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Geoengineering, a set of unconventional, untested, and risky proposals for responding to climate change, has attracted growing attention in the wake of our collective failure so far to mitigate greenhouse gas emissions. Geoengineering research and deployment remain highly controversial, however, not only because of the risks involved, but also because of concern that geoengineering might undermine climate mitigation and adaptation efforts. The latter concern, often described as a moral hazard, has been questioned by some but not carefully explored. This Article examines the critical question of whether geoengineering presents a moral hazard by drawing on empirical studies of moral hazard and risk compensation and on the psychology literature of heuristics and cultural cognition. The Article finds it likely that geoengineering efforts will undermine mainstream strategies to combat climate change and suggests potential measures for ameliorating this moral hazard.

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INTRODUCTION

The primary policy options for addressing climate change fall into two main categories: mitigation and adaptation. Mitigation encompasses efforts to reduce greenhouse gas (GHG) emissions from human activity or to enhance GHG uptake by forests and other carbon sinks. Adaptation refers to adjustments in natural or human systems to the effects or predicted effects of climate change.[1] Geoengineering, a third category of climate policy options, is a catchall term for an array of unconventional, untested, and frequently risky proposals. These techniques generally involve the "engineering" of physical or chemical processes at a planetary scale to counter the consequences of elevated atmospheric concentrations of GHGs.[2]

For many years, climate change discussions avoided consideration of geoengineering as a policy option. Among the leading reasons for the geoengineering taboo was the worry that geoengineering endeavors would undermine mainstream efforts to combat climate change. This concern has been characterized as a problem of moral hazard. Just as insurance can encourage insureds to assume greater risks, the prospect of geoengineering the Earth in response to climate change might exacerbate the very behaviors contributing to climate change. Geoengineering might even create new environmental problems. In recent years, however, continuing increases in GHG emissions have prompted a closer look at geoengineering. At the same time, commentators increasingly dismiss moral hazard as a serious concern. This Article offers an analytical approach to the question of whether geoengineering

1. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 869 (2007).

2. David W. Keith, *Geoengineering*, 409 NATURE 420, 420 (2001).

poses a moral hazard, concludes that dismissal of the question is premature, and suggests measures for countering the moral hazard problem.

I. GEOENGINEERING

Geoengineering proposals rest on one of two basic mechanisms: carbon dioxide removal (CDR), which strives to remove carbon dioxide (CO_2) from the atmosphere; and solar radiation management (SRM), which aims to reflect some of the sun's radiation into space. Atmospheric concentrations of CO_2 are now estimated at 393 parts per million (ppm) and rising, well above preindustrial levels of 280 ppm.[3] CDR techniques would slow this increase and could even move GHG concentrations in the atmosphere back toward their preindustrial state.[4] As GHG levels decline, it is expected that the Earth's climate system would move gradually toward earlier conditions. SRM techniques, in contrast, would have no effect on GHG concentrations. Instead, these techniques would attempt to control climate conditions by reducing the amount of radiation absorbed by the Earth.[5] Because SRM techniques essentially focus on climate change's symptoms rather than its scientific root causes, these methods tend to involve greater risks and uncertainties.

Among the geoengineering techniques that have received the most attention are ocean fertilization, a type of CDR, and stratospheric aerosol deployment, a type of SRM. By fertilizing the ocean with iron or other micronutrients, geoengineers would stimulate the growth of phytoplankton in the hope of dramatically accelerating natural processes that store carbon in the deep oceans.[6] Even if ocean fertilization turned out to be as effective as theorized, however, it could absorb only a modest fraction of the amount of carbon that humans emit into the atmosphere.[7] Moreover, small-scale ocean fertilization experiments and computer modeling thus far have produced unimpressive results that fall far short of theorized yields.[8] In addition,

3. *See* T.J. Blasing, *Recent Greenhouse Gas Concentrations*, CARBON DIOXIDE INFO. ANALYSIS CTR., http://cdiac.ornl.gov/pns/current_ghg.html (last updated Feb. 20, 2013).

4. *See* THE ROYAL SOC'Y, GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY 9 (2009).

5. *See id.* at 23–24.

6. *See id.* at 16–17.

7. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, REP. NO. GAO-11-71, TECHNOLOGY ASSESSMENT: CLIMATE ENGINEERING TECHNICAL STATUS, FUTURE DIRECTIONS, AND POTENTIAL RESPONSES 29 (2011); THE ROYAL SOC'Y, *supra* note 4, at 17; Konstantin Zahariev et al., *Preindustrial, Historical, and Fertilization Simulations Using a Global Ocean Carbon Model with New Parameterizations of Iron Limitation, Calcification, and N_2 Fixation*, 77 PROGRESS OCEANOGRAPHY 56, 79 (2008) (reporting modeling results predicting that even if entire Southern Ocean were fertilized with iron, such efforts could at best stimulate ocean uptake of only 11 percent of 2004 anthropogenic CO_2 emissions).

8. *See* O. Aumont & L. Bopp, *Globalizing Results from Ocean In Situ Iron Fertilization Studies*, 20 GLOBAL BIOGEOCHEMICAL CYCLES GB2017, 13 (2006) (concluding that factors other than iron also influence effectiveness of sequestration and that fertilization outside the Southern Ocean is relatively ineffective); Philip W. Boyd et al., *Mesoscale Iron Enrichment Experiments 1993–2005: Synthesis and*

fertilizing the ocean with iron appears to stimulate the growth of toxic phytoplankton species in particular, with potentially fatal effects on marine animals.[9] The limited investigative efforts to date can reveal only some of the risks of ocean fertilization; the full-scale deployment needed to substantially affect GHG levels could have additional, unforeseen consequences for ocean chemistry and marine ecosystems.[10]

Stratospheric aerosol deployment would involve spraying tiny particles into the stratosphere with the aim of reflecting more sunlight into space and thereby cooling the Earth.[11] In theory—and in contrast to CDR—such a technique would have a fairly rapid cooling effect.[12] However, technical and logistical barriers to implementing stratospheric aerosol release, including selection of sufficiently effective particles and design of specialized aircraft or other mechanisms for releasing the particles, are far from resolved.[13] Furthermore, the technique has serious drawbacks, including modification of the Asian and African summer monsoons.[14] Altering monsoons and other regional climate patterns could have potentially catastrophic ramifications on food supplies for billions of people.[15] Another shortcoming of stratospheric aerosols and other SRM techniques is that they do nothing to address the problem of ocean acidification, which is caused by rising GHG levels in the atmosphere.[16] Increased ocean acidity could destroy many of the Earth's coral

Future Directions, 315 SCI. 612, 612 (2007) (summarizing results of small-scale iron fertilization experiments); Ken O. Buesseler & Philip W. Boyd, *Will Ocean Fertilization Work?*, 300 SCI. 67, 68 (2003).

9. *See* Mary W. Silver et al., *Toxic Diatoms and Domoic Acid in Natural and Iron Enriched Waters of the Oceanic Pacific*, 107 PROC. NAT'L ACAD. SCI. 20,762, 20,762 (2010).

10. *See* Aaron Strong et al., *Ocean Fertilization: Time to Move On*, 461 NATURE 347, 347–48 (2009); THE ROYAL SOC'Y, *supra* note 4, at 17–18.

11. *See* Paul Crutzen, *Albedo Enhancement By Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?*, 77 CLIMATIC CHANGE 211, 211–12 (2006); Alan Robock et al., *Benefits, Risks, and Costs of Stratospheric Geoengineering*, GEOPHYSICAL RES. LETTERS, Oct. 2, 2009, L19703, at 3–7.

12. *See* THE ROYAL SOC'Y, *supra* note 4, at 31.

13. *See id.*; Richard P. Turco & Fangqun Yu, *Geoengineering the Stratospheric Sulfate Aerosol Layer to Offset Global Warming May Not Be Feasible* (Dec. 17, 2008) (unpublished manuscript) (on file with the Ecology Law Quarterly) (explaining that properties of injected aerosol would be far from ideal for blocking radiation).

14. *See* Alan Robock et al., *Regional Climate Responses to Geoengineering with Tropical and Arctic SO_2 Injections*, J. GEOPHYSICAL RES., Aug. 16, 2008, D16101, at 1; Simone Tilmes et al., *The Sensitivity of Polar Ozone Depletion to Proposed Geoengineering Schemes*, 320 SCI. 1201, 1203–04 (2008) (discussing how stratospheric aerosols would exacerbate depletion of protective ozone layer); THE ROYAL SOC'Y, *supra* note 4, at 31 (noting a "range of so far unexplored feedback processes"); Oliver Morton, *Climate Change: Is This What It Takes to Save the World?*, 447 NATURE 132, 135 (2007) (remarking that the stratosphere "is tied to the troposphere below in complex ways that greenhouse warming is already changing").

15. Robock et al., *supra* note 14, at 1, 13.

16. *See* THE ROYAL SOC'Y, *supra* note 4, at 36.

reefs, which serve as important marine habitats.[17] SRM techniques also involve a so-called "termination problem." Once initiated, effective SRM implementation would need to continue for perhaps several hundred years in order to avoid an abrupt temperature rebound. Serious questions surround the international community's ability to sustain such a prolonged and demanding effort. Were such efforts to cease or fail, there would follow extremely swift and dramatic climate change to which human societies and natural ecosystems would have insufficient time to adapt.[18]

Several aspects of geoengineering research and deployment, including the possibility of moral hazard, warrant attention to global governance. On the one hand, some researchers have voiced worries that important research projects are not moving forward, thanks to public concern combined with the absence of an accepted governance structure for geoengineering research.[19] On the other hand, unregulated research projects could have undesirable and unexpected effects on ecosystems and human livelihoods.[20] Beyond research, an individual nation or even a private actor might undertake full-scale deployment of geoengineering unilaterally, potentially precipitating international conflict.[21] The moral hazard concern highlights relationships between geoengineering research and geoengineering deployment, and more broadly between geoengineering and other methods of responding to climate change.

How exactly might geoengineering pose a moral hazard? Although geoengineering might ameliorate some of climate change's most severe impacts, experts generally agree that it is no substitute for mitigation and adaptation.[22] At best, geoengineering would offer only a partial response to climate change: ocean fertilization can absorb no more than a fraction of the GHGs contributing to climate change, and SRM cannot address into perpetuity all the effects associated with higher atmospheric GHG concentrations.

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17. *See* Ken Caldeira & Michael E. Wickett, *Ocean Model Predictions of Chemistry Changes from Carbon Dioxide Emissions to the Atmosphere and Ocean*, J. GEOPHYSICAL RES., Sept. 21, 2005, C09S04, at 1; Elizabeth Kolbert, *The Darkening Sea*, THE NEW YORKER, Nov. 20, 2006, at 66, 69–74.

18. *See* H. Damon Matthews & Ken Caldeira, *Transient Climate—Carbon Simulations of Planetary Geoengineering*, 104 PROC. NAT'L ACAD. SCI. 9949, 9951–52 (2007) (describing how temperatures, previously suppressed by aerosols, would quickly rebound to the levels they would have reached had no geoengineering been implemented).

19. *See* Edward A. Parson & David W. Keith, *End the Deadlock on Governance of Geoengineering Research*, 339 SCI. 1278, 1278–79 (2013).

20. Edward A. Parson & Lia N. Ernst, *International Governance of Climate Engineering*, 14 THEORETICAL INQUIRIES L. 307, 325–27 (2013).

21. *See* Daniel Bodansky, *The Who, What, and Wherefore of Geoengineering Governance*, CLIMATIC CHANGE (Apr. 2013), http://link.springer.com/article/10.1007%2Fs10584-013-0759-7# (exploring such scenarios); Parson & Ernst, *supra* note 20, at 330.

22. *See, e.g.*, Asilomar Int'l Conference on Climate Intervention Techs., *Statement from the Conference's Scientific Organizing Committee*, THE CLIMATE RESPONSE FUND (Mar. 26, 2010), http://climateresponsefund.org/index.php?option=com_content%20&view=article&id=152&Itemid=89; THE ROYAL SOC'Y, *supra* note 4, at ix ("No geoengineering method can provide an easy or readily acceptable alternative solution to the problem of climate change."); Martin Bunzl, *Researching Geoengineering: Should Not or Could Not?*, ENVTL. RES. LETTERS, Oct. 30, 2009, 045104, at 2.

Moreover, geoengineering involves grave uncertainties and potential hazards.[23] Indeed, even geoengineering's strongest supporters in the scientific community agree that mitigation remains essential whether geoengineering efforts proceed.[24] At the same time, attention to geoengineering is increasing and support for geoengineering research is building.[25]

The moral hazard concern is that research and development in geoengineering may undermine public and political support for mitigation and adaptation, notwithstanding geoengineering's limitations.[26] Put differently, geoengineering could be inaccurately perceived as a comprehensive insurance policy against climate change. This misperception could create various incentives that would exacerbate the problems that geoengineering is intended to ameliorate. Individuals might curb voluntary efforts to reduce carbon emissions. Fossil fuel consumption and other GHG-generating behaviors might even increase out of a misguided belief that climate change no longer poses a threat. Societies might divert resources away from mitigation toward geoengineering schemes that ultimately prove futile or unworkable. Finally, political and financial support for mitigation and adaptation policies might decline.[27]

Moral hazard concerns have most often surrounded the more drastic geoengineering techniques, such as ocean fertilization and stratospheric aerosol deployment.[28] Accordingly, unless otherwise specified, this Article uses the term geoengineering to refer to these techniques and assesses the moral hazard they might present. Part II of this Article considers climate adaptation as a case study that suggests how public attitudes towards geoengineering might develop. Part III explains the concept of moral hazard as developed by the insurance industry and economists, and surveys empirical evidence of moral hazard in a

23. *See* THE ROYAL SOC'Y, *supra* note 4, at ix.

24. *See, e.g.*, ASILOMAR SCIENTIFIC ORG. COMM., THE ASILOMAR CONFERENCE RECOMMENDATIONS ON PRINCIPLES FOR RESEARCH INTO CLIMATE ENGINEERING TECHNIQUES 7 (2010) [hereinafter ASILOMAR RECOMMENDATIONS]; T.M.L. Wigley, *A Combined Mitigation/Geoengineering Approach to Climate Stabilization*, 314 SCI. 452, 452 (2006) ("Mitigation is therefore necessary, but geoengineering could provide additional time to address the economic and technological challenges faced by a mitigation-only approach."); David W. Keith, *Why Capture CO_2 from the Atmosphere?*, 325 SCI. 1654, 1654 (2009) (advocating CDR research while emphasizing that "[i]n the near term, efforts to limit climate risk should focus on reducing emissions").

25. *See* ASILOMAR RECOMMENDATIONS, *supra* note 24, at 7, 15; Asilomar Int'l Conference on Climate Intervention Techs., *supra* note 22; THE ROYAL SOC'Y, *supra* note 4, at 57.

26. *See, e.g.*, Max H. Bazerman, *Climate Change as a Predictable Surprise*, 77 CLIMATIC CHANGE 179, 184 (2006) ("[T]he likely illusory belief that a new technology will emerge to solve the problem [of climate change] creates a continuing excuse for the failure to act.").

27. For a more systematic cataloguing of possible moral hazard concerns, see Ben Hale, *The World That Would Have Been: Moral Hazard Arguments Against Geoengineering*, *in* ENGINEERING THE CLIMATE: THE ETHICS OF SOLAR RADIATION MANAGEMENT 113 (Christopher J. Preston ed., 2012).

28. The term geoengineering also encompasses other techniques that involve lesser risks. Painting roofs white on a massive scale, for example, is likely to be comparably benign so far as adverse environmental impacts are concerned, but such techniques promise only a modest effect in countering climate change.

variety of other contexts. In addition, Part III introduces the related concept of risk compensation, which is also pertinent in analyzing how the public and policymakers might respond to geoengineering. Part IV examines moral hazard and risk compensation in the specific context of geoengineering policy. Acknowledging that direct and reliable empirical evidence in this area will be hard to come by, the Article turns to indirect means of analyzing the issue. Part V discusses biases and other psychological mechanisms that are likely to affect perceptions of geoengineering risk. Part VI concludes that the moral hazard of geoengineering should be taken seriously, and Part VII reflects on implications for future geoengineering policy.

II. ATTITUDES TOWARD ADAPTATION: A FORESHADOWING OF ATTITUDES TOWARDS GEOENGINEERING?

Concerns regarding moral hazard in climate policy discussions are not unique to geoengineering. Policymakers once avoided active discussion of climate adaptation for fear of diverting attention away from mitigation.[29] The fear that actively considering adaptation would create a moral hazard has since dissipated, however. Policymakers' initial reluctance to consider adaptation first gave way to grudging acknowledgment and subsequently to full acceptance. Adaptation is now unquestioned as an essential element of climate policy. While it is difficult to determine the factors that have led to these changes in perception, the history of adaptation policy offers hints as to how public perceptions of geoengineering might develop.

A. Initial Reluctance to Consider Adaptation

Adaptation refers to adjustments in natural or human systems in response to the actual or expected effects of climate change.[30] Adaptation can reduce the damage caused by climate change, but it cannot prevent climate change. Moreover, adaptation offers neither a complete nor permanent solution to the

29. Moral hazard concerns also have been raised with respect to carbon capture and storage (CCS). CCS refers to the underground storage of CO_2 generated in fossil fuel combustion and industrial processes, so as to prevent its release into the atmosphere. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CARBON DIOXIDE CAPTURE AND STORAGE, SUMMARY FOR POLICYMAKERS 3 (2005). Moral hazard concerns associated with CCS include enabling further fossil fuel use and diverting resources away from renewable energy development. *See* Paul Baer, *An Issue of Scenarios: Carbon Sequestration as Investment and the Distribution of Risk*, 59 CLIMATIC CHANGE 283, 287 (2003). Though sometimes characterized as a type of mitigation, CCS is not a perfect substitute for mitigation. *See, e.g.*, *id.* at 289. Sequestered carbon may leak into the air, and the sequestration process itself generates additional carbon emissions. Klaus Keller et al., *Carbon Dioxide Sequestration: How Much and When?*, 88 CLIMATIC CHANGE 267, 268 (2008); INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra*, at 4 (explaining that a power plant equipped with CCS requires 10–40 percent additional energy to capture and compress CO_2).

30. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 1, at 869.

problem.[31] The ability to adapt varies widely across and within societies. Poor populations, which are especially vulnerable to climate change, tend to be the least equipped to adapt. Additionally, for some threatened species and ecosystems, adaptation to rapid change simply is not possible.[32]

As a climate policy option, adaptation sometimes is said to be "a decade behind" mitigation, which has been the main subject of policy discussions.[33] The United Nations Framework Convention on Climate Change process in particular has focused on mitigation.[34] During the early part of that process, adaptation was viewed only "as a long-term strategy that should be undertaken once the effects of climate change were more evident."[35] In the United States as well, preoccupation with mitigation led to neglect of adaptation, which was characterized as "unacceptable [and] even politically incorrect."[36]

The focus on mitigation resulted in part from the practical difficulties of crafting adaptation strategies, including the need for detailed information about future conditions.[37] Equally important was the concern that adaptation would undermine support for mitigation.[38] Indeed, policymakers shied away from

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31. *See* Ian Burton et al., *From Impacts Assessment to Adaptation Priorities: The Shaping of Adaptation Policy*, *in* THE EARTHSCAN READER ON ADAPTATION TO CLIMATE CHANGE 377, 379 (E. Lisa F. Schipper & Ian Burton eds., 2009); INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY, SUMMARY FOR POLICYMAKERS 19 (explaining that adaptation cannot cope with all projected effects of climate change, especially over the long term).

32. *See* DAVID HUNTER ET AL., INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 671 (4th ed. 2010); Steve Rayner & Elizabeth L. Malone, *Social Science Insights into Climate Change*, *in* HUMAN CHOICE & CLIMATE CHANGE—VOLUME 4: WHAT HAVE WE LEARNED? 71, 94–95 (Steve Rayner & Elizabeth L. Malone eds., 1998).

33. SIVAN KARTHA ET AL., ADAPTATION AS A STRATEGIC ISSUE IN CLIMATE NEGOTIATIONS, EUROPEAN CLIMATE PLATFORM REPORT #3 4 (2006); *see also* GWYN PRINS ET AL., THE HARTWELL PAPER: A NEW DIRECTION FOR CLIMATE POLICY AFTER THE CRASH OF 2009 14 (2010) (describing adaptation as the "poor and derided cousin of emissions reduction").

34. *See generally* E. Lisa F. Schipper, *Conceptual History of Adaptation in the UNFCCC Process*, *in* THE EARTHSCAN READER ON ADAPTATION TO CLIMATE CHANGE, *supra* note 31, at 359, 359–60 (discussing the UNFCCC's initial focus on mitigation). Although the Framework Convention obligates parties to develop measures to facilitate adaptation, the agreement's clear emphasis is on mitigation. *See* United Nations Framework Convention on Climate Change arts. 2, 4.1(b), (e), 4.2, May 9, 1992, S. Treaty Doc. No. 102–38, 1771 U.N.T.S. 164. The Kyoto Protocol, a supplemental agreement to the Framework Convention, concentrates on emissions reductions, particularly among industrialized countries. Kyoto Protocol to the United Nations Framework Convention on Climate Change arts. 3, 4, Dec. 10, 1997, U.N. Doc. FCCC/CP/1997/L.7/ADD.1, 37 I.L.M. 32.

35. Schipper, *supra* note 34, at 362.

36. Ian Burton, *Deconstructing Adaptation . . . and Reconstructing*, *in* THE EARTHSCAN READER ON ADAPTATION TO CLIMATE CHANGE, *supra* note 31, at 11; *see also* J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363, 365–66 (2010).

37. Roger A. Pielke, Jr., *Rethinking the Role of Adaptation in Climate Policy*, 8 GLOBAL ENVTL. CHANGE 159, 162 (1998); E. Lisa F. Schipper & Ian Burton, *Understanding Adaptation: Origins, Concepts, Practice and Policy*, *in* THE EARTHSCAN READER ON ADAPTATION TO CLIMATE CHANGE, *supra* note 31, at 1, 7.

38. *See* ANTHONY GIDDENS, THE POLITICS OF CLIMATE CHANGE 162 (2009) ("[D]iscussing adaptation was taboo among environmentalists, on the grounds that it would adversely affect efforts directed at combating climate change itself."); MARCO GRASSO, JUSTICE IN FUNDING ADAPTATION

discussing adaptation to avoid even the appearance of being opposed to mitigation.[39] More specifically, as economists Sally Kane and Jason Shogren explain, there was a concern that "[t]he prospect of future adaptation might lull some fraction of society into downplaying the need for mitigation."[40] The fear was that societies might direct resources away from mitigation toward adaptation, or away from climate policy completely.[41] Focusing on adaptation at mitigation's expense, Kane and Shogren note, "would undercut effective risk reduction over time if the actual path of climate change makes future adaptation less effective and much more expensive than expected."[42]

Such concerns were not unfounded and remain relevant today. Adaptation presents a more uncertain course than mitigation. Adapting to a world of climate extremes requires "dealing with sudden, unpredictable, large-scale impacts which descend at random on particular individuals, communities, regions, and industries."[43] Mitigation, in contrast, entails more "gradual, predictable, [and] incremental" costs to individuals and societies.[44] Furthermore, failure to mitigate, even in the short-term, might lead to irreversible consequences. No adaptive response is possible for species extinction and other permanent effects. These important distinctions between mitigation and adaptation may be lost, however, if one focuses solely on comparing their costs. Mitigation and adaptation are simply not fungible. In the long-term, adaptation does not offer a permanent solution to global warming, and mitigation is essential.[45]

In addition to moral hazard concerns, another reason for the reluctance to consider adaptation was the view that it constituted a "defeatist" option.[46] Whereas mitigation was framed as "active, combatting, [and] controlling," adaptation suffered from its characterization as "passive, resigned, accepting," and weak.[47] Consistent with this predominant view, in 1992 then-Senator Al Gore derided adaptation as "a kind of laziness."[48] Adaptation requires

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UNDER THE INTERNATIONAL CLIMATE CHANGE REGIME 13 (2010) (discussing the concern that "adaptation weakens the willingness to control GHG and thus ultimately crowds out mitigation initiatives"); Rayner & Malone, *supra* note 32, at 94 (noting fear that "discussion of the possibility of adaptation will attenuate the pressure to reduce emissions"); Burton, *supra* note 36, at 12.

39. Pielke, *supra* note 37, at 162.

40. Sally Kane & Jason F. Shogren, *Linking Adaptation and Mitigation in Climate Change Policy*, 45 CLIMATIC CHANGE 75, 94 (2000).

41. *Cf. id.* (noting argument "that future societies are better off spending future dollars on adaptation when information on the net effects of climate change is more refined").

42. *Id.*

43. Stephen M. Gardiner, *Ethics and Global Climate Change*, 114 ETHICS 555, 574 (2004).

44. *Id.*

45. *See* Burton et al., *supra* note 31, at 379.

46. *See* Schipper, *supra* note 34, at 361–62; Richard S.J. Tol, *Adaptation and Mitigation: Trade-Offs in Substance and Methods*, 8 ENVTL. SCI. & POL'Y 572, 572 (2005) ("For a long time, it was politically incorrect to speak about adaptation to climate change because it presumably implies accepting defeat in the battle against evil emissions.").

47. Burton, *supra* note 36, at 12.

48. AL GORE, EARTH IN THE BALANCE: ECOLOGY AND THE HUMAN SPIRIT 240 (1992).

substantial effort and resources, of course, but the underlying premise for adaptation—that harmful levels of climate change are unavoidable—was psychologically difficult to accept.

B. Subsequent Acceptance of Adaptation

Notwithstanding the earlier taboo on adaptation,[49] climate policymakers have now come to accept adaptation as a policy option co-equal with mitigation.[50] Adaptation efforts have begun and are now widely acknowledged as essential to address climate vulnerability.[51] Perhaps the leading factor behind the widespread acceptance of adaptation today is the growing recognition that climate impacts are occurring and will only worsen.[52] Past GHG emissions have committed us to inevitable warming in the future, and atmospheric GHGs concentrations will continue to rise for some time even under the most optimistic mitigation scenarios.[53] In addition, adverse impacts of climate change are occurring sooner than many experts previously anticipated.[54]

Meanwhile, mitigation efforts have largely stalled. Years of international negotiations have failed to produce agreement on emission reductions of the magnitude necessary to avoid dangerous levels of climate change.[55] Addressing climate change primarily through mitigation presents a very challenging problem requiring global collective action.[56] Many of the specific measures needed to substantially reduce emissions have encountered political and psychological resistance. Improvements in energy efficiency and low-carbon technologies alone are unlikely to yield the reductions needed. Parties

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49. *See* Roger Pielke, Jr. et al., *Lifting the Taboo on Adaptation*, 445 NATURE 597, 597 (2007) (criticizing taboo on discussion of adaptation).

50. *See* Schipper, *supra* note 34, at 370–71; Shardul Agrawala & Samuel Fankhauser, *Putting Climate Change Adaptation in an Economic Context*, *in* ECONOMIC ASPECTS OF ADAPTATION TO CLIMATE CHANGE: COSTS, BENEFITS AND POLICY INSTRUMENTS 19, 20 (Shardul Agrawala & Samuel Fankhauser eds., 2008) (describing adaptation "as an equally important and complementary response to greenhouse gas (GHG) mitigation").

51. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 31, at 19; GIDDENS, *supra* note 38, at 162. *See also* Robert R.M. Verchick, *Adaptation, Economics, and Justice*, *in* ECONOMIC THOUGHT AND U.S. CLIMATE CHANGE POLICY 277, 280–82 (David M. Driesen ed., 2010) (discussing current international, national, and local adaptation efforts).

52. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 31, at 19, 20; GRASSO, *supra* note 38, at 16.

53. *See* Pielke et al., *supra* note 49, at 597; Gardiner, *supra* note 43, at 573.

54. *See* HUNTER ET AL., *supra* note 32, at 667; *see also* Pielke et al., *supra* note 49, at 597 (noting increasing vulnerability to climate-related impacts).

55. The latest round of climate negotiations, held in Durban, South Africa in December 2011, failed to produce a successor agreement to the 1997 Kyoto Protocol, which had established modest GHG emissions caps for certain countries, applicable for a five-year period ending in 2012. The Durban summit produced only an agreement to adopt by 2015 a binding mitigation regime that would become effective in 2020. Eric J. Lyman, *After Marathon Talks, Countries Set Goal for New Climate Deal in Effect Around 2020*, 42 ENV'T REP. 2859 (2011).

56. *See infra* text accompanying notes 157–158.

expecting to bear much of the costs of mitigation have blocked most efforts to establish mitigation requirements.[57] Lifestyle sacrifices also may be necessary, but the political will to seek or impose them has been absent.

Has the possibility of adaptation undermined mitigation efforts, and might geoengineering have a similar effect? Policymakers essentially took adaptation off the table during the 1990s, focusing instead on mitigation. Consequently, we have limited data on whether adaptation has created a moral hazard. Mitigation has faltered on its own, and it is difficult to determine whether adaptation undermined—or would have undermined—it. This is not to say, however, that moral hazard concerns surrounding adaptation have dissipated. Developing countries such as India and China, which now face rising pressure to reduce their own emissions, have found adaptation "a convenient topic to take the focus off mitigation."[58] Indeed, while mitigation and adaptation are complementary in the sense that they can be deployed together, they inevitably involve tradeoffs in a world of limited resources.[59] Moreover, the long-term commitments involved in climate policy choices hint at the danger that adaptation can become a self-fulfilling prophecy. Today's decisions not to mitigate, reflected for example in continued construction of coal-fired power plants, commit us not only to future emissions but also to future adaptation measures.[60]

A comparison of adaptation and geoengineering suggests that geoengineering may carry a greater danger of moral hazard. In contrast to adaptation, which is unlikely to be seen or characterized as more than a partial response to climate change, geoengineering suggests the possibility of a relatively painless technological fix. Susceptible to framing as an active, triumphalist response to climate change, geoengineering is likely to appeal to persons and interests that are skeptical of climate change and efforts to mitigate it.[61] At the same time, geoengineering's uncertainties and shortcomings may well be lost amidst simplistic assertions about its dramatic effects and low costs.

Notwithstanding these concerns, the possibility that we may ultimately face a stark choice between unabated climate change and highly imperfect geoengineering measures has led some to suggest that open consideration of geoengineering today would *improve* the prospects for effective mitigation by shocking policymakers and the public into redoubling mitigation efforts.[62] The history of attitudes toward adaptation, however, warrants broad skepticism toward this counterintuitive claim. The prospect of having to adapt to flooded shorelines, greater climate extremes, and other devastating impacts of climate

57. *See* Ruhl, *supra* note 36, at 368.
58. Schipper, *supra* note 34, at 370.
59. *See* Pielke, *supra* note 49, at 167.
60. *Cf.* Gardiner, *supra* note 43, at 574.
61. *See infra* Part V.B.
62. *See infra* text accompanying note 113.

change has not prompted a rush to mitigate. The complete absence of any such effect casts doubt on speculation that grandiose yet seemingly affordable proposals to release stratospheric aerosols or fertilize the oceans will bolster support for mitigation, either. Rather, it is far more likely that geoengineering proposals will be perceived—at least by some—as a simple solution to climate change. In a remark demonstrating geoengineering's potential allure, economist and *Freakonomics* co-author Steven Levitt flatly contends that geoengineering "could end [the climate] debate" and allow humanity to "move on to problems that are harder to solve."[63]

III. MORAL HAZARD AND RISK COMPENSATION

To investigate more closely the moral hazard geoengineering may involve, it is useful to revisit the concept of moral hazard as originally developed in the insurance context and to review empirical evidence of moral hazard.

A. Moral Hazard

1. Background

In the insurance industry, moral hazard refers to "the tendency for insurance against loss to reduce incentives to prevent or minimize the cost of loss."[64] For example, a homeowner covered by fire insurance may take fewer precautions to reduce the risk of fire, or a shopkeeper insured against theft may fail to lock his doors when he steps into the back office. More generally, economists employ moral hazard to refer to the tendency for policy measures that ameliorate the consequences of socially undesirable behavior to encourage such behavior.[65] Welfare, workers' compensation, and the rescue of banks "too big to fail" are just some examples of well-meaning policies that can create perverse incentives.[66] For mainstream economists, moral hazard is problematic because it may prevent markets from achieving socially optimal outcomes.[67]

63. Oliver Burkeman, *Asking People to Reduce Their Carbon Emissions Is a Noble Invitation, but As Incentives Go, It Isn't a Strong One*, THE GUARDIAN, Oct. 11, 2009, § G2, at 6.

64. Tom Baker, *On the Genealogy of Moral Hazard*, 75 TEX. L. REV. 237, 239 (1996); *see also* CAROL A. HEIMER, REACTIVE RISK AND RATIONAL ACTION: MANAGING MORAL HAZARD IN INSURANCE CONTRACTS 35 (1985) (characterizing moral hazard "in terms of the separation of policyholders' incentives to prevent loss from their control over loss prevention").

65. *See* Baker, *supra* note 64, at 238 (quoting investment advisor James Glassman on the point that "if you cushion the consequences of bad behavior, then you encourage that bad behavior"); Kenneth J. Arrow, *Uncertainty and the Welfare Economics of Medical Care*, 53 AM. ECON. REV. 941, 961 (1963).

66. *See generally* Baker, *supra* note 64, at 237–39 (discussing moral hazard in relation to well-meaning policies).

67. *See* Sheila C. Dow, Moral Hazard and the Banking Crisis 7 (Oct. 2010) (unpublished manuscript), *available at* http://www.boeckler.de/pdf/v_2010_10_29_dow.pdf; Bengt Holmstrom, *Moral Hazard and Observability*, 10 BELL J. ECON. 74, 74 (1979). Although mainstream economic

Although insurance and other forms of risk-sharing can facilitate socially desirable risk-taking,[68] rational responses to the incentives created by transferring risk can also undermine well-meaning policies and generate unintended consequences.[69]

Several assumptions regarding the beliefs and behaviors of insureds underlie predictions of moral hazard. First, it is assumed that insureds act in an economically rational manner.[70] Based on this assumption, one can expect reduced exposure to losses from risky behavior to create an incentive to engage in greater risk-taking. Second, insureds are presumed to control the level of care taken against adverse events.[71] Insureds who lack such control cannot engage in riskier behavior even if insurance might give them an incentive to do so. Finally, insurance has moral hazard effects to the extent that insureds perceive money to compensate adequately for loss.[72] If insureds are not made whole by insurance proceeds, there remains at least some incentive to exercise care. These assumptions apply not only to moral hazards faced by insureds, but also to the broader universe of perverse incentives that constitute moral hazard.[73]

The preceding assumptions may not be warranted in all situations, however. As psychology studies demonstrate, people often respond to risk in ways that depart from the predictions of rational actor models.[74] Insureds may lack control over exposure to risk: workers often have little say over occupational risks, for example, and consumers may have less control over product risks than manufacturers.[75] Furthermore, money provides only partial compensation for loss in the case of death or serious personal injury.[76] To accurately assess whether a specific situation will present a moral hazard, one must consider whether the assumptions underlying moral hazard are satisfied.[77]

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theory is sometimes characterized as a positive, value-free form of analysis, it implies a consequentialist approach to decision making. Dow, *supra*, at 5–7.

68. *See* Benjamin Hale, *What's So Moral About Moral Hazard?*, 23 PUB. AFF. Q. 1, 10 (2009) (describing how moral hazard is not a negative phenomenon).

69. *See* Richard J. Arnott & Joseph E. Stiglitz, *The Basic Analytics of Moral Hazard*, 90 SCANDINAVIAN J. ECON. 383, 384 (1988) (explaining that moral hazard involves a trade-off between incentives and risk-bearing).

70. *See* Dow, *supra* note 67, at 2; Baker, *supra* note 64, at 276–77.

71. *See* Baker, *supra* note 64, at 279–80.

72. *See id.* at 276–77.

73. *See id.* at 272–76.

74. *See infra* Part V.

75. *See* Baker, *supra* note 64, at 280.

76. *See id.* at 278.

77. As the term "moral" suggests, the concept of moral hazard may carry subjective connotations as well. To engage in behavior constituting a moral hazard is sometimes deemed immoral. *See generally* Hale, *supra* note 68, at 8–20 (considering and rejecting common arguments suggesting that moral hazard induces behavior that is immoral). Popular attitudes disapproving of "welfare queens" and bank bailouts, for example, suggest a social judgment that actors who take advantage of insurance and social safety nets are morally compromised. Indeed, the concept of moral hazard was originally introduced to shore up the moral legitimacy of the insurance enterprise: Insurance companies refused to insure "moral

2. Empirical Evidence

Researchers have found evidence of moral hazard in an astonishing variety of contexts. As empirical studies reveal, people do change their behaviors in response to insurance coverage. More generally, people respond rationally to incentives that cushion adverse consequences of socially suboptimal behavior. The existence of this substantial body of evidence warrants a presumption that geoengineering likewise will have moral hazard effects.

There is strong empirical evidence, for example, that health insurance coverage leads to increased demand for medical care.[78] Similarly, utilization of medical services is positively correlated with the proportion of costs covered by insurance.[79] These findings reflect insurance's ex post effect on behavior: once people become ill, the availability of insurance increases consumption of health care. Health insurance coverage also affects behavior ex ante. While the evidence here is more limited, it indicates that unhealthy behaviors increase and preventive efforts decrease with the presence of insurance coverage.[80]

Workers' compensation insurance also generates moral hazard effects. Increases in benefits are associated with increases in both the duration of claims and the reporting of accidents.[81] Interestingly, *actual* injury rates do not necessarily correspond with workers' compensation coverage.[82] The absence of this specific moral hazard effect has been attributed to the use of experience rating to set employer premiums.[83] Because employers with poor safety records pay higher rates for coverage, employers face a continued incentive to provide for workplace safety notwithstanding insurance coverage.[84]

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hazards"—people of bad character—and they structured insurance contracts so as to avoid creating moral hazards—i.e., temptations for people of good character to do wrong. *See* Baker, *supra* note 64, at 239–41. In considering moral hazard, this Article focuses on analyzing direct behavioral responses to geoengineering, rather than the social valence that may be associated with those responses.

78. *See* Peter Zweifel & Willard G. Manning, *Moral Hazard and Consumer Incentives in Health Care*, *in* 1 HANDBOOK OF HEALTH ECONOMICS 409, 410, 454 (A.J. Culyer & J.P. Newhouse eds., 2000); Eric French & Kirti Kamboj, *Analyzing the Relationship Between Health Insurance, Health Costs, and Health Care Utilization*, 26 ECON. PERSP. 60, 66 (2002).

79. *See* Willard G. Manning et al., *Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment*, 77 AM. ECON. REV. 251, 258 (1987).

80. *See* Dhaval Dave & Robert Kaestner, *Health Insurance and Ex Ante Moral Hazard: Evidence from Medicare* 24–25 (Nat'l Bureau of Econ. Research, Working Paper No. 12764, 2006) (finding that receipt of Medicare increased unhealthy behaviors among elderly males, after controlling for effect of increased physician visits on such behavior); Jonathan Klick & Thomas Stratmann, *Diabetes Treatments and Moral Hazard*, 50 J.L. & ECON. 519, 527–28 (2007) (finding a small but statistically significant correlation between state-mandated health insurance coverage for treatment of diabetics and higher body mass index).

81. *See* Denis Bolduc et al., *Workers' Compensation, Moral Hazard and the Composition of Workplace Injuries*, 37 J. HUM. RESOURCES 623, 625 (2002) (summarizing studies).

82. *See* Richard J. Butler & John D. Worrall, *Claims Reporting and Risk Bearing Moral Hazard in Workers' Compensation*, 58 J. RISK & INS. 191, 202 (1991).

83. *See id.* at 201–02; John W. Ruser, *Workers' Compensation and Occupational Injuries and Illnesses*, 9 J. LAB. & ECON. 325, 347–48 (1991).

84. *See* Ruser, *supra* note 83, at 326.

Compulsory automobile insurance similarly has been found to create a moral hazard: one study found a two percent increase in traffic fatalities for each percentage point decrease in the number of uninsured motorists.[85] Other studies of automobile insurance have found weaker, but nonetheless statistically significant, moral hazard effects. These weaker effects are attributed to the fact that money does not fully compensate for injuries that insured drivers may suffer.[86] In addition, good driver discounts and other forms of experience rating may further ameliorate moral hazard.

Moral hazard has also been studied in connection with flood insurance and disaster relief. The National Flood Insurance Program mandates flood insurance for floodplain property owners who obtain mortgages from federally regulated institutions.[87] The program is intended to encourage landowners, developers, and regulators to consider flood risks as they make decisions about land use and property acquisition.[88] Development in flood-prone areas apparently has increased as a result of the program, however.[89] Furthermore, government subsidization of flood insurance for existing structures has facilitated the continued use and occupancy of at-risk properties.[90] An additional source of moral hazard in this context is disaster relief, which, like flood insurance, provides a cushion against loss.[91]

Empirical evidence of moral hazard is not limited to insureds. Humanitarian intervention to protect vulnerable groups against state-perpetrated genocide can foster expectations of future intervention; such expectations apparently lead rebel groups to take risks that they otherwise would not have taken.[92] Moral hazard also appears in a variety of guises in the

85. *See* Alma Cohen & Rajeev Dehejia, *The Effect of Automobile Insurance and Accident Liability Laws on Traffic Fatalities*, 47 J.L. & ECON. 357, 388 (2004) (also noting that increased fatalities due to increase in number of insureds is partly offset by more careful driving by those who choose to remain uninsured). No-fault limitations on liability, which limit the extent to which drivers can be sued, were also found to have a moral hazard effect of increasing fatalities. *See id.* at 359–60.

86. *See* Baker, *supra* note 64, at 285.

87. *See* FED. EMERGENCY MGMT. AGENCY, NATIONAL FLOOD INSURANCE PROGRAM: PROGRAM DESCRIPTION 30–31 (2002).

88. *See* Raymond J. Burby, *Flood Insurance and Floodplain Management: The US Experience*, 3 ENVTL. HAZARDS 111, 112–13 (2001).

89. *See id.* at 116–17. *See also* Raymond J. Burby, *Hurricane Katrina and the Paradoxes of Government Disaster Policy: Bringing About Wise Governmental Decisions for Hazardous Areas*, 604 ANNALS AM. ACAD. POL. & SOC. SCI. 171, 173–76 (2006) (discussing how federal "safe development" policies, including federal flood insurance and levee construction, facilitated development of low-lying, flood-prone areas in New Orleans area); Jian Wen, Essays on Adverse Selection and Moral Hazard in Insurance Market 120 (Aug. 1, 2010) (unpublished Ph.D. dissertation, Georgia State University), *available at* http://digitalarchive.gsu.edu/cgi/viewcontent.cgi?article=1024&context=rmi_diss (finding establishment of national flood insurance to be positively correlated with population growth in flood-prone areas of Florida).

90. *See* Burby, *supra* note 88, at 117–18.

91. *See* Robert McLeman & Barry Smit, *Vulnerability to Climate Change Hazards and Risks: Crop and Flood Insurance*, 50 CAN. GEOGRAPHER 217, 223 (2006).

92. *See* Alan J. Kuperman, *The Moral Hazard of Humanitarian Intervention: Lessons from the Balkans*, 52 INT'L STUD. Q. 49, 51 (2008).

financial arena. Federal guarantees of bank deposits have greatly reduced bank runs and thereby strengthened the financial system. Unfortunately, they also have encouraged insured institutions to take excessive risks in investing the proceeds of those deposits.[93] International bailouts of debtor countries have caused investors to disregard the risks associated with investing in specific countries and perhaps contributed to over-borrowing by such countries.[94] Government bailouts of financial institutions deemed "too big to fail" and implied promises of future bailouts have had a similar effect of promoting excessive risk-taking.[95] Indeed, the recent global financial crisis is steeped in moral hazard: banks were more willing to make subprime mortgage loans to high-risk borrowers because the banks could largely pass on the risks of those loans by selling them;[96] investment bankers sought to maximize revenue—and their own bonuses—through highly leveraged investments whose downside risks would be borne by others;[97] and credit rating agencies vying for the business of investment banks provided excessively favorable ratings to the banks' securities.[98]

In sum, moral hazard is pervasive. Its effects may be ameliorated in some situations, as where insureds continue to bear substantial risk or where insureds lack full control of the risk of injury.[99] Nonetheless, evidence from a wide range of circumstances demonstrates that individuals, institutions, and societies generally act in riskier ways when risk is transferred.

B. Risk Compensation

Even though some of the assumptions underlying moral hazard may apply in the case of geoengineering, the moral hazard analogy is nevertheless imperfect. Namely, moral hazard assumes the existence of two parties with somewhat divergent interests: insurer and insured, government and welfare recipient, or government and bank too big to fail. An insurer may address this

93. *See* Michael C. Keeley, *Deposit Insurance, Risk, and Market Power in Banking*, 80 AM. ECON. REV. 1183, 1198 (1990); Linda M. Hooks & Kenneth J. Robinson, *Deposit Insurance and Moral Hazard: Evidence from Texas Banking in the 1920s*, 62 J. ECON. HIST. 833, 834–35 (2002) (finding, based on analysis of data from Texas state-chartered banks during period from 1919 to 1926, that the existence of deposit insurance increased the likelihood of bank failure).

94. *See* Giovanni Dell'Ariccia et al., *How Do Official Bailouts Affect the Risk of Investing in Emerging Markets?*, 38 J. MONEY, CREDIT & BANKING 1689, 1690–91 (2006).

95. *See* James Crotty, *Structural Causes of the Global Financial Crisis: A Critical Assessment of the "New Financial Architecture,"* 33 CAMBRIDGE J. ECON. 563, 564 (2009). *See also* Kevin Dowd, *Moral Hazard and the Financial Crisis*, CATO J., Winter 2009, at 141, 142–45 (discussing the moral hazard effects of "subsidized" risk-taking).

96. *See* Viral V. Acharya & Matthew P. Richardson, *Causes of the Financial Crisis*, 21 CRITICAL REV. 195, 196–97 (2009); Benjamin J. Keys et al., *Did Securitization Lead to Lax Screening? Evidence from Subprime Loans*, 125 Q.J. ECON. 307, 308 (2010) (finding that securitization led lenders to screen borrowers less carefully).

97. *See* Crotty, *supra* note 95, at 565.

98. *See id.* at 566.

99. *See* Baker, *supra* note 64, at 285–86.

divergence by monitoring the behavior of insureds or by adopting mechanisms to align more closely insureds' incentives with those of the insurer.[100] If one analogizes geoengineering to an insurance policy, one might deem the "insurer" to be the governmental body that sponsors or approves geoengineering activities, and the "insured" to be the voting public or the policymakers who might be tempted to reduce climate mitigation efforts. As is the case with classic moral hazard, the decision to "insure" via geoengineering may influence the conduct of the "insured." In contrast to the ordinary insurance scenario, however, in the geoengineering situation there is an overlap between the identity of insurer and insured that could reduce their divergence of interests. Thus, the moral hazard literature is relevant to geoengineering not so much because geoengineering involves distinct parties having divergent interests, but because moral hazard is a subcategory of the broader problem of reactive risk—situations in which probabilities of an event change once an actor decides what to do.[101] In other words, geoengineering is analogous to insurance in that geoengineering may cause behaviors and policy preferences to shift in a manner that creates additional risk.

Accordingly, risk compensation theory can complement the moral hazard literature in helping to evaluate how people are likely to respond to geoengineering. Risk compensation theory predicts that measures designed to reduce risk in fact will lead people to behave in more risky ways.[102] Like moral hazard, the theory assumes that people in general are economically rational, that risk-taking is a deliberate act, and that reduced exposure to risk provides incentives for riskier conduct.[103] Classic examples of risk compensation involve mandatory seat belts and other automobile safety interventions. Because these interventions lower the perceived cost of risky behavior, motorists may drive less carefully. As a result, the interventions produce lesser safety benefits than anticipated.[104] The extent to which people compensate for risk—for example, that drivers increase their speed rather than enjoy the increased safety associated with driving at the same speed—depends in large part on individuals' relative preferences for risk and safety.[105] Evidence of risk compensation has been found in various contexts beyond motor vehicle safety: requiring children to wear protective equipment may result in rougher play, for instance; and innovations in HIV prevention and treatment may encourage

100. *See* HEIMER, *supra* note 64, at 37–48.

101. *See id.* at 3.

102. *See* James Hedlund, *Risky Business: Safety Regulations, Risk Compensation, and Individual Behavior*, 6 INJ. PREVENTION 82, 82 (2000).

103. *See id.* at 83.

104. *See* Sam Peltzman, *The Effects of Automobile Safety Regulation*, 83 J. POL. ECON. 677, 681–82 (1975); GLENN C. BLOMQUIST, THE REGULATION OF MOTOR VEHICLE AND TRAFFIC SAFETY 91 (1988) (concluding that safety regulations increased safety for motorists, but less than had been predicted, and that such regulations reduced safety for nonoccupants).

105. *See* Adam Stetzer & David A. Hofmann, *Risk Compensation: Implications for Safety Interventions*, 66 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 73, 74 (1996).

riskier sexual behavior.[106] One review of risk compensation studies concludes that "various amounts of risk compensation have occurred in response to some safety measures but not in response to others," however, and notes the difficulty of accurately establishing, refuting, or measuring risk compensation.[107] Researchers nonetheless have identified a number of factors that influence the presence or extent of risk compensation. These include: the visibility of the safety measure, the extent to which the measure affects one's perception of risk, the motivations underlying individual behavior, and one's ability to control risk.[108] Analyzing the presence of these factors may prove instructive in assessing whether geoengineering activity will shift people's behavior and policy preferences.[109]

IV. THE GEOENGINEERING MORAL HAZARD DEBATE

A. An End to the Geoengineering Taboo

For many years, geoengineering stood at the distant fringes of climate change policy discussions.[110] Geoengineering ideas occasionally surfaced but received little serious attention, as international and domestic climate efforts focused instead on mitigation. A 2006 essay calling for active research into stratospheric aerosols, however, broke the taboo against open consideration of geoengineering.[111] Geoengineering has since attracted growing attention, and in subsequent policy debates the possibility that geoengineering might create a moral hazard has often been dismissed. Philosopher Martin Bunzl describes the moral hazard concern as "exaggerated" and "far-fetched because, at least among policy makers, nobody believes that geoengineering offers anything but a relatively short stopgap to buy time for other action."[112] Similarly, a 2010 geoengineering report issued by a British House of Commons committee asserts that fears of moral hazard are not "evidence-based." It is "equally plausible," the report speculates, that geoengineering research would persuade people that global warming presents a serious threat and that redoubled efforts at mitigation will be necessary to meet that threat.[113]

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106. *See* Michael M. Cassell et al., *Risk Compensation: The Achilles' Heel of Innovations in HIV Prevention?*, 332 BRIT. MED. J. 605, 605 (2006); Barbara A. Morrongiello et al., *Risk Compensation in Children: Why Do Children Show It in Reaction to Wearing Safety Gear?*, 28 J. APPLIED DEVELOPMENTAL PSYCHOL. 56, 60 (2007); *see generally* Hedlund, *supra* note 102, at 86.

107. Hedlund, *supra* note 102, at 86.

108. *Id.* at 88–89.

109. The remainder of this Article will use the term geoengineering moral hazard as shorthand for the possibility of such shifts.

110. *See* THE ROYAL SOC'Y, *supra* note 4, at 4.

111. *See* Crutzen, *supra* note 11; *see also* A.M. Mercer et al., *Public Understanding of Solar Radiation Management*, ENVTL. RES. LETTERS, Oct. 24, 2011, 044006, at 2 (noting influence of Crutzen paper in breaking taboo).

112. Bunzl, *supra* note 22, at 2.

113. HOUSE OF COMMONS SCI. AND TECH. COMM., THE REGULATION OF GEOENGINEERING 23 (2010); *see also* THE ROYAL SOC'Y, *supra* note 4, at 39, 43 (contending that "prospect of

Relatively little data or analysis has accompanied these assertions, however. One geoengineering report that casts doubt on a geoengineering moral hazard, "Experiment Earth?," does refer to focus group discussions to support its unconcern.[114] Those discussions took place in the United Kingdom between members of the general public, scientists, and ethicists. Based on the fact that some public participants expressed a desire to combine different geoengineering approaches with mitigation, the authors of the report argue that geoengineering will not undermine support for mitigation.[115]

A closer examination of the report, however, cautions against drawing such a conclusion. As an initial matter, the report acknowledges that its findings rest on comments from a relatively small group of people and are merely "qualitative and indicative."[116] Moreover, while some comments did suggest combining geoengineering with mitigation, those comments assumed relatively modest methods of geoengineering, biochar and air capture, that pose little risk of catastrophic effects.[117] Biochar, the heating of biomass in a low oxygen environment, promises only limited decreases in atmospheric GHG levels.[118] Air capture, the removal of carbon dioxide from the air using industrial facilities, is at present an extremely inefficient process that may not ever be cost-effective.[119] As such, these methods are unlikely to be perceived—or misunderstood—as complete substitutes for emissions reductions. Indeed, participants' comments specific to the more drastic geoengineering technique of stratospheric aerosol release provide some evidence of moral hazard. Dialogue participants perceived stratospheric aerosol release as "effective" even though the technique faces serious difficulties and even though participants were made aware of these difficulties.[120] In addition, participants characterized stratospheric aerosol release as "easy to switch off"

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geoengineering could galvanise people to act, and demand action, on greenhouse gas emission reductions"). This report is not the first to make such an argument. *See, e.g.*, Comment of Emily Lewis-Brown et. al., to *geoengineering@googlegroups.com* (Sept. 9, 2010), *available at* http://groups.google.com/group/geoengineering/browse_thread/thread/8b4d9afe573c447d/2f6a5193bfd1af17 (discussion thread regarding whether geoengineering presents a moral hazard). Moreover, a recent policy paper aimed at developing a national strategic plan for U.S. geoengineering research makes no mention of moral hazard at all. BIPARTISAN POLICY CTR., TASK FORCE ON CLIMATE REMEDIATION RESEARCH (2011).

114. IPSOS MORI, EXPERIMENT EARTH?: REPORT ON A PUBLIC DIALOGUE ON GEOENGINEERING 82 (2010).

115. *See id.*

116. *Id.* at 1.

117. Biochar would convert atmospheric carbon into a solid form through the heating of organic material in a low-oxygen environment to create charcoal. THE ROYAL SOC'Y, *supra* note 4, at 11–12. Air capture would use industrial processes to absorb carbon dioxide from the ambient air; the carbon dioxide would then have to be stored underground or elsewhere. *Id.* at 15–16.

118. *See id.* at 12.

119. *See id.* at 15–16.

120. IPSOS MORI, *supra* note 114, at 46; *see also supra* text accompanying notes 13–18.

and "controllable."[121] Although as a technical matter it would be simple to stop releasing stratospheric aerosols, doing so would risk a rapid temperature rebound—the aforementioned termination problem[122]—that participants appear to have disregarded.

The increasingly dismissive views regarding the possibility of a geoengineering moral hazard are surprising because the phenomena of moral hazard and risk compensation are undisputed in a variety of other contexts. At their core, these phenomena simply involve rational responses to reduced risk. Although rational actor theory does not account for all behavior, the theory is central to classical economics and to the law-and-economics approach that pervades much of modern legal thought. Indeed, public policies governing subjects ranging from crime and law enforcement to taxes and intellectual property all presume that people respond rationally to incentives. Given the widespread presence of moral hazard and risk compensation, we should demand elaboration and convincing support before accepting the assertion that geoengineering will not undermine climate change mitigation.

B. A Plan for Investigating Geoengineering and Moral Hazard

Fundamentally, the claim that geoengineering presents a moral hazard is an empirical claim about attitudes and behavior. In some contexts, researchers can empirically test whether moral hazard exists without too much difficulty.[123] Researchers can measure whether insured individuals visit physicians more frequently or whether insured motorists drive with less care. Similar empirical tests to measure a geoengineering moral hazard are impractical or infeasible. In theory, one might examine real-world responses to geoengineering *deployment.* Establishing a valid control for comparison purposes would be challenging, however. It is difficult to determine, for example, what mitigation policy a society would have adopted in the absence of a geoengineering project. Moreover, moral hazard information generated after deployment has already occurred would be of relatively little use.[124] It might be more feasible to examine whether geoengineering *tests* cause individuals to reduce mitigation efforts, or societies to change climate policies. For forms of geoengineering like stratospheric aerosol release and ocean fertilization, however, we won't know if geoengineering really will work—and what all the adverse effects will be—without full-scale deployment.[125] Just as small-scale geoengineering field tests can yield only limited information

121. IPSOS MORI, *supra* note 114, at 46. Interestingly, participants even identified moral hazard as a concern raised by the technique. *Id.*

122. *See supra* text accompanying note 18.

123. *See supra* Part III.A.2.

124. *See* Stephen M. Gardiner, *Some Early Ethics of Geoengineering the Climate: A Commentary on the Values of the Royal Society Report*, 20 ENVTL. VALUES 163, 166–67 (2011).

125. *See* Alan Robock, *20 Reasons Why Geoengineering May Be a Bad Idea*, BULL. ATOMIC SCIENTISTS, May–June 2008, at 14, 17–18.

regarding efficacy or side effects, attempts to measure moral hazard effects in the wake of such tests would be of questionable value as well.

Because it may not be possible to accurately measure geoengineering's effects on climate mitigation behaviors and attitudes without full-scale deployment, and because such data would be of little value after the fact, we should consider alternative means of analyzing the moral hazard question. One possibility would be to conduct surveys inquiring whether geoengineering efforts would lead respondents to change their views of GHG mitigation or adaptation. In the United States, the Government Accountability Office (GAO) recently conducted a survey of public attitudes toward geoengineering.[126] When given basic information about specific geoengineering techniques, many respondents expressed concerns about safety but were nevertheless supportive of further research.[127] Based on somewhat comparable levels of expressed support for developing geoengineering technology and technologies that would reduce fossil fuel consumption, the GAO suggests that it is unlikely that people will perceive geoengineering as a substitute for mitigation.[128] The GAO also cautions, however, that "[g]iven low public awareness of geoengineering, it is difficult to determine with any confidence whether the U.S. public would reduce support for mitigation as it learned more about geoengineering . . . ."[129] Indeed, the GAO survey did not ask respondents to consider possible trade-offs between geoengineering and other responses to climate change, nor did it directly inquire about moral hazard concerns.[130]

As surveys can provide only limited information regarding such trade-offs, it is critical to develop a theorized account of how people will respond to geoengineering. Ultimately, attitudes toward geoengineering, mitigation, and adaptation cannot be predicted by relying solely on objective scientific data or on assumptions that people act and think in purely rational ways. How people are likely to perceive the risks of climate change and geoengineering is essential to consider as well. Accordingly, findings from research psychology on risk perception are pertinent to analyzing whether geoengineering will present a moral hazard. Social values also will be important to consider because they influence how people process risk information and risk management policies.[131]

To summarize, pronouncements that geoengineering will not undermine climate mitigation efforts are being made with growing frequency. These pronouncements, however, are contrary to well-grounded assumptions about rational behavior and to empirical evidence of moral hazard in widely varying

126. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 7, at 62–66.
127. *Id.* at 65.
128. *Id.* at 66–68.
129. *Id.* at 67.
130. *See id.* at 66–67.
131. *See* MIKE HULME, WHY WE DISAGREE ABOUT CLIMATE CHANGE: UNDERSTANDING CONTROVERSY, INACTION AND OPPORTUNITY 208–09 (2009).

contexts. The following Parts of this Article investigate the potential moral hazard of geoengineering in light of the psychology of risk perception. Ultimately, moral hazard not only warrants caution in proceeding with geoengineering, but also supports the adoption of policy measures to counter the potential undermining of climate mitigation efforts.

V. INSIGHTS FROM PSYCHOLOGY

Although people often respond rationally to incentives in ways that reflect a moral hazard, they do not always think or act rationally. Nor do public perceptions of risk rest purely on rational assessments of risks and benefits. Moreover, purportedly objective techniques such as risk assessment or cost-benefit analysis face important limitations in terms of the information they can produce, and their application often involves the exercise of unstated value judgments.[132] Risk perceptions are influenced not only by the data generated by these techniques, but also by various psychological phenomena that can cause these perceptions to deviate from what rational actor models may predict. Public acceptance or rejection of geoengineering—and the danger of moral hazard—ultimately will depend on public perceptions of risk. Accordingly, it is critical to consider psychological influences on risk perception in addition to quantitative assessments of risks and benefits.[133]

Risk is conventionally defined as the product of the likelihood of an event and its magnitude.[134] Emotions, attitudes, and psychological mechanisms also shape lay perceptions of risks, however.[135] For example, people perceive familiar, voluntary, and natural risks as less threatening than quantitatively equivalent risks that are unfamiliar, involuntary, and man-made.[136] Moreover, people apply various heuristics, or cognitive shortcuts, when making judgments under conditions of uncertainty.[137] As a result, individuals' perceptions of risk differ systematically from risk calculations based on rational decision making

132. *See* Noah M. Sachs, *Rescuing the Strong Precautionary Principle from Its Critics*, 2011 U. ILL. L. REV. 1285, 1318–21 (2011); John S. Applegate, *A Beginning and Not an End in Itself: The Role of Risk Assessment in Environmental Decision-Making*, 63 U. CIN. L. REV. 1643, 1658–59 (1994).

133. *See* Paul C. Stern, *Contributions of Psychology to Limiting Climate Change*, 66 AM. PSYCHOL. 303, 309 (2011).

134. *See* HOLLY DOREMUS ET AL., ENVIRONMENTAL POLICY LAW 414 (6th ed. 2012).

135. *See* Cass R. Sunstein, *On the Divergent American Reactions to Terrorism and Climate Change*, 107 COLUM. L. REV. 503, 521 (2007) (describing psychometric paradigm); Anthony Leiserowitz, *Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values*, 77 CLIMATIC CHANGE 45, 47, 63 (2006); HULME, *supra* note 131, at 184.

136. *See* DOREMUS ET AL., *supra* note 134, at 421. Risk psychologists attribute differing perceptions of risk to the presence of two reasoning systems: affective reasoning, which is intuitive, automatic, and represents risk as feeling; and analytic reasoning, which is deliberative and "works more slowly." HULME, *supra* note 131, at 200.

137. *See* Thomas Gilovich & Dale Griffin, *Introduction—Heuristics and Biases: Then and Now*, *in* HEURISTICS AND BIASES: THE PSYCHOLOGY OF INTUITIVE JUDGMENT 1, 1 (Thomas Gilovich et al. eds., 2002) [hereinafter HEURISTICS AND BIASES] ("[J]udgment under uncertainty often rests on a limited number of simplifying heuristics rather than extensive algorithmic processing . . . .").

alone. Furthermore, values also influence how people process risk information. As cultural cognition researchers have found, people tend to interpret evidence in a manner that reaffirms their cultural value orientations.[138] People who value individual initiative, for instance, are likely to discount evidence of environmental risks because the acceptance of such evidence might imply restrictions on individual activity.[139] Heuristics, emotional influences, and cultural cognition all have the potential to cause public perception of risks—including those associated with geoengineering—to depart in significant ways from rational choice models.

A. Heuristics and Biases

Although Americans generally support action to combat climate change, they regard the issue to be a relatively low priority.[140] Consider the contrast between public attitudes regarding climate change and the dramatically greater public concern surrounding terrorism, another source of potentially catastrophic yet incalculable risks. Cass Sunstein points to a number of heuristics and biases to explain the disparate public responses.[141] Specifically, Sunstein suggests that several factors contribute to unwarranted perceptions that climate change's risks are low: it is difficult to directly trace any dramatic event or personal harm to climate change; climate change has multiple and diffuse causes; and the most serious projected harms of climate change are long-term and geographically distant.[142]

The heuristics and biases at play in the context of climate change include the availability heuristic, optimism bias, hyperbolic discounting, and outrage. Each of these merits consideration here because each may also influence perceptions of geoengineering. Under the availability heuristic, recent, prominent, or otherwise readily recalled events tend to dominate risk perceptions.[143] People are relatively apathetic to climate risks, the availability heuristic explains, because few, if any, extreme events can be directly attributed

138. *See* Dan Kahan, *Fixing the Communications Failure*, 463 NATURE 296, 296 (2010).

139. *See id.*

140. *See* Juliet Eilperin & Peyton M. Craighill, *Global Warming No Longer Americans' Top Environmental Concern, Poll Finds*, WASH. POST (July 2, 2012), http://www.washingtonpost.com/national/health-science/global-warming-no-longer-americans-top-environmental-concern-poll-finds/2012/07/02/gJQAs9IHJW_story.html; Anthony A. Leiserowitz, *American Risk Perceptions: Is Climate Change Dangerous?*, 25 RISK ANALYSIS 1433, 1440 (2005).

141. Sunstein, *supra* note 135, at 505–07.

142. *Id.* at 507; *cf.* Leiserowitz, *supra* note 135, at 64 (finding that "most of the American public considers climate change a moderate risk that is more likely to impact people and places far distant in space and time").

143. *See* Norbert Schwarz & Leigh Ann Vaughn, *The Availability Heuristic Revisited: Ease of Recall and Content of Recall as Distinct Sources of Information*, *in* HEURISTICS AND BIASES, *supra* note 137, at 103; Elke U. Weber & Paul C. Stern, *Public Understanding of Climate Change in the United States*, 66 AM. PSYCHOLOGIST 315, 319 (2011).

to climate change.[144] Optimism bias describes the tendency for people to discount the probability that they will suffer harm, particularly under conditions of high uncertainty.[145] The inclination to be more optimistic than is statistically justifiable can motivate productive activity and help people recover from "health-related stressors."[146] Unrealistic optimism, however, can undermine action against climate change if people believe that resulting harms will be less significant than scientists predict.[147] Similar to optimism bias, the phenomenon of hyperbolic discounting leads people to underestimate hazards projected to occur far in the future.[148] In the context of climate change, people undervalue climate mitigation benefits, which will accrue largely in the distant future, and overemphasize the direct and more immediate costs of mitigation efforts.[149] Finally, outrage—and support for doing something in response—is strongest when there are identifiable perpetrators and victims; however, the contributors to climate change are numerous and diverse, as are its victims.[150] The diffuse responsibility for climate change not only makes outrage less likely, but also fosters pessimism about one's ability to make a difference in addressing this collective action problem.[151] Together, the availability heuristic, optimism bias, hyperbolic discounting, and lack of outrage undermine public concern about climate change and support for any policy response, whether in the form of mitigation, adaptation, or geoengineering.

While these psychological tendencies may dampen overall concern regarding climate change, these and other tendencies also might foster unduly favorable public perceptions of specific geoengineering options. The release of stratospheric aerosols, for instance, promises to deliver rapid reductions in

144. *See* Weber & Stern, *supra* note 143, at 317–18; Bazerman, *supra* note 26, at 187–88. Weather-related disasters might trigger greater concern about GHG emissions if people believed that climate change caused such disasters. *See* Jeffrey J. Rachlinski, *The Psychology of Global Climate Change*, 2000 U. ILL. L. REV. 299, 311–12 (2000). Climate experts, however, have been reluctant until recently to draw such causal connections. *See* Deborah Zabarenko, *Does Climate Change Increase the Odds of Extreme Weather Events?*, CHRISTIAN SCI. MONITOR (July 10, 2012), http://www.csmonitor.com/Science/2012/0710/Does-climate-change-increase-the-odds-of-extreme-weather-events.

145. *See* David A. Armor & Shelley E. Taylor, *When Predictions Fail: The Dilemma of Unrealistic Optimism*, *in* HEURISTICS AND BIASES, *supra* note 137, at 334, 338–39; Shelley E. Taylor and Jonathon D. Brown, *Positive Illusions and Well-Being Revisited: Separating Fact from Fiction*, 116 PSYCHOL. BULL. 21, 24 (1994) ("[U]nrealistically optimistic beliefs about the future are held by normal individuals with respect to a wide variety of events."); *see also* Robert Gifford, *The Dragons of Inaction: Psychological Barriers that Limit Climate Change Mitigation and Adaptation*, 66 AM. PSYCHOLOGIST 290, 292–93 (2011) (noting that "[u]ncertainty about climate change also quite likely functions as a justification for inaction").

146. *See* Taylor & Brown, *supra* note 145, at 24.

147. *See* Bazerman, *supra* note 26, at 183.

148. *See* Gifford, *supra* note 145, at 292; Sunstein, *supra* note 135, at 545.

149. *See* Elke U. Weber, *Experience-Based and Description-Based Perceptions of Long-Term Risk: Why Global Warming Does Not Scare Us (Yet)*, 77 CLIMATIC CHANGE 103, 109 (2006); Bazerman, *supra* note 26, at 185–86.

150. *See* Sunstein, *supra* note 135, at 542–44.

151. *See* Gifford, *supra* note 145, at 293.

warming at a relatively low implementation cost.[152] Perceptions of this technique's efficacy may be subject not only to optimism bias, but also to overconfidence bias. Overconfidence bias describes a tendency to overvalue the magnitude of a possible outcome and to undervalue the statistical probability associated with that outcome.[153] This tendency may lead people to unduly emphasize the dramatic benefits suggested by stratospheric aerosol proposals and to disregard quantitative assessments of risk and uncertainties associated with the technique. Such risks include ozone depletion, modification of tropical monsoons, and unforeseeable climate changes.[154] Notwithstanding those potentially disastrous consequences, declarations by respected academics that "[t]he economics of geoengineering are . . . incredible"[155] and that geoengineering "transforms the greenhouse issue from an exceedingly complicated regulatory regime to a simple . . . problem in international cost sharing"[156] indicate that overconfidence bias and optimism bias may lead people to overlook such concerns.

Moreover, geoengineering techniques generally offer a psychologically attractive sense of control that climate mitigation does not. Mitigation is difficult, in part, because it requires collective action by a large number of actors over a long time horizon.[157] The temptation to free-ride off of others' actions is substantial, and even nations or individuals who support emissions reductions may fail to curb their own emissions because they perceive that their actions will have little impact.[158] Geoengineering, in contrast, does not require the same degree of collective action. As a technical matter, a handful of countries, a single country, or even a wealthy private actor could carry out a geoengineering scheme.[159] While geoengineering should not be undertaken without international agreement, geoengineering proposals reinforce the belief that humans have the technological capacity to control their environmental future.[160] Such a sense of control, whether well-supported or not, is empowering and resonates with people's desire to make sense of the world as a

152. *See* M. GRANGER MORGAN & KATHARINE RICKE, INT'L RISK GOVERNANCE COUNCIL, COOLING THE EARTH THROUGH SOLAR RADIATION MANAGEMENT: THE NEED FOR RESEARCH AND AN APPROACH TO ITS GOVERNANCE 12–13 (2010) (characterizing SRM as "cheap, fast and imperfect").

153. *See* Dale Griffin & Amos Tversky, *The Weighing of Evidence and the Determinants of Confidence*, *in* HEURISTICS AND BIASES, *supra* note 137, at 230–32.

154. *See supra* notes 14–18 and accompanying text.

155. Scott Barrett, *The Incredible Economics of Geoengineering*, 39 ENVTL. RESOURCE ECON. 45, 49 (2008).

156. Thomas C. Schelling, *The Economic Diplomacy of Geoengineering*, 33 CLIMATIC CHANGE 303, 305 (1996).

157. *See* SCOTT BARRETT, WHY COOPERATE?: THE INCENTIVE TO SUPPLY GLOBAL PUBLIC GOODS 6 (2007).

158. *See id.*; *see also* Gifford, *supra* note 145, at 293.

159. *See* BARRETT, *supra* note 157, at 38–39.

160. *See* Gifford, *supra* note 145, at 293; Dorothee Amelung & Joachim Funke, *Dealing with the Uncertainties of Climate Engineering: Warnings from a Psychological Complex Problem Solving Perspective*, 35 TECH. SOC'Y 32, 38–39 (2013).

well-ordered place.[161]

One final heuristic, the affect heuristic, merits closer examination because of its especially prominent impact on risk perception. Psychologists use the term "affect" to refer to the positive or negative feelings that people experience in response to a stimulus.[162] These feelings, which are fast, automatic, and intuitive, derive from evolutionary responses to uncertain or dangerous situations that demand rapid yet complex decisions.[163] The affect heuristic describes people's reliance on these feelings to guide their judgments and decisions, particularly when decisions are complex, information is incomplete, or cognitive resources are limited.[164] Relatedly, the "risk as feelings" theory predicts that emotions such as worry and fear sometimes exert a greater influence on risk-taking behavior than analytic calculations of costs and benefits.[165]

The affect heuristic is manifested in various ways. Researchers have found, for example, that warnings are more effective when accompanied by vivid imagery than probabilistic descriptions.[166] Such imagery, psychologists explain, triggers strong emotional responses that can motivate people to purchase insurance or take other precautions.[167] Although floods, storms, and other climate phenomena can generate dramatic imagery, the lack of societal consensus on whether a causal link between climate change and such phenomena exists, discussed below, may help to explain the lack of progress on climate mitigation.[168] Another reflection of the affect heuristic is the fact that people's judgments are relatively insensitive to variations in probability when outcomes have strong affective meanings.[169] Public concern about nuclear power or toxic chemicals, for instance, varies little when people encounter information suggesting that the probability of harm is low.[170] Indeed, judgments of risk and benefit tend to be negatively correlated[171]—the greater the perceived benefit of a course of action, the lower the perceived risk

161. *Cf.* Rachlinski, *supra* note 144, at 312 (noting that "[p]eople prefer to see the world as a stable, well-ordered place where disasters have explanations"); Geeta Menon et al., *Biases in Social Comparisons: Optimism or Pessimism?*, 108 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 39, 42 (2009) (finding optimism bias more pronounced when perceived level of control is greater).

162. *See* Paul Slovic et al., *The Affect Heuristic*, in HEURISTICS AND BIASES, *supra* note 137, at 397.

163. *See id.* at 397–98; George F. Loewenstein et al., *Risk as Feelings*, 127 PSYCHOL. BULL. 267, 268 (2001).

164. *See* Slovic, *supra* note 162, at 397, 400.

165. *See* Loewenstein et al., *supra* note 163, at 270–71 (explaining that the affect heuristic assumes that affect provides inputs into decision making, whereas the risk-as-feelings hypothesis posits additionally that "emotions often produce behavioral responses that depart from what individuals view as the best course of action").

166. *See* Slovic, *supra* note 162, at 414; Loewenstein et al., *supra* note 163, at 275.

167. *See* Loewenstein et al., *supra* note 163, at 275.

168. *See id.* at 279.

169. *See id.* at 276; Slovic, *supra* note 162, at 409.

170. *See* Slovic, *supra* note 162, at 409.

171. *See id.* at 410.

associated with that specific action. Antibiotics and X-rays tend to be viewed as posing relatively minor risks because they provide substantial benefits—even if objective information suggests that risks may be substantial as well.[172] This aspect of the affect heuristic suggests that the framing of stratospheric aerosol release or other geoengineering methods as a "solution" to climate change could lead people to discount or ignore the risks and uncertainties that would accompany these methods.

Although there may be psychological biases that would disfavor geoengineering, these appear weak in comparison to those already discussed. One commentator on climate change has suggested a bias in favor of "undoing," whereby "those who cause harm should make reparations that are as close as possible to undoing the harm itself."[173] An undoing bias would tend to favor mitigation over geoengineering, but there is scant evidence that any such bias is motivating mitigation efforts. Because everyone in the world contributes to climate change in some way, any undoing bias may have little effect and would likely be outweighed by people's desire to avoid blaming themselves.

B. Cultural Cognition

Whereas emotions, heuristics, and biases influence risk perceptions across the general population, cultural cognition theory predicts that risk perceptions will vary among individuals depending on their underlying cultural values. The basic premise of cultural cognition theory is that individuals' positive and normative beliefs about the world are shaped by their core values, and these values inevitably color how individuals interpret information.[174] According to the theory, preferences for organizing society fall along two axes: hierarchy-egalitarianism and individualism-communitarianism.[175] A hierarchical view favors a distribution of social goods based on essentially fixed social attributes such as class or gender; conversely, an egalitarian view opposes such a distribution of social goods.[176] A communitarian view favors the subordination of individual interests to the collective; by contrast, an individualist view posits that individuals, rather than the collective, are responsible for their own well-being.[177] According to cultural cognition theory, these preferences for social organization strongly influence how individuals judge societal risks and the

172. *See id.*

173. Jonathan Baron, *Thinking About Global Warming*, 77 CLIMATIC CHANGE 137, 140 (2006).

174. *See* Dan M. Kahan, *The Cognitively Illiberal State*, 60 STAN. L. REV. 115, 117 (2007); DAN M. KAHAN ET AL., THE SECOND NATIONAL RISK AND CULTURE STUDY: MAKING SENSE OF—AND MAKING PROGRESS IN—THE AMERICAN CULTURE WAR OF FACT 2, 11–12 (2007), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1017189.

175. *See* KAHAN ET AL., *supra* note 174, at 2.

176. *See id.*; Kahan, *supra* note 174, at 122–23.

177. *See* KAHAN ET AL., *supra* note 174, at 2; Kahan, *supra* note 174, at 122; *see also* MARY DOUGLAS, NATURAL SYMBOLS: EXPLORATIONS IN COSMOLOGY 54–62 (1970) (discussing classifications of cultural worldviews).

need to regulate those risks.[178] Egalitarians tend to be sensitive to environmental hazards and receptive to regulation of commercial activities that produce social inequality, whereas individualists are inclined to "dismiss claims of environmental risk as specious, in line with their commitment to the autonomy of markets and other private orderings."[179]

Cultural cognition offers one explanation for why Americans' perceptions of the seriousness of global warming vary so widely.[180] As law professor Dan Kahan and his co-authors contend: "[P]ositions on climate change convey values—communal concern versus individual self-reliance; prudent self-abnegation versus the heroic pursuit of reward; humility versus ingenuity; harmony with nature versus mastery over it—that divide them along cultural lines."[181] Consistent with this theory, persons with hierarchical and individualist views tend to be most skeptical of global warming, whereas those with egalitarian and communitarian views tend to be the most concerned by it.[182]

Cultural cognition theory further suggests that instrumental disputes over policy responses to climate change can become imbued with cultural meaning.[183] To the extent that proposals for climate mitigation call for wealth redistribution, heightened regulation, involvement of international institutions, or participation of scientific elites in policy making, these proposals may threaten the values of persons who favor hierarchical and individualist social orderings.[184] In this polarized context, simply proclaiming "the facts" on climate change may not persuade those who feel culturally threatened, and may even increase resistance to mitigation proposals.[185] Such persons, however, may receive geoengineering quite differently. Although geoengineering presumes acceptance of the fact that climate change is occurring, the themes it reflects—human innovation, faith in technology, and domination of nature—

178. *See* Kahan, *supra* note 174, at 117 (suggesting criminalization of marijuana, banning of handguns, and exclusion of gays from the military are examples of issues subject to this phenomenon).

179. Dan M. Kahan et al., *Fear of Democracy: A Cultural Evaluation of Sunstein on Risk*, 119 HARV. L. REV. 1071, 1083–84 (2005).

180. *See* KAHAN ET AL., *supra* note 174, at 3–4; *see also* Rachael Shwom et al., *Understanding U.S. Public Support for Domestic Climate Change Policies*, 20 GLOBAL ENVTL. CHANGE 472, 479 (2010) (discussing how individuals' values and beliefs influence their policy opinions).

181. Dan M. Kahan et al., *The Tragedy of the Risk-Perception Commons: Culture Conflict, Rationality Conflict, and Climate Change* 15 (Cultural Cognition Project, Working Paper No. 89, 2011), *available at* http://ssrn.com/abstract=1871503.

182. *See* KAHAN ET AL., *supra* note 174, at 3–4 (reporting results of a study finding that "[i]ndividuals' worldviews . . . explained individuals' beliefs about global warming more powerfully than any other individual characteristic").

183. *See* Kahan, *supra* note 174, at 129 (contending "the debate over climate changes is of a piece with the debate over the teaching of evolution in public schools, most likely because of the conspicuous role that natural scientists from elite universities play in both").

184. *See* Kahan et al., *supra* note 179, at 1092; Kahan, *supra* note 174, at 141.

185. *See* Kahan, *supra* note 174, at 147 ("To proclaim that one's position on an issue like gun control or global warming rests on a culturally impartial view of the facts impugns the intelligence and character of those who hold competing positions and thus invariably triggers animosity.").

are consistent with hierarchical and individualist views.[186] Greater attention to geoengineering as a climate policy tool, Kahan and his co-authors suggest, could even serve as a means of decreasing cultural polarization over climate change.[187]

In sum, various psychological phenomena may give rise to unjustifiably positive public perceptions of geoengineering. Heuristics and biases will influence risk perceptions among the general public, fostering overconfidence in seemingly easy technological "solutions" and neglect of accompanying risks, and cultural cognition will lead persons of hierarchical and individualistic orientations to favor geoengineering over other climate policy options.

VI. THE MORAL HAZARD OF GEOENGINEERING SHOULD BE TAKEN SERIOUSLY

So what does the discussion so far indicate about the moral hazard of geoengineering? Rational actor theory as well as empirical evidence of moral hazard and risk compensation in various non-climate contexts suggests that geoengineering will likely have some moral hazard effects. The psychological phenomena considered in Part V will probably compound those effects, as optimism bias, overconfidence bias, and cultural cognition foster unduly favorable perceptions of geoengineering. Finally, the history of growing acceptance of adaptation provides a further warning of moral hazard dangers.

The various factors that affect public perceptions of risk do not act in a vacuum, of course. They are situated within a political and social context, and any evaluation of whether geoengineering presents a moral hazard must take into account this context as well. In particular, there have been concerted efforts to deny climate change's existence and downplay its risks. Parties to these efforts have been remarkably effective in cultivating public doubt about climate change. One also can expect these parties to play a significant role in the public discourse on geoengineering. In predicting public and policy responses to geoengineering, we should consider the identity, motivation, and likely stance of the forces behind such efforts, as well as the political dynamics that will surround the framing of geoengineering.

A. Climate Skepticism

Conservative think tanks, electric utilities, and oil companies have taken the lead in promoting "climate skepticism," or the mistrust of scientific findings

186. *See* Dan M. Kahan et al., *Geoengineering and the Science Communication Environment: A Cross-Cultural Experiment* 10 (Cultural Cognition Project, Working Paper No. 92, 2012), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1981907.

187. *Id.* at 19. Kahan et al. dismiss the "moral hazard" concern that "geoengineering might 'let the air out' of efforts to arouse political concern with climate change." *Id.* at 9, 19. It should be noted that Kahan et al. do not discuss the distinct moral hazard concern that is the subject of this article—specifically, that geoengineering might undermine mitigation and adaptation.

with respect to climate change.[188] Through systematic campaigns characterizing climate change science as uncertain, these parties have argued against GHG emission reductions in the absence of definitive scientific evidence.[189] To a large degree, such efforts reflect self-interested industry advocacy, as effective mitigation requirements could impose significant costs on industry. In recent years, however, some companies have begun to acknowledge the benefits of climate mitigation and even embraced pro-environmental positions.[190] Climate skepticism among conservatives, in contrast, has persisted—a phenomenon consistent with cultural cognition theory's prediction that cultural values heavily influence risk perceptions.[191] A strong ideological basis underlies climate skepticism: climate change runs counter to the conservative embrace of capitalism, economic growth, deregulation, and science as means of achieving abundance and prosperity.[192] Climate mitigation conflicts with this hierarchical and individualist worldview to the extent that it calls for government regulation and challenges technology as a force for progress.[193]

Unfortunately, climate skeptics' characterizations of the science often have been misleading, if not blatantly false.[194] Scientists have widely accepted the basic theory behind climate change—the greenhouse effect—for decades.[195] Moreover, there is a strong scientific consensus based on empirical data that human activity is causing global warming and that the resulting impacts will pose substantial risks for humans and the environment.[196]

The climate change literature reflects this consensus, including reports issued by the Intergovernmental Panel on Climate Change (IPCC). The IPCC is

188. *See* JAMES HOGGAN WITH RICHARD D. LITTLEMORE, CLIMATE COVER-UP: THE CRUSADE TO DENY GLOBAL WARMING 42–43, 64–87 (2009); Robert L. Glicksman, *Anatomy of Industry Resistance to Climate Change: A Familiar Litany*, *in* ECONOMIC THOUGHT AND U.S. CLIMATE CHANGE POLICY, *supra* note 51, at 84, 93.

189. *See* Weber & Stern, *supra* note 143, at 321; *see also* Peter J. Jacques et al., *The Organisation of Denial: Conservative Think Tanks and Environmental Scepticism*, 17 ENVTL. POL. 349 (2008) (analyzing efforts of conservative think tanks to dispute seriousness of environmental problems by promoting skepticism of science underlying environmental concerns).

190. *See* Aaron M. McCright & Riley E. Dunlap, *Anti-Reflectivity: The American Conservative Movement's Success in Undermining Climate Science and Policy*, THEORY, CULTURE & SOC'Y, Mar.–May 2010, at 100, 109–10; Glicksman, *supra* note 188, at 98–99.

191. *See supra* Part V.B.

192. *See* McCright & Dunlap, *supra* note 190, at 107; Naomi Oreskes & Erik M. Conway, *Challenging Knowledge: How Climate Science Became a Victim of the Cold War*, *in* AGNOTOLOGY: THE MAKING AND UNMAKING OF IGNORANCE 55, 76–78 (Robert N. Proctor & Londa Schiebinger eds., 2008); Jacques et al., *supra* note 189, at 354.

193. *See* McCright & Dunlap, *supra* note 190, at 110–11; Aaron M. McCright & Riley E. Dunlap, *Defeating Kyoto: The Conservative Movement's Impact on U.S. Climate Change Policy*, 50 SOC. PROBS. 348, 353 (2003).

194. *See* McCright & Dunlap, *supra* note 190, at 111–19; *see generally* HOGGAN, *supra* note 188 (discussing climate skeptics' attacks on climate science).

195. *See* HULME, *supra* note 131, at 42–60 (discussing advances in scientific understanding of climate change beginning in the 1800s); HOGGAN, *supra* note 188, at 17–19.

196. *See* Weber & Stern, *supra* note 143, at 315–16.

a body of experts tasked with synthesizing climate research through a comprehensive process designed to err on the side of *not* finding climate change.[197] Even under this conservative approach, the IPCC's conclusions have been increasingly unequivocal regarding the occurrence of climate change and humanity's role in causing it. As early as 1995, the IPCC found that "the balance of evidence suggests that there is a discernible human influence on global climate."[198] In 2001, the IPCC concluded that "most of the observed warming over the last 50 years is *likely* to have been due to the increase in greenhouse gas concentrations."[199] And in 2007, the IPCC declared that "[m]ost of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations."[200] The IPCC added that human activity has likely contributed already to a number of observed changes, including sea level rise, greater temperature extremes, and altered wind and temperature patterns.[201]

Even scientists associated with climate skeptics concede the evidence of anthropogenic climate change. For example, a 1995 report sponsored by industry interests stated that the scientific basis for climate change "is well established and cannot be denied."[202] More recently, one of the leading scientists on whom climate skeptics have relied, Richard Muller, concluded after a comprehensive data analysis that "[g]lobal warming is real" and that "[h]umans are almost entirely the cause."[203]

Notwithstanding the overwhelming scientific consensus, climate skeptics have succeeded in raising public doubt regarding global warming's existence and causes, and in promoting public resistance to mitigation.[204] A 2009 poll found that just forty-nine percent of the general public attributes global

197. *See* HULME, *supra* note 131, at 88, 97 (discussing the consensus approach frequently adopted by the IPCC); HOGGAN, *supra* note 188, at 74–75.

198. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC SECOND ASSESSMENT: CLIMATE CHANGE 1995 22 (1995).

199. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS, SUMMARY FOR POLICYMAKERS 10 (2001) (emphasis added).

200. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT, SUMMARY FOR POLICYMAKERS 5 (2007) (emphasis in original).

201. *Id.* at 5–6.

202. HOGGAN, *supra* note 188, at 12 (quoting a report issued by scientists at Global Climate Coalition).

203. Richard A. Muller, Op-Ed., *The Conversion of a Climate-Change Skeptic*, N.Y. TIMES, July 30, 2012, at A19; Richard A. Muller, Editorial, *The Case Against Global-Warming Skepticism*, WALL ST. J. (Europe), Oct. 21, 2011, http://online.wsj.com/article/SB10001424052970204422404576594872796327348.html.

204. *See* Weber & Stern, *supra* note 143, at 320–21; HOGGAN, *supra* note 188, at 31–48; NAOMI ORESKES & ERIK M. CONWAY, MERCHANTS OF DOUBT: HOW A HANDFUL OF SCIENTISTS OBSCURED THE TRUTH ON ISSUES FROM TOBACCO SMOKE TO GLOBAL WARMING 169–70 (2010); McCright & Dunlap, *supra* note 190, at 100–26; Riley E. Dunlap & Aaron M. McCright, *Climate Change Denial: Sources, Actors, and Strategies*, *in* ROUTLEDGE HANDBOOK OF CLIMATE CHANGE AND SOCIETY 240, 240–59 (Constance Lever-Tracy ed., 2010).

warming to human activity.[205] Despite the mounting evidence of climate change and its impacts, concern about global warming has declined modestly in recent years, while partisan differences in perceptions of global warming have increased.[206] Such findings underscore the influence of climate skeptics in shaping public perceptions.[207]

B. Climate Change Skeptics and Geoengineering

How is geoengineering likely to be framed amidst substantial climate skepticism? Relatedly, and more pertinent to assessing the moral hazard posed by geoengineering, how is geoengineering likely to be perceived?

Like mitigation efforts, geoengineering operations cannot be justified without an acknowledgment that climate change is occurring. Accordingly, one might initially expect opponents of mitigation to be hostile to geoengineering as well. Geoengineering offers a very different economic calculation, however, for the companies that would bear much of the cost of climate mitigation. Utilities, oil companies, and other carbon-intensive industries would benefit from persuading the public that geoengineering offers a relatively inexpensive and painless option for addressing climate change. A climate policy dominated by geoengineering would facilitate continuation of business as usual, enabling the avoidance—or at least deferral—of fundamental and potentially costly changes to current industry practices. Some companies might even develop a direct financial stake in designing and implementing geoengineering schemes.

For purposes of analyzing public perceptions of geoengineering, the public may fall into two camps according to their underlying views on climate change: believers and skeptics. Persons in both groups are subject to heuristics and biases that foster overconfidence in geoengineering's efficacy and underweighting of geoengineering's risks.[208] Cultural cognition theory suggests, moreover, that climate change skeptics are especially likely to experience moral hazard with respect to geoengineering. This prediction may appear counterintuitive at first, as there is presumably no need for climate change policy measures—geoengineering or otherwise—if climate change is not a problem to begin with. But as cultural cognition theory predicts, the policy options offered in response to a risk can substantially alter public perceptions of that risk.[209]

Specifically, for climate change skeptics who have resisted climate

205. *Public Praises Science; Scientists Fault Public, Media: Scientific Achievements Less Prominent Than a Decade Ago*, PEW RESEARCH (July 9, 2009), http://www.people-press.org/2009/07/09/section-5-evolution-climate-change-and-other-issues/.

206. *See* Jeffrey M. Jones, *In U.S., Concerns About Global Warming Stable at Lower Levels*, GALLUP (Mar. 14, 2011), http://www.gallup.com/poll/146606/concerns-global-warming-stable-lower-levels.aspx.

207. *See* Weber & Stern, *supra* note 143, at 320–21.

208. *See supra* Part V.A.

209. *See supra* Part V.B.

mitigation, geoengineering offers a policy option more consonant with culturally conservative values. Supporting evidence exists in studies examining the influence of cultural values on perceptions of another controversial technology, nuclear power. Persons with individualistic and hierarchical orientations ("hierarchical individualists") tend to be the strongest supporters of nuclear power, whereas persons with more communitarian and egalitarian orientations tend to be its strongest opponents.[210] Not surprisingly, the former group also tends to be relatively skeptical of global warming. When nuclear power is framed as a possible solution to global warming, however, hierarchical individualists have been found to be more open to evidence of global warming.[211] For these persons, geoengineering could have an appeal similar to that of nuclear energy.[212] By illustrating how technology might solve problems faced by humanity, geoengineering could serve as an affirmation of human initiative, capitalism, and scientific progress.[213]

The possibility that one might simultaneously deny climate change and advocate geoengineering is not merely theoretical. The Cato Institute has derided concern over global warming as a "scare" while framing opposition to geoengineering as opposition to economic growth.[214] Views expressed by scholars associated with the American Enterprise Institute (AEI), a conservative think-tank, provide a further illustration. The AEI has financed attacks on climate change science and sponsored programs critical of international efforts to combat climate change and other environmental problems.[215] At the same time, AEI scholars also have expressed strong support for geoengineering research and deployment. Testifying before the House Committee on Science and Technology, Lee Lane, co-director of AEI's geoengineering project, characterized stratospheric aerosols and other similarly speculative SRM techniques as "very likely to be a feasible and effective means of cooling the planet."[216] Advocating that SRM be viewed no differently than any other policy tool for responding to climate change, Lane blithely suggested that SRM "may have more upside potential than does any other climate policy option."[217] Samuel Thernstrom, the other co-director of AEI's geoengineering

210. *See* Kahan, *supra* note 174, at 139–40.

211. *See* KAHAN ET AL., *supra* note 174, at 4–5.

212. *See* Kahan, *supra* note 138, at 297.

213. The United Kingdom's Institution of Mechanical Engineers, for instance, has urged that geoengineering be "fully integrated" into climate change policy. *See* INSTITUTION OF MECHANICAL ENG'RS, GEO-ENGINEERING: GIVING US THE TIME TO ACT? 3–4 (2009), *available at* http://thegreatdebate.org.uk/geo-engineering/GeoDocs/IMechEGeoengineeringReport.pdf.

214. *See* Tina Sikka, *A Critical Discourse Analysis of Geoengineering Advocacy*, 9 CRITICAL DISCOURSE STUD. 163, 170 (2012).

215. *See* Ian Sample, *Scientists Offered Cash to Dispute Climate Study*, THE GUARDIAN, Feb. 1, 2007, http://www.theguardian.com/environment/2007/feb/02/frontpagenews.climatechange; HOGGAN, *supra* note 188, at 73–77; McCright & Dunlap, *supra* note 193, at 358.

216. Lee Lane, *Researching Solar Radiation Management as a Climate Policy Option*, AM. ENTERPRISE INST. (Nov. 5, 2009), http://www.aei.org/speech/100100.

217. *Id.*

project, more recently cautioned that "[g]eoengineering should be seen as a *complement* to mitigation and adaptation, not an *alternative*," and deemed it "implausible that any national leader would argue that geoengineering offers a safe alternative to emissions reductions—or that the American people would go along with the idea."[218] Nonetheless, Thernstrom touted geoengineering for its "unique ability to overcome the inertia in the climate system and provide a degree of rapid cooling, if necessary," and advocated immediate research on geoengineering.[219] The knowledge thereby gained, he contended, "would be relatively cheap and potentially priceless, while continued ignorance of this field would be reckless . . . ."[220]

Perhaps unsurprisingly, the proponents of these views make little mention of geoengineering's drawbacks. They also gloss over the tremendous difficulties of developing effective geoengineering techniques and determining whether they would actually work. Deployment of any serious geoengineering project is estimated to be decades away, even if research efforts were accelerated immediately and even if such efforts ultimately proved successful.[221] Simply put, geoengineering offers no magic bullet.

Efforts to frame geoengineering as a necessary choice under desperate circumstances nevertheless may exacerbate the moral hazard effect. Proponents of geoengineering research have described geoengineering as "the only human response that can fend off rapid and high-consequence climate impacts."[222] Such statements shift attention away from mitigation by "play[ing] on the fears of the public and advocat[ing] technological quick-fixes rather than reasonable debate about instituting difficult changes to our resource-based and extractive mode of existence."[223]

The ease with which geoengineering supporters sometimes make their arguments underscores the potentially widespread psychological and political appeal of geoengineering. Because it is susceptible to framing as a magic bullet against climate change, geoengineering may prove attractive not only to persons whose cultural values align with geoengineering, but also to the broader American public. Studies find that Americans strongly support GHG emission reductions, yet tend to oppose specific policies that would discourage

218. Samuel Thernstrom, *Engineering Our Attitudes: How Geoengineering Can Inform Our Perspective on Climate Policy*, AM. ENTERPRISE INST. (Feb. 19, 2010), http://www.aei.org/speech/energy-and-the-environment/climate-change/engineering-our-attitudes/ (emphasis in original).

219. *Id.*

220. *Id.*

221. *See* THE ROYAL SOC'Y, *supra* note 4, at 57; U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 7, at 13–14.

222. David W. Keith et al., *Research on Global Sun Block Needed Now*, 463 NATURE 426, 426 (2010) (discussing SRM); *see also* Stephen M. Gardiner, *The Desperation Argument for Geoengineering*, 46 POL. SCI. & POL. 28, 28 (2013) (noting arguments in which "[d]esperation becomes a trump card").

223. Sikka, *supra* note 214, at 168.

fossil fuel consumption.[224] Interpreting this apparent contradiction, the author of one such study suggests that American public opinion on climate change is "in a 'wishful thinking' stage of opinion formation, in which they hope the problem can be solved by someone else (government, industry, etc.), without changes in their own priorities, decision making or behavior."[225] Geoengineering, in hinting at a cheap and easy resolution—or at least postponement—of our climate reckoning, plays directly into this wishful thinking. Even if politicians recognize the problems associated with geoengineering, they face little incentive to dispel any illusions the public may hold. Rather than make difficult choices that impose costs on the electorate, it will be easier for elected officials to point to a technological fix that may one day arrive, obviating the need for sacrifice or a departure from business as usual.[226] By suggesting additional potential options for responding to climate change, geoengineering reduces the political pressure for near-term mitigation and provides opponents of mitigation with a new rationale for further delay.[227] In the end, people might want so much to believe that geoengineering will work that they may allow politicians and interested parties to convince them that it will work, regardless of evidence to the contrary.

VII. POLICY IMPLICATIONS

The foregoing analysis demonstrates a considerable danger that geoengineering will undermine mitigation and adaptation efforts. This Part discusses potential policy responses for countering such risk. Although the analogy to insurance moral hazard is imperfect, the tools insurers use to mitigate moral hazard can provide a useful organizing framework for discussion. Such tools were developed to manage reactive risk and thus can apply not only in the insurance context, but also in other circumstances in which people might modify their behaviors in response to reduced risk exposure.[228] Insurers' tools against moral hazard include: (1) estimating future risk and adjusting premiums in light of policyholders' traits and claims histories (i.e., rating and underwriting); (2) loss-sharing, contingent rewards, and other methods of aligning an insurer's and insured's interests in preventing loss; and (3) giving control of loss-prevention activities to third parties—such

224. *See* Leiserowitz, *supra* note 135, at 62.

225. *Id.* at 63.

226. *Cf.* Stephen M. Gardiner, *Is "Arming the Future" with Geoengineering Really the Lesser Evil?: Some Doubts About the Ethics of Intentionally Manipulating the Climate System*, *in* CLIMATE ETHICS: ESSENTIAL READINGS 284, 287 (Stephen M. Gardiner et al. eds., 2010) (warning, with respect to geoengineering, that "each generation of the affluent is vulnerable to moral corruption: if members of a generation give undue priority to what happens within their own lifetimes, they will welcome ways to justify overconsumption and give less scrutiny than they ought to arguments that license it").

227. *See* Edward A. Parson, *Reflections on Air Capture: The Political Economy of Active Interventions in the Global Environment*, 74 CLIMATIC CHANGE 5, 8 (2006).

228. *See* HEIMER, *supra* note 64, at 218.

as government agencies or certification organizations—which do not face the same moral hazard incentives as insureds do.[229] Delineating in advance the conditions for deploying geoengineering, emphasizing geoengineering's limitations, and providing independent oversight of geoengineering activities are analogous tools for countering risk compensation in the context of geoengineering.

A. Delineating the Terms of Any Geoengineering Activity

Insurance underwriting involves collecting information, evaluating risk exposure, and determining premiums and coverage.[230] In addition to enabling proper insurance pricing, these tools can be used to constrain insureds' ability to adjust their behavior in response to reductions in perceived risk. To the extent that geoengineering might function as an insurance policy for the Earth's climate, that policy should be supported by the equivalent of careful underwriting. Such underwriting should include not only data collection and risk evaluation, but also careful delineation of the terms, if any, under which geoengineering would take place. Specifically, the international community should strive to develop a consensus on whether to support, allow, or prohibit geoengineering research or development. International discussions should take place in advance of significant field research and deployment, and these discussions should involve broad and meaningful public participation.

If a decision is made to allow field research to proceed, limiting such research to techniques that involve a lesser risk of moral hazard can prevent the undermining of mitigation efforts. The use of "artificial trees" to capture GHGs from the atmosphere, for instance, might be preferred over solar radiation management techniques. Artificial trees, which are pollution control devices that would employ chemical processes to remove carbon from the air, not only present lesser environmental risks but also employ mechanisms that make these devices less likely to be misperceived as a "magic bullet" substitute for mitigation.[231] If full-scale geoengineering efforts are contemplated, an international agreement should spell out narrow and precise conditions under which deployment would be permitted. For example, should a consensus develop in favor of reserving geoengineering for climate emergencies, the international community should carefully define what constitutes an emergency and identify specific circumstances that would—or would not—meet that definition. Agreed-upon preconditions for geoengineering deployment would be challenging to enforce and vulnerable to amendment. Nonetheless, they

229. *See id.* at 194–209; *see also* William M. Sage, *Managed Care's Crimea: Medical Necessity, Therapeutic Benefit, and the Goals of Administrative Process in Health Insurance*, 53 DUKE L.J. 597, 606 (2003) (discussing devices used by insurers to protect themselves against moral hazard, including cost-sharing and tools of managed care).

230. *See* HEIMER, *supra* note 64, at 196–98.

231. *See* Gregor Betz, *The Case for Climate Engineering Research: An Analysis of the "Arm the Future" Argument*, 111 CLIMATIC CHANGE 473, 484 (2012).

could serve as guiding norms that would reduce the temptation to view geoengineering as a simple climate fix.

B. Framing Geoengineering

Insurers use various loss-sharing techniques such as deductibles and co-payments to counter insureds' reduced incentive to prevent loss.[232] The applicability of loss sharing to climate policy may not be immediately obvious, as the primary goal of climate policy is to avoid loss, not to share it. Yet geoengineering itself represents a form of loss sharing, because it is no more than a partial and temporary "solution" to climate change. Making this point absolutely clear to the public and policymakers is essential. Just as insurers make efforts to provide policyholders with information that will help to minimize losses,[233] scientists, advocates, and the media should clearly communicate information regarding geoengineering's risks, uncertainties, and limitations. If geoengineering research proceeds, analysis of risks and refinement of techniques should be of equal priority to ensure the generation of risk information. In addition, a portion of any funding for geoengineering research and development should be directed toward public outreach. These outreach efforts must be designed specifically to counter the psychological phenomena that may lead the public to judge geoengineering as more effective and less problematic than it actually is. As an antidote to optimism bias, worst-case scenarios could be highlighted and dramatized. Additionally, educational efforts should emphasize the centuries of commitment that geoengineering would involve, as well as its potentially uncontrollable side effects, to counter the sense of control geoengineering might otherwise foster.

Risk compensation studies provide one insight that suggests a very different alternative approach for countering moral hazard. According to those studies, people respond to safety measures with riskier behavior only if those measures are salient.[234] Consequently, limiting the visibility of geoengineering efforts may offer one mechanism for countering people's tendency to compensate for risk. Such a strategy would be troubling and should be avoided, however, as it is contrary to fundamental democratic values of transparency and public deliberation. Instead, geoengineering must be the subject of public debate, and outreach should strive to make clear that geoengineering is no more than a temporary palliative for a persistent and serious problem.

C. Making Geoengineering Contingent on Mitigation and Adaptation

To induce desirable behavior, insurers may offer rewards contingent on

232. *See* Douglass Farnsworth, *Moral Hazard in Health Insurance: Are Consumer-Directed Plans the Answer?*, 15 ANNALS HEALTH L. 251, 263–65 (2006).

233. *See* HEIMER, *supra* note 64, at 201; Farnsworth, *supra* note 232, at 267 (discussing decision-support tools that provide information to employees regarding health plan selection and treatment).

234. *See supra* Part III.B.

activity that reduces the risk of loss, or they may impose punishments for increasing such risk.[235] Health insurers may offer rebates or discounts to insureds for entering wellness programs that promote health or prevent disease.[236] These techniques align the interests of insurer and insured, and curb the motivation of insureds to compensate for reduced risk. Analogous mechanisms could be developed to tie any geoengineering activity to concrete measures that advance preferable climate strategies such as mitigation.

At first glance, it may seem unlikely that support could be galvanized for increased mitigation when weak mitigation efforts have brought us to the point of seriously considering geoengineering. Contemplation of the likely tenor of international discussions nonetheless suggests a way to link support for mitigation with support for geoengineering. Specifically, many nations will probably be wary of geoengineering because of its adverse impacts and various uncertainties.[237] These nations may be more open to allowing certain geoengineering activities, however, as long as other nations step up their commitments to mitigation and adaptation. In other words, financial or political support for geoengineering could be conditioned on support for more conventional forms of climate action. For instance, a nation or group of nations might pledge to finance twenty dollars of adaptation for every dollar committed to geoengineering research and development. Alternatively, nations might agree to condition any deployment of geoengineering on the adoption of specified climate mitigation measures or strategies.[238] Such commitments could be made as voluntary pledges or be formalized in international agreements. To counter the danger that countries might renege on these commitments in the face of geoengineering activity, upfront and verifiable action on these commitments would be essential.

D. External Oversight of Geoengineering

A final set of tools that insurers use to reduce moral hazard involves external oversight of the behavior of insureds and other parties that can influence risk. Insurers may monitor insured behavior or conduct audits and utilization reviews, and regulators may establish and enforce standards that reduce risk.[239] Geoengineering policy similarly demands external oversight,

235. *See* HEIMER, *supra* note 64, at 201–03.

236. *See* Tom Baker, *Health Insurance, Risk, and Responsibility After the Patient Protection and Affordable Care Act*, 159 U. PA. L. REV. 1577, 1602-06 (2011).

237. In 2010, for example, the parties to the Convention on Biological Diversity issued a decision urging that no geoengineering activities take place unless "science based, global, transparent and effective control and regulatory mechanisms" are in place. CONVENTION ON BIOLOGICAL DIVERSITY, REPORT OF THE TENTH MEETING OF THE CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY, DECISION X/33: BIODIVERSITY AND CLIMATE CHANGE § 8(w) (2011), *available at* http://www.cbd.int/cop10/doc/.

238. *Cf.* Betz, *supra* note 231, at 484 (suggesting, as an example, a rule that geoengineering not be applied unless GHG emissions are reduced by 90 percent).

239. *See* HEIMER, *supra* note 64, at 14–16; Farnsworth, *supra* note 232, at 259–60.

where narrow self-interests are likely to predominate if geoengineering is left to the scientific community or to entities that may profit from geoengineering. Decision-making authority for geoengineering field research or deployment must be vested in neutral entities with no stake in geoengineering. Moreover, to counter the risk compensation concern, mechanisms should be developed to persistently raise arguments for mitigation. A designated mitigation advocate could be given a prominent role in geoengineering policy and decision-making forums. Ultimately, decision-making authority over geoengineering should be as democratically accountable as possible, and this can be accomplished through oversight by international political bodies.

Problematic incentives nonetheless may persist unless persons who take risks are required to bear the consequences of risk-taking.[240] One possible mechanism for internalizing risk is to require the posting of a bond to cover the potential damages that might result from risky conduct.[241] Such a mechanism, however, is not an attractive option for addressing geoengineering risks due to the magnitude of potential damages, the incompensability of much of the harm that may occur, and the difficulty of demonstrating causation. But the importance of internalizing risk does shed further light on how decision making on geoengineering policy should occur. Specifically, those most vulnerable to the potential adverse impacts of geoengineering should have a significant—and perhaps decisive—role in deciding whether to implement geoengineering. Consider that one of the primary concerns surrounding the proposed deployment of stratospheric aerosols is the potential loss of monsoon precipitation upon which billions of people in Asia and Africa depend. For this and similar scenarios, the nations most likely to be adversely affected deserve a key role in determining geoengineering policy.

CONCLUSION

Geoengineering endeavors, including research short of full-scale deployment, will likely undermine efforts to mitigate or adapt to climate change. Geoengineering presents a strong economic, political, and psychological temptation to defer difficult and costly actions to future generations. This temptation, whether characterized as moral hazard, risk compensation, or political opportunism, is a serious concern because geoengineering is widely acknowledged to be an inferior, problematic, and at best temporary option for responding to climate risks. Reducing GHG emissions remains essential and urgent. In assessing geoengineering options, policymakers and the public must remain cognizant of the moral hazard danger

240. *See* Dowd, *supra* note 95, at 143, 163.

241. For one such proposal, see Bidisha Banerjee, *The Limitations of Geoengineering Governance in a World of Uncertainty*, 4 STAN. J.L. SCI. & POL'Y 15, 33–34 (2011).

and take steps to counter it.