimed to divide the developing world into two camps: a) China and other rapidly developing countries (who would be expected to commit to emissions cuts) and b) the rest of the developing world (which would receive a large amount of aid and not be expected to make emission cuts). The Chinese response was designed to maintain their status as a developing country not expected to make emissions reductions (Lynas, 2009).

In both cases, these countries are responding to internal political pressures. The Obama administration knows that it has no chance of getting an international agreement ratified by the Senate unless it covers China. The politics of this have been clear for over a decade. In 1997, by a vote of 95 to 0, the Senate passed the Byrd-Hagel Resolution, which stated that the Senate would not ratify Kyoto if developing countries were not required to participate on the same timetable. Thus, the Obama administration was attempting to divide and conquer the developing countries in a strategic move aimed at getting an agreement that could be ratified by the US Senate. From the Chinese point of view, it is unreasonable to expect China and other developing nations to commit to emission reductions at this point when the US has not formally agreed to emissions reductions (i.e., to "go first" as expected by the UNFCCC process), and most of the developing country signatories have failed to meet their Kyoto commitments.

To summarize, the UN member nations reached broad consensus on an ethical framework for international agreements on the environment and development before climate change emerged as a major issue. When it did, the basic structure of that framework was incorporated into the UNFCCC process. Similarly, following on the success of the Montreal Protocol (which limited ozone depleting substances), there was general agreement on the appropriate policy vehicle for dealing with climate change, a cap-and-trade system. These two pieces became the central components of the Kyoto Protocol. Stated another way, the early years of the international cli-

mate change discussions were characterized by consensus on both the ethical structure and the policy instrument. A crack in this consensus appeared when the US failed to ratify Kyoto, though the ongoing support of the Democratic party for Kyoto led the rest of the world to hope that the US would ultimately join and, hence, acted to minimize the significance attributed to the crack. By the mid-2000s, as the emissions of China and India continued to increase, the Democrats realized that it was politically impossible to get the US to ratify an agreement structured like Kyoto. This led not only to the Obama administration position at Copenhagen, but also to the embrace of a carbon tax (rather than a cap-and-trade system) by such notables as Nobel economist Joseph Steiglitz, the former head of Clinton's Council of Economic Advisors (Stiglitz, 2006). In other words, a complete break from the earlier consensus.

Rock, Paper, Scissors

The preceding sections have described and documented the three historical patterns shown in Figure 1. Interest in geoengineering was initially high as a variety of proposals were brought forward, fell to virtual insignificance as the scientific and policy problems with the various suggestions were recognized, and has recently seen a significant revival (the U shaped green line). These discursive shifts about geoengineering occurred as the level of scientific certainty about climate change went from low to high (the red line) and the extent of international policy consensus went from high to low (the blue line). This final section aims to articulate a general model of discursive action and, more particularly, to use that model to explicate the documented patterns.

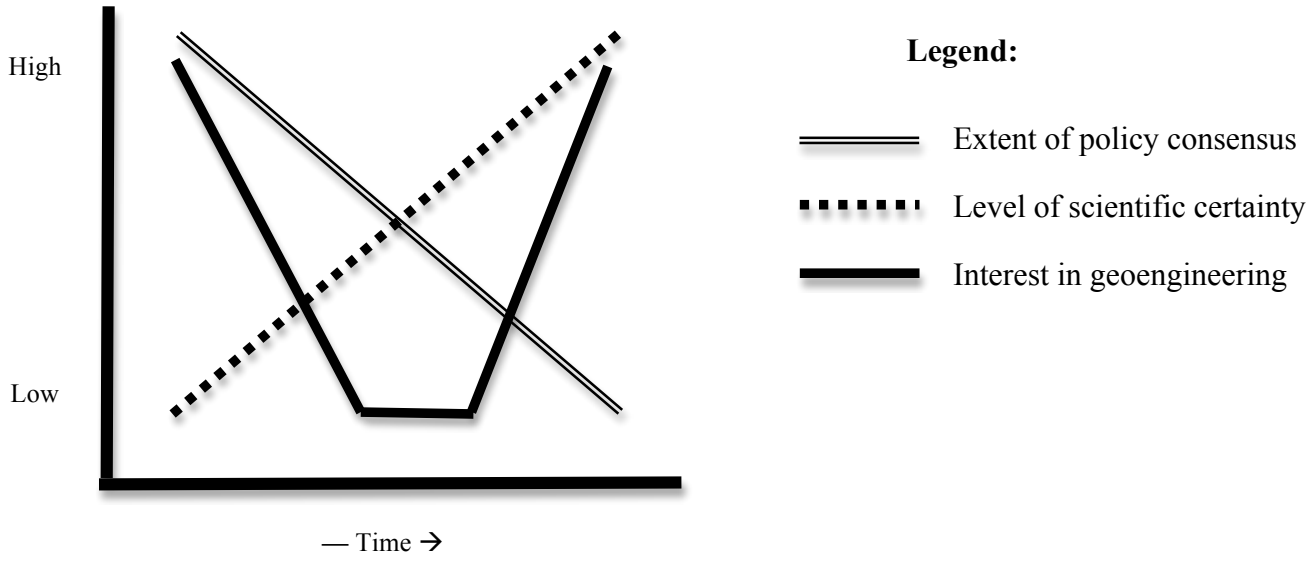

Figure 1. Historical changes in three areas of climate change discourse

Standard accounts of the relationship between discursive spaces tend toward causal asymmetry. By this I mean that a) the explanations emphasize a specific set of causal factors and b) the direction of causation runs from one realm to another. Thus, for example, we get accounts of how media depictions of thin adolescent girls instil a negative body image or, in the area of climate change, of how expenditures of money by Exxon-Mobil and others have spawned a cli-

mate-denial industry in the US (Hoggan and Littlemore, 2009), which accounts for the continued space given to the idea that climate change is not settled science in the US relative to other countries (Brulle, 2003). My objection is not to such accounts but, rather, to the absence of human agency in them. In their place, I would substitute a discursive model based on a modified version of the game rock, paper, scissors. The game, as typically played, involves a) two or more people who simultaneously display one of three hand gestures and b) a set of rules for determining who wins (rock smashes scissors, scissors cut paper, paper covers rock). A key feature of the game is that individuals decide upon a particular throw based on an expectation of what their opponent will throw. Thus, if I expect my opponent to throw paper, I will throw the gesture that wins in that situation, scissors. In other words, actors make choices with the aim of achieving a particular outcome. But the outcome is not determined solely by their decision; it is an emergent product of the actions of all players. Thus, in the example above, I would lose rather than win if the other player threw rock.

How does this apply to climate change discourse? In particular, why has the scientific community, which previously marginalized geoengineering, embraced it even though the objections that previously led to its marginalization still remain? Scientists were unwilling to embrace geoengineering (throw the geoengineering gesture) when it was perceived as a loser. Given the discursive context of the late 1980s and early 1990s (relatively low scientific certainty about the details of the climate change problem and high consensus about the policy framework for limiting emissions through cap-and-trade), advocacy of geoengineering proposals was seen as out of step. It is hard to appreciate now, but the rapidity of the global response to the emergence of climate change as a major policy issue was remarkable. In less than a decade, it went from a virtually undiscussed policy issue to one with a negotiated (though not ratified and implemented) international policy process (the Kyoto Protocol of 1997). Given the apparent will of the international community to implement a binding cap-and-trade system, there was no perceived need for the geoengineering solution.

Over time, two features of the discursive context changed. First, the science became more certain and the urgency of the problem more immediate (both because of the possibility of tipping points and because the Kyoto Protocol turned out to be largely ineffective and global emissions continued to rise). Second, the optimism that a negotiated political solution could be found dissipated as emissions continued to rise and the apparent consensus on how to proceed fell apart. In this new context, throwing the geoengineering gesture, despite the recognized limitations, becomes a potentially winning strategy. If the politicians are unwilling to step up to the plate, the scientists and engineers will take over.

While this article has focused on explaining the shift in geoengineering discourse, it should be noted that the same rock, paper, scissors model could be used to account for other aspects of climate change discourse. Thus, for example, the last few years have seen a significant number of economists abandon their support for the traditional policy vehicle (cap-and-trade) in favor of an alternative (a carbon tax). This is the economic equivalent of the rise of geoengineering discourse, the emergence of a new throw that is viewed as potentially winning because the previous throw (cap-and-trade) appears inconsistent with developments in other discursive realms (i.e., unable to get adopted by the US Congress). In another example, Brulle (2003) documented the existence of national differences in traditional media coverage of climate change, with North American media giving significant space to climate deniers and treating the problem as unsettled science, whereas European media emphasized the scientific consensus. Following the release of *An Inconvenient Truth*, with its articulation of Oreskes' findings of a con-

sensus position in the scientific literature, traditional North American media treatment began to approximate the coverage in Europe. Realizing that they could no longer win with the same throw (because traditional media were not giving them the same platform they had in the past), climate deniers shifted their attack to new media. Google "climategate" and you will see what I mean.

All of these examples have one general point in common. Climate discourse takes place in a number of different discursive realms where actors proceed primarily in terms of the norms and reward structures of their particular discursive realm. However, it is inappropriate to view these different discursive realms as either autonomous or connected in some simple and unidirectional manner (e.g., media has such and such an effect on public opinion). These individual relations between realms are small facets of a larger picture in which actors play to the norms and reward structures of their own institutional realm while taking account of the moves made by actors in other discursive spaces, thus generating a game that approximates rock, paper, scissors.

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