SOCIOPOLITICAL FEEDBACKS AND CLIMATE CHANGE

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The Article investigates sociopolitical feedbacks in the economy-climate system. These feedbacks occur when climate change affects the social or political processes that determine mitigation or adaptation levels, which in turn affect future climate damages. We discuss two possible feedbacks: an economic disruption pathway and a political disruption pathway. In both, climate damages earlier in time undermine mitigation and adaptation policies, which exacerbates future climate damages. Using data on participation in multilateral environmental agreements, we explore the political disruption pathway. Coupled with prior work demonstrating the potential for climate damages to exacerbate civil conflict, our empirical analysis indicates that climate-induced political disruptions may impede climate policymaking, increasing the threat of future damages. We estimate how feedbacks of this sort affect predictions of temperature change and damages in the Dynamic Integrated Climate Economy (DICE) model. We find that, especially if feedbacks affect participation in international emissions-reduction efforts, anticipated temperature change and damages are substantially higher than currently estimated. Finally, we discuss how policymakers can respond to the existence of these feedbacks, especially by facilitating the resilience of climate policies and governance to climate-related shocks.

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Introduction

In the mid-1970s, average annual atmospheric concentrations of carbon dioxide surpassed 330 parts per million (ppm).[1] In an alternative world of heightened climate sensitivity, that threshold could have signified the dawn of significant climate change, and humanity would have faced the challenge of stabilizing atmospheric concentrations at, say, 300 ppm. At the time, the Cold War continued to structure international relations, China had barely emerged from the Cultural Revolution, and turmoil in the Middle East would soon lead to an oil embargo that severely stalled the U.S. economy.[2] During a period of economic instability and international hostility, it seems improbable that human societies could have mustered the trust and goodwill needed to commit to binding emissions limits.

In that alternative world, unabated greenhouse gas emissions would almost certainly have triggered large-scale disruptions in the climate system. As climate damages were unleashed, countries would have faced economic losses and threats to their political stability, making international agreement even more difficult to achieve. A spiraling and self-reinforcing cycle of emissions, climate damages, and political and economic instability would have begun, severely threatening human well-being and development.

Fortunately, climate stability is not disrupted by atmospheric concentrations of carbon dioxide of 300 ppm: in the real world, that number is at least 350 ppm, and perhaps higher.[3] In any case, it was not until the mid-1990s that it became generally clear that steps to curb greenhouse gas emissions were needed, a time not of Cold War and global recession, but of historically high levels of prosperity, international integration, and peace. Fortuitously, threats to

1. Charles D. Keeling et al., *A Three-Dimensional Model of Atmospheric CO_2 Transport Based on Observed Winds: 1. Analysis of Observational Data*, 55 Geophysical Monograph 165, 223–24 (1989) (collecting observations from Mauna Loa Observatory).

2. Eric Hobsbawm, The Age of Extremes: A History of the World, 1914–1991, at 244–46 (1996).

3. *See* Nat'l Research Council, Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia 97–104 (2011) (discussing climate impacts over a range of atmospheric concentrations); James Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim?*, 2 Open Atmospheric Sci. J. 217, 226 (2008) (endorsing a goal of 350 ppm).

the climate system occurred at a moment in time when humankind was uniquely well situated to confront them.

But even in the best of times, effectively addressing climate change has proven extremely difficult. Although there are strong reasons to cut emissions—which range from the scientific, to the economic, to the moral—climate change also implicates deeply contested value questions and raises a host of distributional issues.[4] Opposition to effective action has been heated, and well-funded interests have often questioned the validity of climate science.[5] Even proponents of cutting greenhouse gases have disagreed sharply over how limits should be achieved, and how quickly.[6]

The election of Donald Trump to the presidency of the United States undid the tentative consensus among major emitting nations in favor of confronting climate change. After backing out the Paris Climate Change Accord, this administration has pursued several paths to reverse progress on climate change and prop up carbon-intensive fuel sources, most notably coal.[7] As atmospheric concentrations of carbon dioxide continue to increase—surpassing 400 ppm in 2013—ever-more aggressive action is needed, but the political will behind that action has proven fleeting.

In this Article, we explore the possibility that humankind is wasting a short window of opportunity to address climate change, one that may soon shut as climate damages incapacitate effective political action. If the climate system passes a threshold that triggers a feedback loop between climate damages and political and economic instability, it may become impossible to muster the coordinated global response necessary to avoid even more severe risks in the future. By waiting too long, human societies may find that international conflict and immediate economic threats have made effective climate action impossible.

The phenomenon of climate change arises from a large number of interactions that occur in diverse, linked human-environment systems that are spread across the globe. Some of these interactions are well understood. For example,

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4. *See generally* MIKE HULME, WHY WE DISAGREE ABOUT CLIMATE CHANGE: UNDERSTANDING CONTROVERSY, INACTION, AND OPPORTUNITY (2009) (discussing the intersection of climate change with conflicting moral and ethical frameworks).

5. *See generally* NAOMI ORESKES & ERIK M. CONWAY, MERCHANTS OF DOUBT: HOW A HANDFUL OF SCIENTISTS OBSCURED THE TRUTH ON ISSUES FROM TOBACCO SMOKE TO GLOBAL WARMING (2010).

6. *See* David Roberts, *The Left vs. a Carbon Tax: The Odd, Agonizing Political Battle Playing out in Washington State*, VOX (Nov. 8, 2016), https://perma.cc/K9RA-PWML (discussing a split within the progressive coalition over the state carbon tax effort). *Compare* NICHOLAS STERN, HER MAJESTY'S TREASURY, STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE 25 (2006), *with* William D. Nordhaus, *A Review of the* Stern Review on the Economics of Climate Change, 45 J. ECON. LIT. 686 (2007).

7. *See* Sabin Center for Climate Change Law, *Climate Deregulation Tracker*, COLUMBIA LAW SCHOOL, https://perma.cc/DBE8-Z2AL.

it is a long known and well-established fact that carbon dioxide gas traps heat.[8] But many other features of the physical climate system—comprising many interacting natural systems—are much less well understood, and the degree of and vulnerability to climate change is also affected by a large number of complex human behaviors, from the economic growth that drives emissions to the technological development or political decision-making that can mitigate, or exacerbate, climate risk.[9] Considerable effort has been devoted in the physical and social sciences to understanding climate change and the risks that it poses to human societies, and there has long been sufficient understanding of climate risks to justify action to cut greenhouse gas emissions.[10] Despite this relatively advanced state of knowledge, however, there exists entire categories of interactions that remain underexplored, especially those at the intersection of human societies and the climate.

One such underappreciated human-environment interaction is the potential for *sociopolitical feedbacks*. In any system, a feedback occurs when an output of the system is also an input. Feedbacks are common in the climate system, and positive climate feedbacks are a major source of risk. One well-known potential feedback would occur if warming causes excess permafrost melt, which then leads to the release of methane gases, which spurs additional warming.[11] Feedbacks such as these undergird the existence of thresholds in the climate system known as "tipping points."[12]

Sociopolitical feedbacks occur when human behavior affects the climate, and the climate, in turn, affects that behavior in an ongoing dynamic relationship. For example, current greenhouse gas emissions could lead to climate damages that cause economic dislocation in the future. That relationship would spur a sociopolitical feedback if those economic shocks made it difficult for that future society to continue investing in efforts to reduce greenhouse gas emissions. This *economic disruption pathway* would create a self-reinforcing cycle in

8. *See, e.g.*, Robert A. Toth et al., *Spectroscopic Database of CO_2 Line Parameters: 4300–7000 cm^{-1}*, 109 J. Quantitative Spectroscopy & Radiative Transfer 906, 906 (2008); Jack H. Taylor & Harold W. Yates, *Atmospheric Transmission in the Infrared*, 47 J. Optical Soc'y of Am. 223, 223 (1956); Gordon Sutherland & Guy S. Callendar, *The Infra-Red Spectra of Atmospheric Gases Other Than Water Vapour*, 9 Rep. on Progress in Physics 18, 22–23 (1942).

9. *See* Intergovernmental Panel on Climate Change (IPCC), Climate Change 2014: Synthesis Report (2015), https://perma.cc/N9JB-QSJD [hereinafter IPCC Synthesis].

10. *See* Intergovernmental Panel on Climate Change (IPCC), Climate Change: The IPCC Scientific Assessment (1990), https://perma.cc/5PEG-KJ67.

11. *See generally* Edward A. Schuur et al., *Climate Change and the Permafrost Carbon Feedback*, 520 Nature 171 (2015).

12. IPCC Synthesis, *supra* note 9, at 128 (defining tipping points as "[a] level of change in system properties beyond which a system reorganizes, often abruptly, and does not return to the initial state even if the drivers of the change are abated").

which climate disruption sets off a chain of events that ultimately results in more severe climate change. Such self-reinforcing cycles are referred to as *positive feedbacks* and can have consequences akin to physical feedbacks such as warming-induced permafrost melt. Despite their significance, however, the potential for feedback loops between human societies and the climate they are embedded in has largely eluded researchers.

In this Article, we explore in some depth one potential sociopolitical feedback that occurs through a *political disruption pathway*. This feedback is based on the relationship between climate damages and civil conflict. There is an existing body of social science research that indicates that climate change may cause or exacerbate internal conflict within countries in the future. We build on this work to empirically estimate the relationship between civil discord and the willingness of countries to engage in international environmental cooperation of the type that is necessary to respond to climate change. If climate change causes civil conflict, and civil conflict reduces the willingness or ability of countries to engage in climate policy, then the political disruption pathway has the potential to generate a self-reinforcing sociopolitical feedback of increasing climate damages.

Although the link between climate and conflict has been explored by other researchers, the relationship between civil conflict and environmental cooperation has not. To address this lacuna and provide evidence for the existence of this potential sociopolitical feedback, we engage in an empirical analysis of international environmental cooperation over the past several decades. For this analysis, we merge data on environmental treaty-making at the year and country levels with information on conflict compiled by international monitors to construct a panel dataset that covers the second half of the twentieth century. Analysis of this data shows a significant and meaningful negative relationship between civil conflict and environmental treaty-making that is robust to many different model specifications and control strategies.[13] Coupled with political science theory on agenda setting, our results suggest that civil conflict—including conflict that could be induced by climate instability—leads to lower levels of environmental cooperation. The bottom line of this research is that climate change–induced conflict may make countries increasingly unable or unwilling to take the steps necessary to prevent even worse outcomes in the future.

Not all potential sociopolitical feedbacks have such dire consequences. *Negative feedbacks* are the opposite of self-reinforcing cycles and have the effect

13. In social science research based on statistical analysis of non-experimental data, a major set of challenges arise in the context of *causal identification* when two (or more) variables are correlated. Two variables, A and B, may be correlated for many reasons other than that A causally influences B. For example, B may causally influence A—this would be *reverse causation*—or a third unobserved variable, C, may causally influence both A and B—this would be influence from an *omitted variable*. A variety of techniques have been developed to respond to these challenges. Our analysis examines these issues in depth in Parts II.B and II.C.

of dampening the severity of ultimate outcomes. A negative (i.e., beneficial) sociopolitical feedback would occur if early manifestations of climate change leads people who are skeptical about climate policy to update their preferences concerning the desirability of limits on greenhouse gas emissions. But if positive self-reinforcing sociopolitical feedbacks dominate, the social costs of greenhouse gas emissions are even greater than currently understood.

To illustrate the consequence of self-reinforcing sociopolitical feedbacks for climate damages, we engage in a modeling exercise using the Dynamic Integrated Climate-Economy ("DICE") model, one of the integrated assessment models used by the U.S. government when it set a social cost of carbon during the Obama Administration.[14] The social cost of carbon is a monetary estimate of the damages of greenhouse gas emissions, and it is used by agencies when engaging in cost-benefit analysis of their rulemakings.[15] We estimate a model with a set of sociopolitical feedbacks that are triggered at 2° Celsius excess warming, the benchmark adopted by the leading international climate agreements.[16] We examine how feedbacks that undermine technological investment or efforts to reduce emissions would affect the long-term costs of emissions. We find that, especially when cooperation is implicated, accounting for feedbacks substantially increases the estimates of the long-term damages caused by emissions today.

Sociopolitical feedbacks in the economy-climate system are dangerous, and steps should be taken to avoid or mitigate them when possible. The most obvious policy measure to avoid triggering these feedbacks is to reduce greenhouse gas emissions to levels that will avert the worst climate change damages. This policy should be pursued at all levels of government and, indeed, by private actors where governments fail to act. But even aggressive measures to combat climate change may not be enough at this point.[17] Existing policies that have already been put in place, and those that are adopted in the near future, are themselves subject to disruption based on climate change damages induced by past emissions.[18]

14. Interagency Working Group on the Social Cost of Carbon, Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, at 4–5 (2010), https://perma.cc/Q8NY-ZMFT [hereinafter Interagency Working Group]. The Obama-era social cost of carbon has been abandoned by the Trump Administration. Exec. Order No. 13,783, Promoting Energy Independence and Economic Growth, 82 Fed. Reg. 16,093 (Mar. 28, 2017).

15. Interagency Working Group, *supra* note 14, at 5.

16. *See* U.N. Framework Convention on Climate Change, Adoption of the Paris Agreement, U.N. Doc. FCCC/CP/2015/L.9 (Dec. 12, 2015).

17. *See* Intergovernmental Panel on Climate Change (IPCC), Global Warming of 1.5°C (2018), https://perma.cc/9G87-4322.

18. The need to construct long-term climate policies that are not subject to reversal based on short-term shifts in political will has been recognized by several environmental law scholars. *See, e.g.*, Ann E. Carlson & Robert W. Fri, *Designing a Durable Energy Policy*, 142 Daeda-

We will explore two additional measures to respond to sociopolitical feedbacks. The first involves making climate policies more resistant to reversal, by, for example, incentivizing large, sunk, upfront expenditures (as occurs with renewable portfolio standards) or creating substantial reliance interests (as would occur with a revenue-neutral carbon tax). These politics may be maintained even if the political will behind them is volatile. A second alternative would focus on creating more resilient governance institutions. We define resilience in this context as *insulation* from positive self-reinforcing feedbacks and *openness* to dampening negative feedbacks. One basic mechanism to build in this type of resilience would be to facilitate the ability of democratically accountable actors to easily ratchet up the stringency of climate protection while placing checks on their ability to ratchet down protections. Ultimately, policy should be responsive to democratic will, but slowing down that responsiveness under certain circumstances could reduce the likelihood of the political equivalent of a bank run.

Given its interdisciplinary bent, this Article makes contributions in several fields. Most generally, we contribute to the growing body of legal scholarship on the interaction of society, law, and the environment in the context of climate change and the social cost of carbon.[19] Others have recognized the centrality of the social cost of carbon in legal, administrative, and political decision-making about climate policy.[20] We draw out the mutually interconnected nature of policy and the climate and argue that this dynamic affects both the social cost of greenhouse gas emissions and appropriate climate policies. Additionally, we contribute to the growing body of work within the physical and social sciences on the need to model coupled human-environment systems as such—we both highlight and explore a particularly important application of this insight.[21] Our empirical analysis of conflict and environmental treaty-making extends related

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LUS 119, 122–23 (2013); Richard Lazarus, *Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future*, 94 CORNELL L. REV. 1153, 1153–54 (2009). Sociopolitical feedbacks are an additional source of instability that make it both more challenging and more pressing to design politics that are able to persist over time.

19. *See, e.g.*, Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 COLUM. J. ENVTL. L. 203 (2017); Michael A. Livermore, *Setting the Social Cost of Carbon, in* 1 CLIMATE CHANGE LAW, ELGAR ENCYCLOPEDIA OF ENVIRONMENTAL LAW 32 (Daniel Farber & Marjan Peeters eds., 2016); Elisabeth J. Moyer et al., *Climate Impacts on Economic Growth as Drivers of Uncertainty in the Social Cost of Carbon*, 43 J. LEGAL STUD. 401 (2014); Jonathan S. Masur & Eric A. Posner, *Climate Regulation and the Limits of Cost-Benefit Analysis*, 99 CAL. L. REV. 1557 (2011).

20. *See, e.g.*, Jody Freeman & Jim Rossi, *Agency Coordination in Shared Regulatory Space*, 125 HARV. L. REV. 1131, 1199 (2012) (describing the Obama Administration's effort to develop a government-wide social cost of carbon as an "effective and exemplary" effort to harmonize policy across federal agencies).

21. *See, e.g.*, Jianguo Liu et al., *Complexity of Coupled Human and Natural Systems*, 317 SCIENCE 1513 (2007) (synthesizing multiple case studies from around the world that investigate couplings between human and natural systems).

work in empirical legal studies, international relations, and political science on international environmental cooperation.[22] Finally, our analysis of the effects of sociopolitical feedbacks sheds light on an underexplored subject within the robust literature on economy-climate models.[23]

The remainder of this Article proceeds as follows. Part I first discusses the legal context for the arguments presented in this paper, specifically agencies' legal duties to engage in rational consideration of relevant environmental effects of their decisions. We then introduce the concepts of sociopolitical feedbacks and explain two potential examples, the economic disruption pathway and the political disruption pathway. Part II then zooms in on the political disruption pathway through an empirical analysis of the relationship between conflict and international environmental cooperation. Using a newly constructed panel dataset on environmental treaty-making and conflict, we find that conflict—and especially internal domestic strife—has a robust and consistent negative relationship with environmental treaty-making. This finding closes the loop on a positive sociopolitical feedback with the potential to lead to self-reinforcing climate damages. Part III zooms back out to sociopolitical feedbacks more generally and their interaction with estimates of the damages associated with greenhouse gas emissions. We find that there are considerable effects, especially for feedbacks that undermine cooperation on climate mitigation. Part IV discusses potential legal and policy responses to the potential for sociopolitical feedbacks, mostly centered on the question of how to make climate-relevant decision-making and policies robust to these feedbacks.

I. Linked Economy-Climate Systems

This Part begins with a discussion of the legal framework establishing agencies' obligations to engage in reasoned decision-making and the role that courts have played in prompting agencies to consider scientific and economic research on climate change. If, as we argue in the balance of the Article, there is good reason to believe that sociopolitical feedbacks are relevant to climate-related decision-making, agencies are legally bound to adequately investigate and consider that class of effects. Against that legal background, the remainder of this Part explains the concept of sociopolitical feedbacks and the two hypothesized pathways that might lead to feedbacks between the climate and political and economic systems.

22. For literature reviewed, see *infra* Part II.A.

23. *See generally* Peter H. Howard & Thomas Sterner, *Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates*, 68 Envtl. Resource Econ. 197 (2017) (providing a brief history of literature on economy-climate models).

A. Agency Obligations to Consider the Social Costs of Climate Change

Climate change is a complex global phenomenon that cannot be directly perceived—it can only be inferred from a wide collection of diffuse data points that are given meaning by scientific theories. For a lay person, even a relatively well-informed non-expert, belief in the existence of climate change largely amounts to a question of trust. When trust in scientific institutions conflicts with partisan loyalty, it is far from clear that the former always wins out.[24] Nevertheless, the American legal order only allows for limited degrees of partisanship in its institutions.[25] In particular, administrative agencies are limited in the extent to which they can simply implement the party agenda of their political supervisors. Procedural and substantive norms relating to expertise, impartiality, and legality constrain agencies from being entirely responsive to party programs.[26] Courts also enjoy a high level of freedom from direct partisan influence by virtue of both institutional design (via life tenure) and a strong norm of independence from the political branches.[27]

Indeed, courts have played an important role in prodding the political branches—especially the executive—to confront the growing body of scientific research on climate change. In *Massachusetts v. EPA*,[28] the Supreme Court heard a challenge to a decision of the George W. Bush Administration to deny a petition for rulemaking to address greenhouse gas emissions from automobiles. In finding for Massachusetts and co-petitioners, the Court reviewed and endorsed the extensive scientific literature on climate change.[29] Upon remand from that decision, EPA issued an "endangerment finding" for greenhouse gas

24. *See* Dan M. Kahan, *Climate-Science Communication and the* Measurement Problem, 36 ADVANCES IN POL. PSYCH. (SUPPLEMENT 1) 1, 8–14 (2015).

25. *See* Michael A. Livermore, *Political Parties and Presidential Oversight*, 67 ALA. L. REV. 45, 110–32 (2015).

26. *See id.*

27. Judicial independence does not imply that courts are apolitical or non-responsive to majoritarian desires, or that the appointment process does not shape the law. But even if judicial ideology or judges' values do affect their decision-making, if that is done in a principled—rather than partisan—fashion, there is at least room for deliberation and rational argument.

28. 549 U.S. 497 (2007).

29. The first lines of Justice Stevens's opinion read: "A well-documented rise in global temperatures has coincided with a significant increase in the concentration of carbon dioxide in the atmosphere. Respected scientists believe the two trends are related. For when carbon dioxide is released into the atmosphere, it acts like the ceiling of a greenhouse, trapping solar energy and retarding the escape of reflected heat." *Massachusetts*, 549 U.S. at 504.

emissions based on an extensive scientific record.[30] The endangerment finding was subsequently upheld by the D.C. Circuit.[31]

Perhaps as important, courts have forced agencies to acknowledge threats posed by climate change when conducting economic analysis of their decisions. In *Center for Biological Diversity v. National Highway Traffic Safety Administration*,[32] the Ninth Circuit heard a challenge to a fuel economy standard that was based on an economic analysis that assigned no weight to greenhouse gas emissions reduction. The agency argued that it could not value emissions reductions because of uncertainty over the magnitude of climate damages. The court rejected that reasoning, holding that "while the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero."[33]

The *CBD v. NHTSA* decision spurred an effort by the Obama Administration to generate an economic estimate of the damages caused by greenhouse gas emissions. An interagency taskforce was convened, spearheaded by the Office of Management and Budget in the White House and involving agencies as diverse as the EPA and Treasury Department.[34] The work of this taskforce culminated in a substantive technical document that reported a "social cost of carbon" value that was used by agencies in their cost-benefit analyses of climate-related actions.[35] The foundation for this social cost of carbon are models developed by environmental economists that estimate the relationship between climate effects and economic damages.[36] Because these models influence how the social cost of carbon is estimated, technical choices can have an important effect on whether relatively more stringent climate actions are justified under a cost-benefit framework.[37]

The social cost of carbon developed by the Obama Administration was used for several years in a variety of regulatory contexts, and was ultimately

30. *See* Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,496 (Dec. 15, 2009).

31. *See* Coal. for Responsible Regulation v. EPA, 684 F.3d 102 (D.C. Cir. 2012). In *Utility Air Regulation Group v. EPA*, 134 S. Ct. 2427 (2014), the Supreme Court reviewed elements of the D.C. Circuit's opinion in *Coalition for Responsible Regulation* while explicitly leaving the endangerment finding undisturbed. *Id.* at 2438 (noting that certiorari review was granted with respect to "only one question," which was unrelated to the endangerment finding).

32. 538 F.3d 1172, 1200 (9th Cir. 2008).

33. *Id.*

34. *See* Interagency Working Group, *supra* note 14. *See generally* Michael Greenstone, Elizabeth Kopits & Ann Wolverton, *Developing a Social Cost of Carbon for U.S. Regulatory Analysis: A Methodology and Interpretation*, 7 Rev. Envtl. Econ. & Pol'y 23 (2013).

35. *Id.*

36. *See* Livermore, *supra* note 19.

37. For background on the use of cost-benefit analysis to evaluate agency rulemaking, see generally Richard L. Revesz & Michael A. Livermore, Retaking Rationality: How Cost-Benefit Analysis Can Better Protect the Environment and Our Health (2008).

upheld by a Seventh Circuit panel against an industry challenge in *Zero Zone v. Department of Energy*.[38] In that decision, the court rejected a number of arguments raised by the industry and found that the agency's method of valuing climate damages was rational.[39] Although the Trump Administration has disavowed the Obama-era social cost of carbon, the work of the interagency task force estimate remains the leading economic estimate of the damages associated with greenhouse gas emissions.[40]

There are several types of legal obligations on agencies that require them to accurately account for climate change damages in their decisions. Most specifically, the act that empowers an agency action may have statutory requirements concerning what the agency must (and must not) consider when making decisions. For example, the Supreme Court held in *Massachusetts v. EPA*[41] that Clean Air Act section 202 foreclosed consideration of general policy in favor of a narrow scientific inquiry into whether "greenhouse gases [do or] do not contribute to climate change."[42] The *CBD v. NHTSA* court was interpreting a provision of the Energy Policy and Conservation Act when it found that the agency was obligated to assign a value to greenhouse gas emissions reduction in its economic analysis.[43]

There are also more general requirements. The National Environmental Policy Act contains a broad requirement that agencies consider the environmental consequences of all their major actions.[44] This obligation adheres to all agency actions unless specifically exempted, and climate damages must be included in agency environmental impact analyses.[45] In addition, the Administrative Procedure Act prohibits agency decisions that are arbitrary or capricious.[46] If an agency fails to consider climate impacts when they are relevant to its decision, it would run afoul of this standard.[47] In *Juliana v. United States*,[48] a U.S. District Court even found constitutional grounds for requiring agencies to

38. 832 F.3d 654, 660–61 (7th Cir. 2016).

39. *Id.* at 654. Professor Cass Sunstein has characterized the decision as "one of the most important climate change rulings ever." Cass R. Sunstein, *A Court Ruling That Could Save the Planet*, BLOOMBERG OPINION (Aug. 12, 2016, 7:30 AM), https://perma.cc/LL46-9J45.

40. *See* Richard L. Revesz et al., *Best Cost Estimate of Greenhouse Gases*, 357 SCIENCE 655 (2017).

41. 549 U.S. 497 (2007).

42. *Id.* at 533.

43. 538 F.3d 1172, 1200 (9th Cir. 2008).

44. National Environmental Policy Act of 1969 §§ 101–102, 42 U.S.C. §§ 4331–4332 (2012).

45. *See* Wildearth Guardians v. U.S. Bureau of Land Mgmt., 870 F.3d 1222, 1236–37 (10th Cir. 2017); Sierra Club v. FERC, 867 F.3d 1357, 1374–75 (D.C. Cir. 2017).

46. Administrative Procedure Act of 1946, 5 U.S.C. § 706(2)(A) (2012).

47. "Normally, an agency rule would be arbitrary and capricious if the agency has relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in

confront climate change, finding that "the right to a climate system capable of sustaining human life is fundamental to a free and ordered society."[49] Any substantive duty to protect the climate would naturally include a procedural obligation to consider climate impacts for at least some category of decisions. In many cases, appropriate consideration of climate impacts will include quantitative and monetary estimates of damages, such as the Obama-era social cost of carbon.[50]

Identifying new categories of economic dynamics that affect the social cost of carbon can have particular legal significance. Courts are often hesitant to second-guess the judgement of agencies when they are making technical choices on the "frontiers of scientific knowledge."[51] On the other hand, courts are more comfortable engaging in probing review when agencies "entirely failed to consider an important aspect of the problem."[52] The balance of this Article focuses on shedding light on a previously unidentified set of climate risks—sociopolitical feedbacks in economy-climate systems—that agencies have, to date, "entirely failed to consider." Given their legal obligations, agencies should begin the process of investigating this class of climate risks and incorporating that information into their analysis—most prominently by updating estimates of the social cost of carbon. If they fail to do so, courts may be called on to prod them along.

B. Sociopolitical Feedbacks

Climate change is a complex phenomenon involving multiple interconnected physical, biological, and social systems operating at global scales over long time periods. All predictive climate models at least implicitly imbed the connection between the actions of human societies and the climate system—emissions forecasts are, in essence, predictions about future human behaviors. But none of the leading models accurately incorporate the true depth of the potential feedback between human and climate systems.

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view or the product of agency expertise." Motor Vehicle Mfrs. Ass'n of U.S. v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43–44 (1983).

48. 217 F. Supp. 3d 1224 (D. Or. 2016).

49. *Id.* at 1250.

50. In addition to the U.S. federal government, several states—including New York and Minnesota—now use versions of the social cost of carbon when making energy policy decisions. *See* Peter Fairley, *States Are Using Social Cost of Carbon in Energy Decisions, Despite Trump's Opposition*, INSIDE CLIMATE NEWS (Aug. 14, 2017), https://perma.cc/KKS2-65YH. Private actors interested in accurate internal carbon pricing can also rely on estimates such as the social cost of carbon. *See* MANJYOT BHAN AHLUWALIA, CTR. FOR CLIMATE AND ENERGY SOLS., THE BUSINESS OF PRICING CARBON 17 (2017).

51. *See, e.g.*, Pub. Citizen Health Research Grp. v. Tyson, 796 F.2d 1479, 1504–05 (D.C. Cir. 1986).

52. *See, e.g.*, Pac. Coast Fed'n of Fishermen's Ass'ns v. U.S. Bureau of Reclamation, 426 F.3d 1082, 1090 (9th Cir. 2005).

Perhaps the most detailed effort to more formally recognize the connection between society, economy, and climate has come in the form of economy-climate integrated assessment models ("EC-IAM") developed within the field of environmental economics.[53] Natural scientists have developed extremely sophisticated models of the climate system and how that system responds to human inputs such as greenhouse gas emissions, changes in albedo cover, or deforestation.[54] Substantial work has also been done in a range of disciplines on the vulnerability of human systems to climate disruption.[55] But economists took the first major steps in developing models of the dynamic human-climate system capable of providing quantitative estimates of the costs of climate change and current emissions.[56] When the Obama Administration, under the influence of the Ninth Circuit's decision in *CBD v. NHTSA*, sought to develop a social cost of carbon for use in cost-benefit analysis of climate-related regulation, it turned to the three leading EC-IAMs.[57] Using updated data and several policy choices concerning matters such as appropriate discount rates, the interagency working group used the three chosen EC-IAMs to generate the range of values to be used for social cost of carbon, which then affected the economic value estimated for all climate-relevant agency rulemakings during the Obama Administration.

Because EC-IAMs represent the most well-recognized attempt to date to link human and climatic systems, we will use them as the starting place to explain the concept of sociopolitical feedbacks. In addition, by demonstrating the importance of those feedbacks within the general EC-IAM framework, we also show their importance for public policy setting by virtue of the link between EC-IAMs and the social cost of carbon.

EC-IAMs start with projections concerning future population and macroeconomic production (i.e., gross domestic product ("GDP")), which are translated into emissions projections based on an *emissions intensity function*. EC-IAMs then rely on physical models to translate emissions projections into estimates of changes in the composition of the atmosphere and global mean temperature, based on a *climate sensitivity function*. Those estimates, in turn,

53. *See generally* William D. Nordhaus, Managing the Global Commons: The Economics of Climate Change (1994); Richard S. J. Tol, *The Damage Costs of Climate Change: Toward More Comprehensive Calculations*, 5 Envtl. & Resource Econ. 353 (1995); Christopher Hope, John Anderson & Paul Wenman, *Policy Analysis of the Greenhouse Effect: An Application of the PAGE Model*, 3 Energy Pol'y 327 (1993). For a recent review of EC-IAMs and their limitations, see Delavane Diaz & Frances Moore, *Quantifying the Economic Risks of Climate Change*, 7 Nature Climate Change 774 (2017).

54. *See* IPCC Synthesis, *supra* note 9.

55. *See id.*

56. *See, e.g.*, William D. Nordhaus, *An Optimal Transition Path for Controlling Greenhouse Gases*, 258 Science 1315 (1992).

57. *See* Greenstone, Kopits & Wolverton, *supra* note 34, at 25.

serve as the input into *damage functions* that translate temperature change into economic consequences.[58]

EC-IAMs embed human behavioral factors into modeling parameters concerning economic growth, emissions intensity, and damages. Human behavior can affect all of these factors as individuals respond to market incentives, public policy choices, and social or cultural norms. For example, technological progress—and associated economic growth—is affected by the rate of innovation at individual companies;[59] carbon intensity is affected by government policies toward low-carbon energy generation or carbon sequestration;[60] and exposure to climate risk is affected by individual adaptation decisions (e.g., farmers deciding what crops to plant).[61] Behavior to *mitigate* climate change reduces greenhouse gas emissions, while *adaptation* measures are meant to reduce damages associated with a given level of climate change. Geoengineering measures, such as intentional seeding of the atmosphere with sulfate aerosols in an attempt to reduce climatic response to rising GHG concentrations, represents a third type of public policy intervention.[62]

Many of the functions at the heart of EC-IAMs represent the aggregated decisions of the entire global population, acting in a diffuse manner in a diverse range of social, political, and economic settings, both unintentionally and with the goal of mitigating or adapting to climate risks. But human decisions are not only an input of the economy-climate system; they are also an output. A municipal government, enjoying a period of relative prosperity, may invest in clean energy to reduce emissions or infrastructure improvements to limit exposure to increased weather variability. But that same government in the future, wracked by the social and economic consequences of climate change, may be ill-positioned to continue making those same kinds of investments, and efforts to mitigate or adapt to climate change may suffer as a consequence.

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58. Although any decision to mitigate emissions can be described as a feature of emissions intensity and production, in most EC-IAMs abatement is treated separately. *See* Diaz & Moore, *supra* note 53. In the DICE model, discussed extensively *infra* Part III, the costs of abatement are modeled based on a "backstop technology."

59. *See generally* NATIONAL BUREAU OF ECONOMIC RESEARCH, R & D, PATENTS, AND PRODUCTIVITY (Zvi Griliches ed., 1984).

60. *See* Pelin Demirel & Effie Kesidou, *Stimulating Different Types of Eco-Innovation in the UK: Government Policies and Firm Motivations*, 70 ECOLOGICAL ECON. 1546 (2011).

61. *See, e.g.,* Kathleen Segerson & Bruce L. Dixon, *Climate Change and Agriculture: The Role of Farmer Adaptation*, *in* THE IMPACT OF CLIMATE CHANGE ON THE UNITED STATES ECONOMY 75 (Robert Mendelsohn & James E. Neumann eds., 2004). Others have noted that an increase in expenditures on adaption to climate change could reduce funds available for research and development of mitigation technologies. *See* Samuel Frankhauser & Richard S. J. Tol, *On Climate Change and Economic Growth*, 27 RESOURCE & ENERGY ECON. 1 (2005); Moyer et al., *supra* note 19.

62. The risks and challenges associated with geoengineering, although interesting, are outside the scope of this Article.

Stated another way, investment in climate mitigation and adaptation can be thought of as being undertaken sequentially over several time periods. If climate damages in Period 1 reduce mitigation and adaptation investments to avoid or limit damages in Period 2, then those damages will be higher. Then, in Period 2, there will be even less investment in mitigation and adaption to avoid or limit damages in Period 3, leading to higher damages and less investment. And so on. The result is an escalating, self-reinforcing cycle of increasing exposure and harm.

Current EC-IAMs—including those used by the Obama Administration to construct the social cost of carbon—do not account for the potential for sociopolitical feedbacks. Instead, these models typically treat the influence between the economy and climate as unidirectional, beginning with economic production and ending with an estimate of economic damages associated with climate change.

Recently, researchers have begun to examine the effects of one important feedback in the system—the possibility that climate damages will affect economic growth and therefore macroeconomic production.[63] Empirical analysis of economic production trends generally finds a negative relationship between temperature and income.[64] Climate-related reduction in macroeconomic production will negatively affect human consumption, but may reduce emissions as well. The feedbacks associated with climate damages and growth are likely negative for the climate system, meaning that they lead to *less* severe climate change. This is because extreme climate outcomes become less probable as future emissions are dampened by the effects of current emissions on economic growth. But as noted by economist Martin Weitzman and others, this effect nevertheless would have profoundly harmful consequences for human well-being as future generations suffer substantial consumption losses compared to currently modeled damages.[65]

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63. *See, e.g.*, Frances C. Moore & Delavane B. Diaz, *Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy*, 5 NATURE CLIMATE CHANGE 127 (2015); Simon Dietz & Nicholas Stern, *Endogenous Growth, Convexity of Damage and Climate Risk: How Nordhaus' Framework Supports Deep Cuts in Carbon Emissions*, 125 THE ECON. J. 574 (2015); Moyer et al., *supra* note 19; Melissa Dell, Benjamin F. Jones & Benjamin A. Olken, *Temperature Shocks and Economic Growth: Evidence from the Last Half Century*, 4 AM. ECON. J. MACROECON. 66 (2012); Ravi Bansal & Marcelo Ochoa, *Welfare Costs of Long-Run Temperature Shifts* (Nat'l Bureau of Econ. Research, Working Paper No. 17574, 2011); Fabio Eboli, Ramiro Parrado & Roberto Roson, *Climate-Change Feedback on Economic Growth: Explorations with a Dynamic General Equilibrium Model*, 15 ENVTL. & DEV. ECON. 515 (2010); Fankhauser & Tol, *supra* note 61.

64. *See* John K. Horowitz, *The Income-Temperature Relationship in a Cross-Section of Countries and its Implications for Predicting the Effects of Global Warming*, 44 ENVTL. RESOURCE ECON. 475, 475 (2009).

65. *See* Martin Weitzman, *On Modeling and Interpreting the Economics of Catastrophic Climate Change*, 92 REV. ECON. & STAT. 1, 1 (2009).

To date, economists who have studied the potential for a growth feedback have assumed that the relationship between the two is relatively direct, via reduced productivity of capital (for example, if climate increases the rate of depreciation of infrastructure), reduced productivity of labor (for example, if workers are less productive in hotter climates), or both, due to decreased total factor productivity (for example, decreased efficiency of earlier investment).[66] But climate may also have more indirect, yet nevertheless important, effects. For example, societies could respond to climate damages by lowering the savings rate, engaging in protectionist trade policies, expropriating foreign investments, or reducing expenditures on public goods such as education or infrastructure. While it is difficult to identify ex ante the types of political responses that might accompany climate change, government policy creates the conditions for increasing macroeconomic production and may respond to climate change in a variety of ways that harm long-term growth.

Beyond effects on growth, there are several other potential feedbacks between the climate system and human societies. The potential for sociopolitical feedbacks in the economy-policy-climate system are represented in Figure 1. In this model, the socioeconomic effects of climate change affect choices that are made at the global, regional, domestic, sub-domestic, and individual levels. The three domains of policy choice are growth, mitigation (including carbon sequestration), and adaptation, which affect GDP, emissions intensity, and damages.

66. *See* Moore & Diaz, *supra* note 63; Dietz & Stern, *supra* note 63; Francesco Bosello, Fabio Eboli & Roberta Pierfederici, *Assessing the Economic Impacts of Climate Change - An Updated CGE Point of View*, (FEEM Working Paper No. 2.2012; CMCC Research Paper No. 125, 2012); Roberto Roson & Dominique Van der Mensbrugghe, *Climate Change and Economic Growth: Impacts and Interactions*, 4 INT'L J. SUSTAINABLE ECON. 270, 270 (2012).

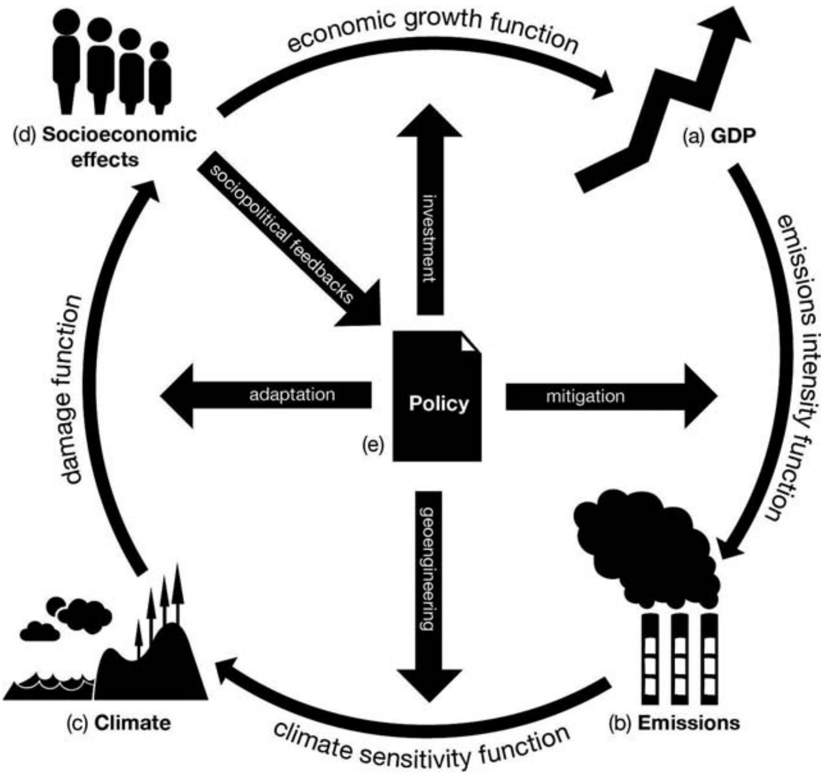

Figure 1. Economy-climate integrated assessment models with sociopolitical feedbacks. (a) Standard economy-climate models begin with predictions concerning global economic production. These predictions are generated from an economic growth function. **(b)** Future emissions are predicted by translating economic production estimates into emissions based on forecasted emissions intensity of the global economy. **(c)** Emissions predictions are translated to average temperature change on the basis of a climate sensitivity function. **(d)** Socioeconomic effects are derived on the basis of a damage function, which represents the sensitivity of human systems to the physical effects associated with climate change. **(e)** Policy choices made by societies can intervene at each step in the economy-climate system by affecting emissions intensity via mitigation, climate sensitivity via geoengineering, damages via adaptation, and economic growth via investment. The socioeconomic effects from climate change may, in turn, affect policy choices.

There are two types of possible sociopolitical feedbacks: positive, self-reinforcing feedbacks and negative, dampening feedbacks. With respect to emissions intensity and vulnerability, a self-reinforcing feedback would occur if damages reduce investment in mitigation and adaptation, thereby increasing emissions intensity and vulnerability, which, in turn, increase future economic damages, which feeds back (via policy mechanisms) into increased emissions intensity and vulnerability. Such positive self-reinforcing feedbacks amount to vicious cycles in which climate damages lead to more climate damages. But positive feedbacks can also lead to virtuous circles as well. Action on climate change now could help preserve the conditions necessary for future investment, which in turn leads to fewer and less severe damages.[67]

It is also possible for sociopolitical feedbacks to be negative, dampening the vulnerability of the system to emissions. One such negative self-inhibiting feedback would be climate damages that affect political preferences.[68] In the United States, there remain significant portions of the population that doubt the reality of anthropogenic climate change, including a substantial majority of Republican-affiliated voters.[69] The causes of these beliefs are complex and have been given substantial study by behavioral and social scientists.[70] Disbelief in the reality of climate change has proven remarkably stable in the face of even a consistent and overwhelming consensus among the scientific community that greenhouse gas emissions are causing, and will continue to cause, climate change.[71] Nevertheless, it is possible that lived experience with the consequences of climate change, such as wildfires, floods, crop failure, or disease infestation, may cause people to update their views and come to favor climate policies.[72] Although we focus on positive sociopolitical feedbacks in this Article, the question of whether positive or negative sociopolitical feedbacks are likely to dominate is an important topic for future research and discussion.

C. Pathways

In this subpart, we will discuss two potential pathways that could generate sociopolitical feedbacks: an economic disruption pathway and a political disruption pathway. We will first examine these pathways in general terms, explaining

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67. *Cf.* John R. Oneal & Bruce Russett, *Clear and Clean: The Fixed Effects of the Liberal Peace*, 55 Int'l Org. 469 (2001); Bruce Russett, John R. Oneal & David R. Davis, *The Third Leg of The Kantian Tripod for Peace: International Organizations and Militarized Disputes, 1950–85,* 52 Int'l Org. 441 (1998).

68. Information that reduces the likelihood of fat-tailed risks substantially lowers the value of climate insurance. *See* David L. Kelly & Zhuo Tan, *Learning and Climate Feedbacks: Optimal Climate Insurance and Fat Tails*, 72 J. Envtl. Econ. & Mgmt. 98 (2015).

69. *See* Cary Funk & Brian Kennedy, Pew Internet & American Life Project, The Politics of Climate (2016), https://perma.cc/7L6D-57NJ.

70. *See generally* Susan Clayton et al., *Psychological Research and Global Climate Change*, 5 Nature Climate Change 640 (2015).

71. John Cook et al., *Consensus on Consensus: A Synthesis of Consensus Estimates on Human Caused Global Warming*, 11 Envtl. Res. Letters 48,002 (2016) (finding that 97% of peer-reviewed articles published between 1991 and 2011 are consistent with anthropogenic climate change).

72. At least in the United States, there are reasons not to be overly optimistic that experience will substantially influence political views on climate change policy, as partisan affiliation appears to affect the likelihood that people will attribute any given phenomenon, such as severe weather, to climate change. *See* Emily Guskin & Brady Dennis, *Majority of Americans Now Say Climate Change Makes Hurricanes More Intense*, Wash. Post (Sept. 28, 2017), https://perma.cc/F79X-HDJC.

how they work through hypothetical examples. Then we will delve more specifically into the empirical literature concerning the relationship between climate change and economic and political disruptions.

The first pathway involves economic disruption caused by climate damages. Such disruptions are relatively easy to imagine: a sudden fall in agricultural productivity, the failure of critical infrastructure, or a string of high-impact natural disasters could all lead to severe economic disruptions that would result in a decline of national productivity. Given the interconnectedness of the global economic system, even if these harms did not befall the country in question, they could generate effects that propagated through the system, resulting in widespread costs. In the face of economic crisis, the attention of national leaders could turn from long-term global issues such as climate change to more pressing matters of economic stabilization. Investments in mitigation or adaption might find themselves sacrificed for the needs of the day.

To make the notion of an economic disruption pathway more concrete, imagine a scenario in which a group of climate-related risks interact with the interconnected global economic system to induce a series of economic disruptions.[73] For example, climate change could create the conditions for more severe versions of even the very intense recent California wildfire seasons.[74] Climate change could also threaten economic growth in China and Southeast Asia, for example, through a warm temperature–incubated disease that could severely strain health care systems and affect economic productivity. Negative economic shocks such as these could induce a financial crisis if a range of heretofore thought-uncorrelated financial instruments suddenly, unexpectedly, and simultaneously lose value. A feedback would set in if the political exigency of the financial crisis, recession, and employment decline drove political leaders to attempt to jumpstart economic growth by, among other policy changes, reducing regulatory burdens and cutting taxes (including carbon taxes). If politicians respond this way, climate mitigation goals would fall by the wayside as economic stabilization became the overriding focus of domestic and international policy.

The second pathway involves *political* disruption caused by climate damages. For example, climate change–related events could lead to a wave of out migration from Bangladesh to nearby countries, causing political upheaval through an already unstable region. This climate change damage would turn into a positive self-reinforcing feedback if political leaders in India or China responded by embracing nationalist or isolationist positions or simply focused on the immediate crisis at hand, rather than long-term problems such as climate change. The basic relationships in these scenarios are between greenhouse

73. *See* Jody Freeman & Andrew Guzman, *Climate Change and U.S. Interests*, 109 COLUM. L. REV. 1531 (2009).

74. *See* Joseph L. Crockett & A. Leroy Westerling, *Greater Temperature and Precipitation Extremes Intensify Western U.S. Droughts, Wildfire Severity, and Sierra Nevada Tree Mortality*, 31 J. CLIMATE 341 (2018).

gases, climate damages, economic or political disruption, and policy change. These relationships are illustrated in Figure 2.

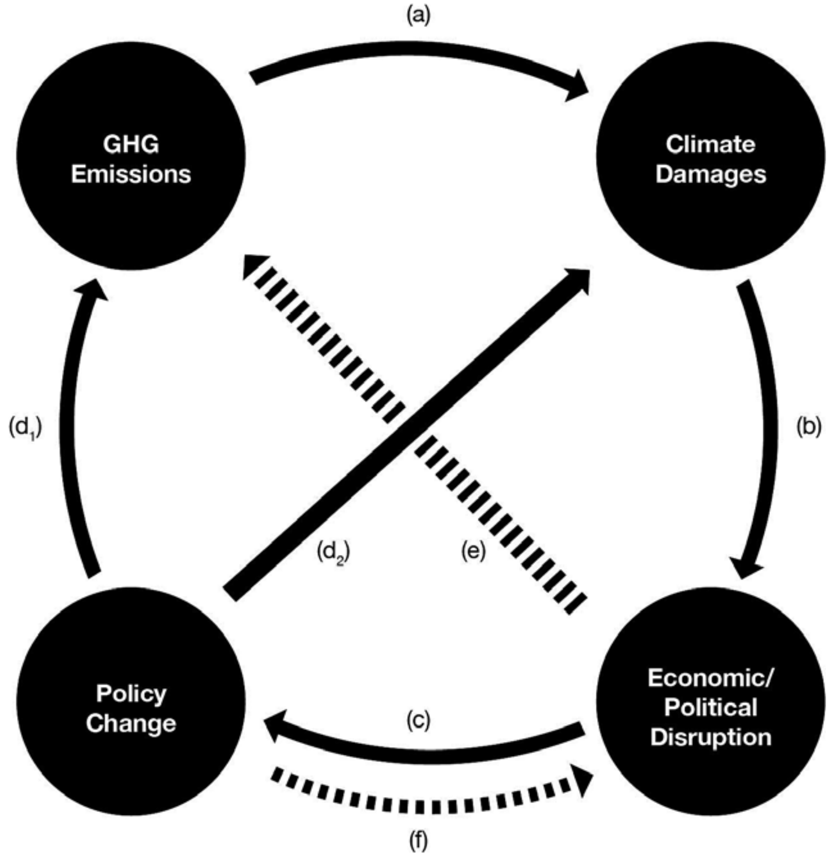

Figure 2. Relationships that drive an economic disruption pathway for sociopolitical feedbacks. **(a)** Greenhouse gas emissions lead to climate damages, such as reduced agricultural productivity. **(b)** Some climate damages could result in economic or political disruption including political violence. **(c)** These disruptions could lead to policy changes, such as withdrawal or under-enforcement of a mitigation regime, or cession of adaptation activities. **(d)** The policy changes could, in turn, affect greenhouse gas emissions **(d_1)** or vulnerability to future climate change **(d_2)**. **(e)** Economic or political disruption could also directly affect greenhouse gas emissions, for example by dampening economic growth. **(f)** Finally, policy choices that result from economic or political disruption, such as a decision to enact trade barriers, might affect the future likelihood of further disruption.

There is a considerable body of research that examines the link between climate damages and economic and political disruption.[75] Buhaug, Gleditsch,

75. *See, e.g.*, Jon Barnett & W. Neil Adger, *Climate Change, Human Security and Violent Conflict*, 26 POL. GEOGRAPHY 639 (2007); Solomon M. Hsiang, Marshall Burke & Edward Miguel, *Quantifying the Influence of Climate on Human Conflict*, 341 SCIENCE 1212 (2013); Melissa

and Theisen advance four narratives on how climate change can drive conflict by contributing to political instability, economic instability, migration, or inappropriate governmental response.[76] Weak political institutions are ill positioned to address direct climate-related catastrophes (such as droughts or famines), and responding to these crises may undermine the ability to adequately deliver other public goods (such as health care, education, and infrastructure). Climate change can contribute to economic instability when decreased availability of a resource (such as food) drives down effective household incomes, which can compound existing intergroup inequalities and reduce the governmental funds available to adapt to climate change. Migration driven by natural disasters or sea level rise could cause influxes of climate refugees, increasing environmental, economic, social, and political stresses in receiving areas, particularly when the incoming refugees are of a different nationality or ethnic group. Finally, unpopular responses to climate change, such as draconian emissions-reduction mandates, could result in social uprisings in response.[77]

Large-scale crises can exacerbate destabilizing tendencies in societies with histories of armed violence and deep political and social fragmentation. Nations in the developing world, which are anticipated to bear the brunt of climate change due to a lack of adaptive capacity, are considered especially vulnerable to climate change–related social crises because their economic and political institutions tend to be less stable than those in the developed world.[78] Climate damages may also affect the ability of political communities to achieve internal cooperation. Economic shocks, which can be brought about by climatic instability, are associated with internal political transitions, which are one indicator of societal strife.[79]

Dell, Benjamin F. Jones & Benjamin A. Olken, *What Do We Learn from the Weather? The New Climate–Economy Literature*, 52 J. ECON. LITERATURE 740 (2014); Marshall Burke, Solomon M. Hsiang & Edward Miguel, *Climate and Conflict*, 7 ANN. REV. ECON. 577 (2015); Tamma A. Carleton & Solomon M. Hsiang, *Social and Economic Impacts of Climate*, 353 SCIENCE 1112 (2016); Colleen Devlin & Cullen S. Hendrix, *Trends and Triggers Redux: Climate Change, Rainfall, and Interstate Conflict*, 43 POL. GEOGRAPHY 27 (2014); Cullen S. Hendrix & Idean Salehyan, *Climate Change, Rainfall, and Social Conflict in Africa*, 49 J. PEACE RES. 35 (2012); Edward Miguel, Shanker Satyanath & Ernest Sergenti, *Economic Shocks and Civil Conflict: An Instrumental Variables Approach*, 112 J. POL. ECON. 725 (2004).

76. *See* Halvard Buhaug, Hils Petter Gleditsch & Ole Magnus Theisen, *Implications of Climate Change for Armed Conflict*, *in* SOCIAL DIMENSIONS OF CLIMATE CHANGE: EQUITY AND VULNERABILITY IN A WARMING WORLD 75 (Robin Mearns & Andrew Norton eds., 2010).

77. Weather can also directly lead to conflict by "changing the environment" or increasing human aggression. Dell, Jones & Olken *supra* note 75, at 768.

78. *See generally* Antony Millner & Simon Dietz, *Adaptation to Climate Change and Economic Growth in Developing Countries*, 20 ENV'T & DEV. ECON. 380 (2015); Buhaug, Gleditsch & Theisen, *supra* note 76.

79. *See generally* Neila Cáceres & Samuel W. Malone, *Optimal Weather Conditions, Economic Growth, and Political Transitions*, 66 WORLD DEV. 16 (2015).

There is substantial literature studying the effect of weather on social and political conflict.[80] In particular, there are a variety of cross-country and subnational studies that indicate that higher temperatures and lower-than-average precipitation (including droughts) cause civil conflicts and political instability, particularly via lower household income.[81] While there are various studies showing the effect of weather on social and political conflict, there has been some ambiguity in the effect due to various empirical and statistical challenges.[82] Two important recent papers, however, better identify the connection between climate change and social and political conflict.[83] The first uses more than 50 years of data to show that the probability of conflict doubled in the tropics during El Niño years as compared with La Niña years.[84] Based on this analysis, El Niño contributed to 21% of the civil conflicts in the tropics taking place between 1950 and 2004, providing some evidence that warmer temperatures do result in more social conflict.[85] The second study conducts a meta-analysis across sixty multi-disciplinary papers.[86] The authors find that the median effect of a 1-standard-deviation change in climate variables over time causes a 13.6% change in the risk of intergroup conflict and a 3.9% change in interpersonal violence.[87] Even though the magnitude of this effect is heterogeneous (that is, varies over time and space), given that scientists predict a 2- to 4-standard-deviation change in temperature by 2050,[88] possible increases in conflict as the result of climate change are likely to be significant this century in many areas across the globe.[89]

Based on this prior work, there is good reason to be concerned that climate change could lead to economic or political disruption. For a self-reinforcing feedback pathway to exist, however, policy makers must also respond to these crises by making decisions that undermine climate mitigation or adaptation, which in turn would increase damages in the future, perpetuating a vicious

80. This literature is summarized in Dell, Jones & Olken, *supra* note 75.

81. *Id.*

82. The statistical issues in these studies include: (1) the low explanatory power of weather on conflict (that is, the noise); (2) a variety of statistical problems, including endogenous controls and spatial correlation; (3) the difficulty of measuring weather, particularly precipitation due to the negative effect of too much (for example, floods) and too little (for example, droughts); and (4) the difficulty of determining if weather changes the timing of conflict or actually causes conflict. *See id.*

83. *See* Solomon M. Hsiang, Kyle C. Meng & Mark A. Cane, *Civil Conflicts Are Associated with the Global Climate*, 476 NATURE 438 (2011); Carleton & Hsiang, *supra* note 75, at 1117–18.

84. *See* Hsiang, Meng & Cane, *supra* note 83, at 439.

85. *Id.*

86. *See* Hsiang, Burke & Miguel, *supra* note 75.

87. *Id.* at 608–09.

88. *Id.* at 608.

89. *See* Solomon M. Hsiang & Marshall Burke, *Climate, Conflict, and Social Stability: What Does the Evidence Say?,* 123 CLIMATIC CHANGE 39, 52–53 (2014).

cycle of increasing damages. In the following Part, we focus on this second step in the context of the political disruption pathway to determine whether countries do indeed respond to political crises in ways that could undermine effective climate action.

II. The Political Disruption Pathway

In this Part, we first discuss our empirical strategy for examining the risk that political disruption will undermine climate policy. The crux of that strategy is to analogize climate policy to international environmental treaty formation, which has decades of reliable observations from which to draw useful conclusions. We then discuss our data, model, and primary results. In short, we find a consistent significant and meaningful negative relationship between conflict and environmental cooperation, which holds up to several robustness checks. This analysis provides considerable support for the view that climate policymaking can be negatively affected by political disruption.

A. Conflict and Environmental Cooperation

Research into the social consequences of climate change has generally found that increased global temperatures will create considerable risks of political and economic disruption.[90] There are intuitive reasons to believe that these disruptions would undermine climate policy, based on the scenarios discussed in Part I.C. In addition, there is a literature in political science that examines the consequences of the limited attention of policy makers who can only handle a finite agenda.[91] When economic or political disruptions take up a significant portion of the agenda space of policymakers, there is simply less room for other issues. There may also be a tendency for domestic policy makers to focus on near-term, internal issues rather than long-term and more remote matters.[92] There are few issues as pressing or immediate as an economic or political crisis, and few issues as long-term and remote as climate change mitigation. For this reason, a tendency for economic or political disruption to push climate policy off the agenda may be particularly likely.

To investigate whether this hypothesized relationship holds, we examine the historical relationship between extreme forms of political disruption—internal civil conflict—and international environmental cooperation, which we use

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90. *See supra* notes 63–64, 75–89 and accompanying text.

91. *See generally* Agenda Setting, Policies, and Political Systems: A Comparative Approach (Christoffer Green-Pedersen & Stefaan Walgrave eds., 2014); Frank R. Baumgartner & Bryan D. Jones, Agendas and Instability in American Politics (2d ed. 2009).

92. *See* Alan M. Jacobs, Governing for the Long Term: Democracy and the Politics of Investment 28 (2011).

as a predictor for likelihood of engaging in climate policymaking. The hypothesis that we will test is whether internal civil conflict makes it more difficult to engage in environmental cooperation in the form of environmental treaty-making.

Although it would be desirable to estimate the relationship of political disruption on climate policy directly, data scarcity makes that type of analysis difficult.[93] We use environmental treaty-making as the dependent variable in our analysis in part because there is a long history of this form of environmental cooperation and it can be observed and recorded. Other forms of cooperation, while important, may easily escape notice and any collected data may be biased.

We believe that it is reasonable to extrapolate from international environmental cooperation to climate policymaking for two main reasons: First, international environmental cooperation is akin to climate action in several respects. Most obviously, climate mitigation or adaptation measures are a form of environmental policy making, and one that will often have international implications. International environmental cooperation also tends to involve long-term issues and common interests, as in the case of climate change, and so is likely to be subject to similar political dynamics.[94]

Second, and perhaps more compellingly, international cooperation is itself useful (even vital) for successful climate policy. Climate change is well described by non-cooperative game theory in which individual rational self-interested behavior will not achieve collectively rational results.[95] The scale of the non-cooperative problem is particularly grand for climate change—as a global phenomenon, even large political units, such as nation states, are insufficiently aggregated to "internalize" the costs of greenhouse gas pollution.[96] Some form of international cooperation is needed to induce rational states to cut emissions to efficient levels.[97] Adaptation measures do not generate the same global coor-

93. To our knowledge, there is no comprehensive dataset of country-level mitigation or adaptation actions. Because participation in climate treaties has been nearly universal, limiting our analysis to only those treaties would not allow for meaningful statistical analysis.

94. *See generally* SCOTT BARRETT, ENVIRONMENT AND STATECRAFT: THE STRATEGY OF ENVIRONMENTAL TREATY-MAKING (2003).

95. *See* Howard & Schwartz, *supra* note 19, at 227–32.

96. *See* Ulrich Wagner, *The Design of Stable International Environmental Agreements: Economic Theory and Political Economy*, 15 J. ECON. SURVS. 377, 378–81 (2001).

97. Although international coalitions are likely necessary for effective climate action, they are difficult to form and maintain in this context. *See generally* Valentina Bosetti et al., *Incentives and Stability of International Climate Coalitions: An Integrated Assessment*, 55 ENERGY POL'Y 44 (2013); Oran Young, *Effectiveness of International Environmental Regimes: Existing Knowledge, Cutting-Edge Themes, and Research Strategies*, 108 PROC. NAT'L ACAD. SCI. 19853 (2011); David G. Victor, *Toward Effective International Cooperation on Climate Change: Numbers, Interests and Institutions*, 6 GLOBAL ENVTL. POL. 90 (2006); Henry Tulkens, *Cooperation vs. Free Riding in International Environmental Affairs: Two Approaches*, *in* GAME THEORY AND THE ENVIRONMENT 30 (Nick Hanley & Henk Folmer eds., 1998).

dination problems, but aside from individual efforts, some level of cooperation is needed to achieve adaptation, and many of the most effective adaptation opportunities require coordinated action by at least some aggregated groups.[98]

If one accepts that international environmental cooperation, in the form of treaty-making, provides a useful lens on the likelihood of climate action, the first place to look for the effects of political disruption is the existing research literature on the determinants of international environmental treaty formation.[99] Within this literature, there are a number of variables that have been examined.[100] Common socioeconomic variables include GDP and GDP per capita on the theory that countries with larger economies sign more treaties and richer countries demand higher environmental quality.[101] Research has also examined the cost of compliance; the most frequently used cost variables are environmental variables that measure the quantity of air pollution (SO_2 and CO_2) and measures of natural resource base, though only the former has been shown to be consistently significant.[102] Common political variables include measures of democracy and civil liberties.[103] Political variables are included based on the

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98. *See* Karen Pittel & Dirk T.G. Rübbelke, *Transitions in the Negotiations on Climate Change: From Prisoner's Dilemma to Chicken and Beyond*, 12 INT'L ENVTL. AGREEMENTS: POLITICS, L. & ECON. 23, 37 (2012).

99. *See, e.g.*, Eric Neumayer, *Do Democracies Exhibit Stronger International Environmental Commitment? A Cross-Country Analysis*, 39 J. PEACE RES. 139 (2002); J. Timmons Roberts, Bradley C. Parks & Alexis A. Vásquez, *Who Ratifies Environmental Treaties and Why? Institutionalism, Structuralism and Participation by 192 Nations in 22 Treaties*, 4 GLOBAL ENVTL. POL. 22 (2004); Antoine Cazals & Alexandre Sauquet, *How Do Elections Affect International Cooperation? Evidence from Environmental Treaty Participation*, 162 PUB. CHOICE 263 (2015); Anastassia Obydenkova & Raufhon Salahodjaev, *Intelligence, Democracy, and International Environmental Commitment*, 147 ENVTL. RES. 82 (2016).

100. *See generally* Gabriele Spilker & Vally Koubi, *The Effects of Treaty Legality and Domestic Institutional Hurdles on Environmental Treaty Ratification*, 16 INT'L ENVTL. AGREEMENTS: POL., L. & ECON. 223 (2016).

101. Population and a dummy variable for developing nations are sometimes included instead, or in addition to, GDP per capita to proxy for this curve. *See, e.g.*, Ronald B. Davies & Helen T. Naughton, *Cooperation in Environmental Policy: A Spatial Approach*, 21 INT'L TAX & PUB. FIN. 923 (2014).

102. *See* Peter Egger, Christoph Jessberger & Mario Larch, *Trade and Investment Liberalization as Determinants of Multilateral Environmental Agreement Membership*, 18 INT'L. TAX & PUB. FIN. 605, 619 (2011) [hereinafter Egger, *Trade and Investment*] ("In line with our expectations, a higher degree of pollution in terms of CO2 emissions reduces a country's willingness to commit itself to less pollution through MEAs."); *see also* Spilker & Koubi, *supra* note 100; Peter Egger, Christoph Jessberger & Mario Larch, *Impacts of Trade and the Environment on Clustered Multilateral Environmental Agreements*, 36 WORLD ECON. 331 (2013) [hereinafter Egger, *Impacts of Trade*]; James C. Murdoch, Todd Sandler & Wim P.M. Vijverberg, *The Participation Decision Versus the Level of Participation in an Environmental Treaty: A Spatial Probit Analysis*, 87 J. PUB. ECON. 337 (2003).

103. *See* Kurt J. Beron, James C. Murdoch & Wim P. M. Vijverberg, *Why Cooperate? Public Goods, Economic Power, and the Montreal Protocol*, 85 REV. ECON. & STATS. 286 (2003).

theory that democracies with robust protection for civil liberties will be more responsive to citizen demands.[104] A common control variable is trade openness (exports plus imports divided by GDP) based on the theory that trade forms connections between nations that can facilitate negotiations.[105] Other variables include geographic relationships between countries,[106] power dynamics,[107] and economic reliance on natural resources.[108]

This empirical literature does not address the influence of conflict on environmental treaty formation. There are related literatures, however, that analyze the impacts of environmental treaties (specifically multinational river treaties) and other forms of international cooperation (specifically membership in international government organizations ("IGO")) on conflict. For example, studies have found that river treaties tend to reduce conflict.[109] Within the literature on cooperation, the most extensively studied area is that of participation in IGOs. Many IGOs are explicitly intended to reduce conflict and include obligations to avoid certain armaments (like landmines) or practices (such as recruiting child

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104. *Id.*

105. *See, e.g.*, Cazals & Sauquet, *supra* note 99, at 270; Spilker & Koubi, *supra* note 98, at 230–33; *see also* Egger, *Trade and Investment*, *supra* note 102 (constructing a measure of trade openness that specifically captures trade liberalization); Egger, *Impacts of Trade*, *supra* note 102 (same). Studies differ to the extent to which they address the potential endogeneity of trade and IGO membership. *See* Cazals & Sauquet, *supra* note 99, at 270; Spilker & Koubi, *supra* note 100, at 230–33.

106. Measures of spatial (geographic) relationships are common. *See* Davies & Naughton, *supra* note 101; Spilker & Koubi, *supra* note 100. These papers used estimators that account for spatial autocorrelation, spatial lags, and the number of countries that ratified a treaty (including in a nation's region), respectively.

107. Beron, Murdoch & Vijverberg, *supra* note 103, controls for a nation's share of exports to control for weaker negotiation power. Spilker & Koubi, *supra* note 100, also controls for NGO and IGO membership, theorizing that they increase domestic and international leverage for the given state.

108. *See, e.g.*, Egger, *Trade and Investment*, *supra* note 102, at 615 (finding that increasing the percentage of total land devoted to agriculture reduces MEA signing). Natural resource availability may also affect conflict. *See generally* Michael L. Ross, *How Do Natural Resources Influence Civil War? Evidence from Thirteen Cases,* 58 INT'L ORG. 35 (2004); Heinz Welsch, *Resource Abundance and Internal Armed Conflict: Types of Natural Resources and the Incidence of 'New Wars,'* 67 ECOLOGICAL ECON. 503 (2008); Päivi Lujala, Nils Petter Gleditsch & Elisabeth Gilmore, *A Diamond Curse? Civil War and a Lootable Resource*, 49 J. CONFLICT RESOL. 538 (2005).

109. *See* Jaroslav Tir & Douglas M. Stinnett, *Weathering Climate Change: Can Institutions Mitigate International Water Conflict?*, 49 J. PEACE RES. 211, 219–22 (2012) (finding that treaties with more institutionalized features can help prevent conflict); Sara McLaughlin Mitchell & Neda A. Zawahri, *The Effectiveness of Treaty Design in Addressing Water Disputes*, 52 J. PEACE RES. 187, 194–98 (2015) (finding the same).

soldiers), or to negotiate over sources of conflict (such as borders) rather than resort to arms.[110]

The empirical literature on IGOs tests updated versions of Immanuel Kant's vision of a "perpetual peace," in which democracy, interdependence through trade, and international law are theorized to lead to the peaceful resolution of conflict. Although the relationship of peace (and conflict) to trade and a country's political structure has been well established, the influence of IGO membership is less clear.[111] In addressing potential inferential issues in their analysis of the role of cooperation on conflict, two studies estimate the reverse effect (i.e., conflict-reducing cooperation).[112] Both find that conflict tends to reduce participation in IGOs. The first uses a panel of dyad (two-country pair) data, and tests the relationship between disputes and several variables, including joint IGO memberships; the countries' political structure; whether the countries are allies; exports; and per capita GDP.[113] All variables are significant and have the expected sign, including conflict. This study indicates that conflict does appear to interfere with IGO participation. The second study uses regional and temporal fixed effects to analyze the impact of transitions to democracy on IGO memberships, controlling for several variables, including political governance, years since independence, GDP, and recent conflict.[114] In this analysis, conflict was again found to reduce the number of IGOs joined.[115]

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110. *See, e.g.*, Ryan Kocse, Note, *Final Detonation: How Customary International Law Can Trigger the End of Landmines*, 103 GEO. L.J. 749, 755–58 (2015) (discussing anti-landmine treaties).

111. *See* John R. Oneal, Bruce Russett & Michael L. Berbaum, *Causes of Peace: Democracy, Interdependence, and International Organizations, 1885–1992*, 47 INT'L STUD. Q. 371, 372–74 (2003) (reviewing the literature on influence of IGO membership on conflict). The literature suggests various explanations for the mixed conclusions regarding the impact of IGO membership on conflict. *See* Christopher C. Anderson, Sarah M. Mitchell & Emily U. Schilling, *Kantian Dynamics Revisited: Time Varying Analyses of Dyadic IGO-Conflict Relationships*, 42 INT'L INTERACTIONS 644 (2016) (assessing the declining benefit of IGO membership since the end of the Cold War); Erik Voeten, International Organization Membership and Militarized Conflict: A Distributive Perspective (Aug. 26, 2016) (unpublished manuscript), https://perma.cc/WM8Y-EU9T (assessing the distributive implications of IGO membership); Jun Xiang, *Dyadic Effects, Relevance, and the Empirical Assessment of the Kantian Peace*, 43 INT'L. INTERACTIONS 248 (2017) (proposing a new statistical model and arguing that approaches in prior studies led to biased estimates).

112. *See* Russett, Oneal & Davis, *supra* note 67, at 442; Edward D. Mansfield & Jon C. Pevehouse, *Democratization and the Varieties of International Organizations*, 52 J. CONFLICT RESOLUTION 269, 285 (2008); *see also* Steve Chan, *Discerning the Causal Relationships Between Great Powers' Membership in Intergovernmental Organizations and Their Initiation of Militarized Disputes*, 22 CONFLICT MGMT. & PEACE SCI. 239, 248–55 (2005) (using autoregression to examine the effect of militarized disputes on IGO membership and vice versa for major powers over three time periods). All these papers focused on interstate conflict rather than civil conflict, as is common in the Kantian literature and river treaty literature.

113. Oneal, Russett & Berbaum, *supra* note 111.

114. Mansfield & Pevehouse, *supra* note 112, at 269–70.

115. *Id.* at 238.

For purposes of our analysis, this prior work holds three lessons. The first is to provide a set of variables that have already been found to affect environmental treaty-making: accounting for these as control variables will increase the soundness of our results. The second lesson is that conflict has been found to affect some forms of international cooperation, specifically IGO participation. If these results are sound, there is a relatively short conceptual step to the environmental cooperation that is the focus of our empirical analysis. The third lesson is that, as in many empirical exercises of this sort that rely on observational data rather than controlled experiments, there are knotty inferential questions that must be addressed, and all conclusions come with some necessary caveats. Prior studies have dealt with this inferential issue in several ways.[116] We spend considerable effort in Part III.C examining the robustness of our results.

B. Data, Model, and Main Results

The dependent variable for our analysis—environmental treaty signing—is drawn from the University of Oregon's International Environmental Agreement ("IEA") Database, which compiles information on bilateral, multilateral, and "other" environmental agreements from 1857 to 2016.[117] Environmental agreements are defined in the IEA Database to include "efforts to regulate human interactions with the environment that involve legally binding commitments ('agreements') among governments ('international') that have environmental protection as a primary objective ('environmental')."[118] Membership data exists for over 1,200 unique environmental treaties and approximately 250 unique countries, former unions, and independent organizations. Of these trea-

116. Prior approaches include two-stage least squares (and other instrumental variable and two-stage estimators); generalized least squares/prohibit; distributed lags; autoregressive models; simultaneous equations; and reverse logit. *See, e.g.*, Oneal & Russett, *supra* note 67; Oneal, Russett & Berbaum, *supra* note 111; Chan, *supra* note 112; Håvard Hegre, John R. Oneal & Bruce Russett, *Trade Does Promote Peace: New Simultaneous Estimates of the Reciprocal Effects of Trade and Conflict,* 47 J. PEACE RES. 763 (2010); Johannes Karreth & Jaroslav Tir, *International Institutions and Civil War Prevention,* 75 J. POL. 96 (2013); Mansfield & Pevehouse, *supra* note 112.

117. Data are from Ronald B. Mitchell, *International Environmental Agreements* (*IEA*) *Database Project (Version 2018.1)*, UNIVERSITY OF OREGON, https://perma.cc/H7QT-DP5M [hereinafter IEA Database Project]; *see also* Ronald B. Mitchell, *International Environmental Agreements: A Survey of Their Features, Formation, and Effects*, 28 ANN. REV. ENV'T & RES. 429, 434 (2003) (describing the data).

118. IEA Database Project, *supra* note 117. Included in this definition are binding agreements, amendments, and protocols. The database distinguishes environmental agreements from non-binding instruments: non-binding agreed minutes, non-binding agreements, arrangements, declarations, exchanges of notes, plans of action, and non-binding statutes.

ties, we focus exclusively on multilateral environmental agreements ("MEA") which represent approximately 98% of environmental treaties in the database.[119]

Our primary explanatory variable of interest is conflict—data for that variable is derived from the Center for Systematic Peace ("CSP"), which conducts research on issues of violence in human relations and societal-systematic development. CSP created the Integrated Network for Societal Conflict Research ("INSCR") using open-source data on conflict, polity type, and stability.[120] The dataset includes variables measuring violence in the event of attempts to gain independence, international conflict, international warfare, civil violence, ethnic violence, and ethnic warfare.[121] Our analysis differentiates between two types of violence: civil conflict and interstate conflict. Civil conflict includes episodes of civil or ethnic violence within a country's borders. Interstate conflict includes episodes of military engagement (international violence and war) within a country's borders.[122] Both types of conflict are measured on a continuous scale ranging from 0 to 40 for civil conflict and 0 to 20 for interstate engagements.[123] To account for the potential of cross-country spillover effects, we include re-

119. The share of MEAs to environmental treaties is relatively stable over time; there are 1,038 MEAs and 1,065 environmental agreements from 1970 to 2012 according to the IEA Database (roughly 97%). Although the data include actions of signing, ratifying, and entry into force, we focus on signatures, as ratification and entry into force are often redundant measures of previously joined treaties. Observations of countries dropping from an environmental treaty are also omitted. In the case where a country leaves a treaty but joins another in the same year, only affirmative treaty actions are analyzed.

120. We use two data sets from the Center for Systemic Peace (INSCR): MAJOR EPISODES OF POLITICAL VIOLENCE, 1946–2012, CTR. FOR SYSTEMIC PEACE, https://perma.cc/V3JM-H7WQ [hereinafter Major Episodes] and POLITY IV ANNUAL TIME-SERIES, 1800-2014, CTR. FOR SYSTEMIC PEACE, https://perma.cc/58RU-SUA9 [hereinafter Polity IV]. We accessed these data on June 8, 2016. For accompanying information regarding these datasets, see MONTY MARSHALL, CTR. FOR SYSTEMIC PEACE, MAJOR EPISODES OF POLITICAL VIOLENCE (MEPV) AND CONFLICT REGIONS 1946–2016 (2017), https://perma.cc/J5KT-5J9S [hereinafter MARSHALL 2017]; MONTY MARSHALL, TED GURR & KEITH JAGGERS, CTR. FOR SYSTEMIC PEACE, POLITY IV PROJECT REGIME CHARACTERISTICS AND TRANSITIONS 1800-2016 DATASET USERS' MANUAL (2017), https://perma.cc/5CLB-CQ6F [hereinafter MARSHALL, GURR & JAGGERS 2017].

121. Specifically, the dataset includes a score from 0 to 10 for each country/year for international violence, international war, civil violence, civil war, ethnic violence, and ethnic war occurring within each country in a given time period; scores are considered consistently defined across categories. The data further organizes nations into geopolitical regions and measures the activity of violence within regions and bordering nations. *See* Polity IV, *supra* note 120.

122. Due to the focus on the conflict experience of a nation's people, the dataset accounts for only conflict within a nation's boundaries. The data excludes a country's engagement in military conflict outside of its borders. *See* MARSHALL 2017, *supra* note 120, at 2.

123. Episodes of violence that result in more displaced persons and higher death rates have higher scores. *See* MARSHALL 2017, *supra* note 120, at 10–11.

gional conflict variables made up of the sum of national conflict scores in each region.[124]

Figure 3 displays the total number of MEAs signed by countries given the presence of conflict, as measured by the sum of their civil and interstate conflicts (i.e., national total conflict score). The information depicted in Figure 3 is in line with the hypothesis that conflict impedes treaty signing, but additional analysis is needed to establish any causal relationship, especially in light of possible unobserved time-related variables.

We have a number of control variables in our analysis. According to theory and previous results, more democratic nations sign more treaties, and we draw on the INSCR for information on the political structure of a country.[125] We include several other variables based on the literature, which are constructed with World Bank data. We control for GDP per capita, GDP, trade openness, the percentage of GDP from resource extraction, carbon dioxide emissions, and number of adjacent nations.[126]

After joining the above datasets (resulting in the loss of some observations due to missing data), we further restrict our attention to a subset of our dataset: we drop island states because they are less likely to experience conflict and sign treaties; and we limit our attention to the modern era (defined as 1970 to 2012) because the relationship between IGO membership and conflict may vary over time.[127]

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124. Given that it is unclear how to relevantly define regions for the purposes of analyzing conflict, we test four alternative regional conflict calculations, each using an alternative definition of region: geopolitical regions developed by the Center for Systematic Peace, see MARSHALL 2017, *supra* note 120, at 6, 16–17; geographic (i.e., sub-continent) regional definitions; a neighbor calculation that defines a unique region for each country using only its bordering countries, see MARSHALL 2017, *supra* note 120, at 6, 12–15; and a distance-weighted conflict calculation that avoids regional definitions altogether. Given concerns about countries entering and exiting the dataset (mostly due to the rise and fall of nations), we also normalize each regional conflict calculation by the number of countries in a region with a conflict score in a given year in our sensitivity analyses.

125. This includes type of government, longevity of the government type, and fragmentation of the government. These data are on a -10 to 10 scale over time, with -10 being an autocracy and 10 being a full democracy. MARSHALL, GURR & JAGGERS 2017, *supra* note 120, at 8, 17.

126. Our expected sign for the control variables is as follows: GDP (positive); trade openness, defined as the sum of the absolute value of export and imports divided by GDP (positive); resource dependence (negative); carbon dioxide emissions (negative); number of borders (positive).

127. *See* Anderson, Mitchell & Schilling, *supra* note 111, at 646–50. Given our unbalanced panel, which is partially driven by the collapse and formation of nations due to conflict, limiting our attention to post-1970 also balances potential bias (two-thirds of nations in our final dataset are observed in each year of the study) while maintaining the vast majority of observations.

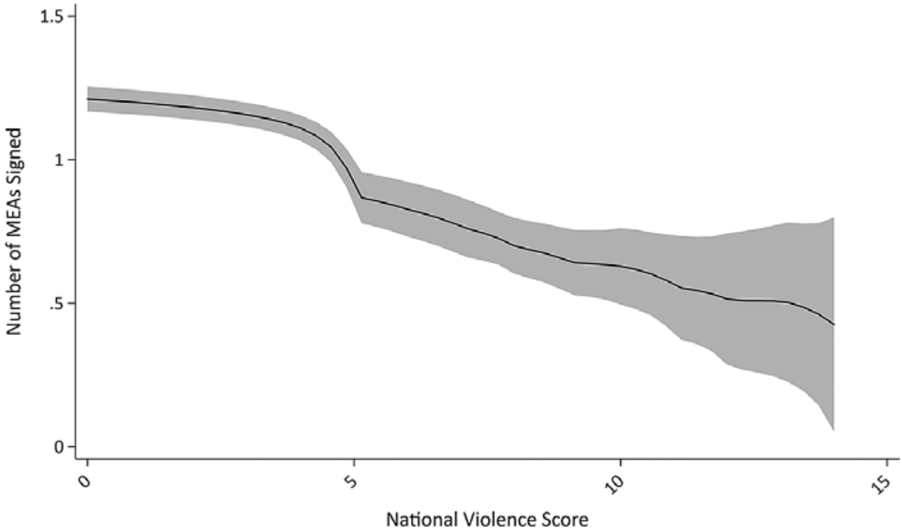

Figure 3. Multilateral environmental agreements and national total conflict score. National total conflict (x-axis) versus the number of multilateral environmental agreement (MEA) signings (y-axis) with 95th percent confidence intervals. There is a visually apparent negative relationship between national conflict scores and participation in MEAs. The steady rate of decline in treaties signed as conflict increases is paralleled with an increase in uncertainty—this reflects the fact that some high-conflict countries have still participated in MEAs.

Our preferred statistical model is a fixed-effects regression with the number of treaties signed by a country in a year as the dependent variable, conflict as the predictor variable of interest, and a set of control variables based on the treaties literature. The marginal impacts of conflict for our base model are reported in Table 1.

Specification	(1)	(2)	(3)	(4)
	Total Conflict		Civic & Interstate Conflict	
VARIABLES	signed	signed	Signed	Signed
National Conflict	-0.0429***	-0.0399***		
	(0.0134)	(0.0139)		
Regional Conflict	-0.0646	-0.112		
	(0.0945)	(0.132)		
National (Civil)			-0.0438***	-0.0383***
			(0.0130)	(0.0139)
National (Interstate)			-0.0251	-0.0420
			(0.0309)	(0.0402)
Regional (Civil)			0.0652	-0.0479
			(0.113)	(0.150)
Regional (Interstate)			-0.401**	-0.272
			(0.156)	(0.252)
Constant	0.531***	-17.31***	0.520***	-17.24***
	(0.0941)	(3.720)	(0.0925)	(3.735)
Observations	6,169	4,708	6,169	4,708
Number of country FE	167	151	167	151
Adjusted R-squared	0.289	0.318	0.290	0.317
Likelihood	-9760	-7668	-9758	-7668
Non-conflict controls		X		X
All Conflict	***	***	***	**
Civil Conflict	-	-	***	**
Interstate conflict	-	-	***	
Non-Conflict	-	***	-	***

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 1. Regression analysis of MEA signings and conflict. National conflict is a highly significant predictor of MEA signings, controlling for country and year fixed effects as well as time/place varying control variables. Models (1) and (2) aggregate national and regional conflict variables, with only the second including non-conflict controls. Models (3) and (4) disaggregate national and regional conflict variables into their civil and interstate components, with only the latter including non-conflict controls. National civil conflict is consistently significant in both models, despite the potential for control variables to absorb some of the true effect from conflict to MEA signing.

A country and year fixed effects model includes indicator variables for each country and each year, which is a widespread statistical method to control for unobserved variables associated with country characteristics or globally relevant events. We include specifications without the non-conflict control variables because we are concerned that adding these control variables will mask pathways through which conflict impacts environmental treaty formation. As is discussed in more detail in the next section, we also conduct our analysis with a number of alternative model specifications for the sake of checking robustness.

We run four specifications, varying the format of the dependent and the control variables: (1) total (aggregating civil and interstate) conflict without non-conflict control variables, (2) total conflict with non-conflict control variables, (3) civil and interstate conflict variables without non-conflict control variables, and (4) civil and interstate conflict variables with non-conflict control variables.[128] Across all specifications, we find that conflict is jointly predictive at the 1% or 5% levels, with non-conflict controls somewhat reducing the statistical significance of conflict in the fourth specification.[129] Similarly, when the conflict variables are split into their civil and interstate components, national civil conflict variables are significant across all relevant specifications.[130]

The impact of conflict on MEA signing is also of practical significance. Focusing on specifications 3 and 4, a unit increase in national civil conflict decreases the number of treaties signed by roughly 0.04. Therefore, a 10-unit increase in civil conflict (25% of the 40-unit scale) reduces signings by 0.4, which is equivalent to one-third of the mean number of yearly signings. To put this value in perspective, the coefficient on polity is between 0.0163 and 0.0187, implying that a one-unit decrease in polity (from democracy to autocracy) decreases signings by approximately 0.02. If countries shift five polity units (that is, 25% of the 20-unit scale), the result is to reduce signings by 0.1, roughly a quarter of the equivalent shift due to civil conflict.

C. *Robustness and Causal Inference*

For several decades, social science researchers have been attuned to the problem of overstated causal claims based on insufficiently robust analysis of data.[131] The resulting attention to the validity of causal claims that can and cannot be made based on observational data has been referred to as the "credibility revolution."[132] The crux of the matter is that different statistical models can lead to different results given the same underlying data, and even where robust relationships exist between variables of interest, there are many possible causal routes that could lead to those relationships. In this section, we discuss

128. The regional conflict variables are distance-weighted.

129. To address the ongoing debate in the literature over the use of fixed effects, we test for random effects. Using a robust Hausman test, we reject the null hypothesis of the consistency of the random effects estimator at the 1% threshold.

130. At the regional scale, we generally do not find that conflict is significant, depending on the definition of "region" used.

131. *See generally* Joshua D. Angrist & Jörn-Steffen Pischke, *The Credibility Revolution in Empirical Economics: How Better Research Design is Taking the Con out of Econometrics*, 24 J. ECON. PERSP. 3 (2010) (reviewing relevant literature).

132. *Id.* at 4.

the sensitivity analyses that we have undertaken to examine whether our results are robust to different model specifications (i.e., whether they persist even under different assumptions). We also discuss our analyses to test whether *reverse causation* is present in our results—that is, rather than conflict impeding treaty signing (which is our favored interpretation), treaty signing tends to reduce conflict. As we describe in more detail below, our results are robust to multiple specifications, and our tests for reverse causality based on approaches drawn from the relevant social science literature provide some confidence that the primary arrow of causation runs from conflict to treaty formation rather than the other way around.

To test the robustness of our results to model specification, we estimate two alternative models. The first alternative model replaces time fixed effects with a function that captures time trends in treaty signing. The second alternative model controls for unobserved treaty characteristics by estimating a logistic regression where the dependent variable is whether a given country signed a given MEA, the predictor variable of interest is conflict, and region and treaty fixed effects are included, as are the familiar control variables. Both the alternative models generate essentially the same results, with national civil conflict consistently having a significant and meaningful negative effect on treaty signing. All these models are also run with an alternative method for delineating regions, with no substantial effect on results.

Beyond these initial sets of robustness checks, we are also concerned with the potential for reverse causation between our predictor and dependent variables. As noted above,[133] the literature on conflict and international cooperation has accentuated the potential for treaties to reduce conflict, the opposite causal arrow from our hypothesis that stability leads to increased treaty-making.

At a conceptual level, this issue is less obviously apparent for environmental treaties than for treaties that are explicitly designed to reduce conflict. A treaty that reduces arms or commits countries to arbitrate certain types of disputes in neutral forums has a relatively straightforward potential effect on conflict. Although some environmental treaties having to do with the joint management of shared resources may reduce the potential for conflict, the theoretical link from large multilateral environmental treaties to lower levels of conflict is quite attenuated.

Although there are theoretical reasons to be skeptical concerning the possibility of reverse causation, we nonetheless deploy several strategies to test our results. As discussed above, our three models collectively account for country fixed effects, time fixed effects, treaty fixed effects, and time-spatial varying control variables. These treatments help address the general issue of failing to account for unobserved time or country-based variables. We also split our conflict variable into civil and interstate conflict. It is much more plausible that

133. *See infra* notes 107–10 and accompanying text.

treaty signing could reduce the risk of interstate conflict than civil conflict. In our analysis, however, we find that *civil* conflict is the more powerful predictor, with interstate conflict showing as statistically significant in only some of our models and specifications. This result reduces the worry about reverse causation.

One econometric tool for addressing the potential for reverse causality in our analysis would be an instrumental variable.[134] An instrumental variable is one that is correlated with the outcome of interest (e.g., treaty signing) but does not have a direct causal effect on the outcome. Instead, causality runs from the instrument through a treatment variable (e.g., conflict). If the instrument is essentially randomly assigned, then it can be used to estimate the causal effect from the treatment to the outcome, without having to worry about unobserved variables, reverse causality, or other confounding factors that interfere with statistical inference. Unfortunately, we have not identified a variable that fits the relatively strict conditions necessary to instrument for conflict, because many variables that could plausibly influence conflict could also be related in some way to factors that directly affect treaty signing.[135]

Given this difficulty, we follow the existing best practice in the relevant social science literature in applying a technique called distributed lags.[136] This procedure involves including lags of the dependent variable as explanatory variables until they are no longer significant, and then including the corresponding lags of previously included control variables. The theory behind this procedure is that if the observed correlation between conflict and treaty signatures is due to prior treaties that reduced conflict, then controlling for those prior treaties should eliminate that effect.

We find that the lagged MEA signings are not significant in any specifications and conflict variables are jointly significant (at the 1% level) across all specifications.[137] These regressions further reduce concerns of reverse causation.

We also run the distributed lag model in reverse, with conflict as the dependent variable and MEA signings as the predictor variable. The idea behind this procedure is to directly test the reverse causation hypothesis, accounting for lagged effects from prior conflict on MEA signings. When we estimate the

134. *See, e.g.*, Michael D. Makowsky & Thomas Stratmann, *More Tickets, Fewer Accidents: How Cash-Strapped Towns Make for Safer Roads*, 54 J.L. & ECON. 863, 879 (2011) (using instrumental variables); John M. de Figueiredo, *How Much Does Money Matter in a Direct Democracy?*, 78 S. CAL. L. REV. 1065, 1071 (2005) (using the same).

135. *Cf.* Rafael Reuveny & Omar M.G. Keshk, *Reconsidering Trade and Conflict Simultaneity: The Risk of Emphasizing Technique Over Substance*, 30 CONFLICT MGMT. & PEACE SCI. 11, 17 (2013) ("[O]ur models of macroeconomics, international economics, international relations, and international political economy, and so on, do not really include exogenous variables. We have long known that all of our variables are endogenous to the forces we ask them to explain.").

136. *See, e.g.*, Oneal, Russett & Berbaum, *supra* note 111.

137. The same analysis was done with the alternative definition of "region" with similar results.

distributed lagged model for these reverse specifications (i.e., including lagged values of conflict and previously included control variables), treaty signings are no longer significant.[138] These results further strengthen the argument that causation runs from conflict to MEA signing.

An additional test involves removing or controlling for the potential source of endogeneity. We take the 3% and the 18% of MEAs that correspond to weapons and shared waterways (respectively) as the most likely culprit. We rerun our main model and the first alternative (i.e., time trend controls), dropping these treaty types, and then again with these treaty types identified with an indicator variable. In both these alternative specifications, we find results similar to our primary results. The second alternative model already includes treaty fixed effects, and so, in theory, controls for the characteristics shared by arms and waterway treaties. Nevertheless, we add an additional control by interacting conflict variables with treaty type. Again, our results are similar, and national civil conflict remains a significant and meaningful predictor of MEA signings.

Given our lack of instrumental variable or other similarly reliable causal identification method (e.g., discontinuity analysis), we perform several more robustness checks for the sake of completeness.[139] Our fundamental findings are not changed through any of the alternative specifications.[140]

Given the strong conceptual reasons that conflict would negatively affect environmental cooperation and the consistent and robust negative relationship

138. The sole exception is for the one-period lag of signing when interstate conflict is the endogenous variable and non-conflict and other control variables are included, but even then, signed variables are jointly insignificant.

139. To test whether the unbalanced panel biases our results, we conduct two analyses: we drop new and former countries, and we re-estimate our primary model using shorter time periods. None of these alternative specifications changes our results. Excluding OECD countries from our analysis, we find that national civil conflict remains significant (in the primary as well as two alternative models), although the significance of some of the other conflict variables weakens. This is not surprising given the large number of data points that were dropped. We also run several versions of the primary model, adding an additional year of lag in each iteration of the model, until the most recently added lagged variables are no longer significant. We then sum the conflict variables across the time periods and conduct a joint significance test. We find that this analysis does not change our results: the net impact of conflict variables remains negative and statistically significant, and indeed, the coefficients and their statistical significance are quite similar to the base regression, particularly national civil conflict. Finally, to address the issue of whether the relationship between MEA signings and conflict is non-linear, we run a series of tests based on discrete indicator correlates to our conflict variables. We continue to find that conflict negatively impacts MEA signings, with national civil conflict having the most robust relationship.

140. We found one oddity when conducting this analysis, which was that regional civil conflict appeared to increase treaty signing in some specifications. This finding is only significant in some specifications, and so may be a data quirk or the result of overfitting—accordingly, it should be treated skeptically. Nevertheless, one possible explanation for such a relationship would be that regional civil conflict removes potential counterparties from treaty negotiations, which may make it easier for the remaining parties to arrive at an agreement.

between national civil conflict and MEA signings in our analyses, there is a firm basis to conclude that a country that experiences an increase in civil conflict (for example, due to climate change) would be less able or willing to engage in environmental cooperation, including participation in environmental treaties. The political disruption pathway, then, is at the very least a plausible sociopolitical feedback worthy of additional study and analysis.

III. The Social Cost of Policy Collapse

In this Part, we explore the effect of sociopolitical feedbacks on estimates of the economic harm that is caused by greenhouse gas emissions. We begin by introducing the economy-climate models that are used to derive these estimates and describing the parameter values in these models that are plausibly involved in sociopolitical feedbacks. We then estimate two types of policy feedbacks: damages that cause a decline in investment in technological development; and damages that impair countries' ability or willingness to engage in cooperation to reduce emissions. We find that both types of policy feedbacks result in increased damage estimates, with cooperation-related feedbacks having particularly pronounced effects.

A. Estimating the Social Costs of Emissions

As discussed in Part I.B, the social cost of carbon is a monetary estimate in present-day terms of the marginal damages associated with an additional unit of greenhouse gas emission.[141] The most prominent version of the social cost of carbon was set by an interagency working group during the Obama Administration.[142] This estimate was based on the outputs of four EC-IAMs, one of which is the DICE model created by William Nordhaus. The models used for the U.S. government social cost of carbon did not account for sociopolitical feedbacks, and only recently have researchers begun to explore how such feedback might affect the current value of emissions reduction.

We analyze the potential importance of a climate-induced cooperation breakdown using the DICE model. DICE-2013R integrates a simple climate model and a simple neoclassical growth model in order to capture the relationships between the two systems.[143] By connecting these two models using greenhouse gas emissions, climate damage, and abatement and abatement cost functions, Nordhaus captures each step in the climate-economic process that

141. *See* Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 Nature 173, 173 (2014).

142. Interagency Working Group, *supra* note 15.

143. The climate model consists of three reservoirs: the atmosphere, shallow ocean, and deep ocean. The economic model is a Ramsey-type optimal growth model with a Cobb-Douglas production function.

translates a unit of CO_2 emissions into welfare loss. In DICE, collective social decision making is modeled via a risk-averse social decision-maker that selects society's investment rate in physical capital and natural capital each time period. Greenhouse emissions that result from economic production degrade natural capital.

The model can be run on two settings: (1) a *business-as-usual* ("BAU") *setting*, whereby no climate policy is introduced, and (2) an *optimal setting*, whereby the optimal climate policy is introduced. In the optimal setting, the model generates a savings rate and abatement path that maximizes global social welfare. In the BAU setting, society fails to adopt climate change policy.

Assumptions about sociopolitical variables implicitly enter the DICE model through multiple pathways that connect the climate model and the economic model. These pathways include emissions, cost of abatement, and climate damages. Key components of these processes are products of the global sociopolitical system, including emissions intensity, the price of carbon-free or carbon-removal technologies (which Nordhaus refers to as backstop technologies), participation in the emissions control effort, and adaptation to climate change. In the DICE model, all these variables are exogenously coded—meaning that they are hardwired into the model by the analyst. Because the relevant sociopolitical variables are set exogenously, sociopolitical feedbacks—which arise from the interaction of these variables with others—are not represented.

To examine how estimates of predicted temperature change and damages would change if sociopolitical feedbacks were accounted for in the models, we rerun the DICE-2013 model with revisions to account for these effects. Specifically, we assume that after crossing the 2° Celsius temperature threshold, the cooperation required to engage in effective mitigation policy becomes more difficult. As a consequence of crossing this threshold, we examine three possibilities: (1) an *intensity* effect, in which emissions intensity flattens out rather than continuing to decline over time; (2) a *backstop* effect, in which the backstop price flattens out rather than continuing to decline over time; and (3) a *participation* effect, in which participation in a global abatement policy collapses. We examine the consequences of these effects for the DICE model's estimates of future temperature change and climate damages.

We model six scenarios: each effect (intensity, backstop, participation) is examined in the BAU and optimal settings. For purposes of comparison, we examine two cases, a *Base* case that is the standard DICE-2013 model with no sociopolitical feedbacks, and a *Political Feedbacks* case that includes the effects under examination. The temperature change of 2° Celsius above pre-industrial levels is selected for our analysis because it has long served as the focal point in international climate negotiations as the level that avoids the worst climate damages. We discuss below the sensitivity of our analysis to this choice.

B. Technological Development

The economic system connects directly to the climate system through greenhouse gas emissions. In DICE, emissions are modeled as a direct consequence of economic production: the larger the amount of global economic output, the more emissions that are created. The relationship between economic production and emissions is called emissions intensity and is expressed as a unit of greenhouse gas emissions (e.g., a ton of carbon dioxide equivalent) per unit of economic production (e.g., dollars of GDP). More carbon-intensive industries have, by definition, greater emissions intensity. As countries decarbonize their economies, they reduce their emission intensities.

The leading EC-IAMs predict a gradual decline in the emissions intensity of the global economy. This amounts to a prediction that the global economy will decarbonize in the coming decades as a general background process. DICE-2013 anticipates a reduction in emissions intensity of roughly 1% per year over the next 200 years in the no-policy baseline scenario.[144] This value was arrived at using data on regional variation in emissions intensity and per capita GDP—richer countries tend to have lower emissions intensities than poorer countries. Past experience in wealthy countries also indicated that emissions intensity tends to decline as per capita income increases.[145] The DICE model extrapolates from these trends to predict that emissions intensity will similarly decline for the entire global economy alongside economic growth.

The economic system also affects emissions via abatement decisions. In DICE, abatement cost in a given time period is a function of the abatement level, the price of the carbon-free backstop technology (i.e., a technology that replaces fossil fuels or removes them from the atmosphere), and global participation in abatement policy in that time period. DICE includes an exogenous decline in the backstop price over time due to the improvement in carbon-saving technologies, such that its initial price is $344 per ton of CO_2 emissions (in 2005 U.S. dollars) in 2010 for 100% carbon removal decreases at the constant rate of 2.5% every five years, reaching $218 in 2100 and $131 in 2200. The abatement cost function is calibrated based on the backstop price.[146]

We put to the side questions about the plausibility of the exact predictions in the DICE model concerning the decline in emissions intensity and the costs

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144. William Nordhaus & Paul Sztorc, DICE 2013R: Introduction and User's Manual 14 (2013).

145. *See* J. Wesley Burnett, John C. Bergstrom & Michael E Wezstein, *Carbon Dioxide Emissions and Economic Growth in the U.S.*, 35 J. Pol'y Modeling 1014, 1019–26 (2013); *see also* Ying Fan et al., *Changes in Carbon Intensity in China: Empirical Findings from 1980-2003*, 62 Ecological Econ. 683, 685 (2007).

146. The abatement function is assumed to be strictly monotonically increasing in abatement and convex. The function is calibrated such that the marginal cost of abatement equals the backstop price for 100% abatement in each period.

of zero-carbon technology. These are the predictions in one of the leading models and they are sufficient for our illustrative purposes.

There are non-policy reasons that emissions intensity and the backstop price might fall over time—for example, energy efficiency technologies can generate private net benefits while reducing the carbon footprint of economic activity, and background innovation may reduce the cost of zero-carbon electricity generation. But to a substantial extent, reducing emissions intensity or lowering the backstop price will be contingent on public policy choices.[147] Deploying energy efficiency technologies may be cost-effective for individual actors sometimes, but an optimal level of energy efficiency in the face of externalities will require public policy. Absent external prompts, rational self-interested firms and individuals will not switch to a more expensive option, even when it is in society's best interest to do so. The price of the backstop technology is even more a function of public decision-making.[148] There are many obstacles to the introduction of carbon-free and capture technologies "related to cost, environmental impacts, and public acceptance."[149] Given the absence of a carbon market and the significant positive externalities from developing carbon-free technologies, governments have a major role to play in funding research and development of these technologies and creating incentives for adoption through regulations, taxes, and subsidies.[150]

As at least partially policy-determined features of the economic system, emissions intensity and the backstop price are both subject to sociopolitical feedbacks if climate change damages make countries less willing to engage in climate mitigation policies (including investments in technological development). If this is the case, the gradual decline in emissions intensity and backstop price that is hardwired into the DICE model may not be accurate. Rather, these two exogenously set variables may be endogenous to interactions in the economy-climate system, with climate damages interfering with the decline of emissions intensity and a backstop price that is anticipated in the current model. We test the effect of a potential sociopolitical feedback on technological development on climate damages by perturbing the assumed decline in emissions intensity and backstop price and re-estimating the DICE model under those scenarios.

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147. *See* Fredrik N.G. Andersson & Peter Karpesam, *CO2 Emissions and Economic Activity: Short- and Long-Run Economic Determinants of Scale, Energy Intensity and Carbon Intensity*, 61 Energy Pol'y 1285, 1293 (2013).

148. *See* Massimo Tavoni et al., *The Value of Technology and of its Evolution Towards a Low Carbon Economy*, 114 Climatic Change 39, 47–48 (2012).

149. Klaus S. Lackner et al., *The Urgency of the Development of CO2 Capture from Ambient Air*, 109 Proc. Nat'l. Acad. Sci. 13,156, 13,156 (2012).

150. *See* Reyer Gerlagh, Snorre Kverndokk & Knut Einar Rosendahl, *Optimal Timing of Climate Change Policy: Interaction Between Carbon Taxes and Innovation Externalities*, 43 Envtl. & Resource Econ. 369, 377–80 (2009).

In the *Base* case (i.e., DICE without sociopolitical feedbacks), the model predicts a gradual reduction in emissions intensity: by 2050, emissions intensity is forecasted to fall by 33%; by 2200 there is an 82% reduction in emissions intensity from current levels. For our first *Policy Feedback* case, we construct a second emissions intensity pathway that assumes a rapid halt in the decline of emissions intensity after the 2° Celsius threshold. The *Base* and *Policy Feedback* cases diverge at 2050, when the model predicts that the temperature threshold is passed and intensity flattens.[151] We program this different forecast regarding the emissions intensity pathway into DICE-2013R to examine how it affects predictions concerning temperature change and damages.

The effects of *Policy Feedback* in the optimal setting are not substantial. In the BAU setting, however the effects of *Policy Feedback* on temperature become appreciable by the century's end, at which time the *Policy Feedback* scenario predicts a nearly tenth-of-a-degree increase in comparative temperatures. By the end of the forecast period, the difference in temperature has approached nearly a degree. This is a meaningful increase in temperatures, potentially the difference between severe and catastrophic outcomes. In the BAU analysis, the *Base* case predicts an increase in temperatures of just over six degrees—an already catastrophic level of temperature change. The *Policy Feedback* case estimates an increase in temperature just under seven degrees.

These temperature changes can be converted to damages in the DICE model, presented as a fraction of gross global economic output. These estimates should be treated with some caution, as predicting damages at high levels of temperature change is a highly speculative undertaking.[152] Tracking temperature change, by the end of the century, there is an appreciable increase in damages of 0.24% of global economic output. By the end of the forecast period, the reduction becomes 3.2% of global production. Again, in the BAU setting, this change is particularly important because it is additional to a *Base* reduction of 10.5%.

In the second *Policy Feedback* case, we assume an immediate halt to the backstop technology price decline after the 2° Celsius threshold. By 2050, the backstop price is forecasted to fall by 18% in both models. By the end of our 200-year forecast—after the *Base* and *Policy Feedback* scenarios diverge—there is a 62% reduction in backstop price in the *Base* case and a roughly 21% reduction in the *Policy Feedback* cases. In the BAU setting, we see little difference in temperature or damages between the *Base* and *Policy Feedback* cases. In the optimal scenario, we see a steady, positive increase in temperature and damages between the *Base* and *Policy Feedback* cases starting in 2100. By 2200, positive percentage differences in temperature and damages are 20% (equivalent to ap-

151. Rather than the 82% reduction in emission intensity predicted in the *Base Case*, there is only a 38% decline in emissions intensity in the *Policy Feedback* case by 2200.

152. *See* Howard & Sterner, *supra* note 24, at 203.

proximately half a degree Celsius) and 40% (equivalent to 0.66% of GDP) respectively.

The two major technological effects are illustrated in Figure 4. The takeaway from these two model runs is that sociopolitical feedbacks that affect technological development can have considerable consequences, both in a BAU scenario and in a scenario that involves some investment in mitigation. In a BAU path, a flattening of the reduction in emissions intensity generates substantial additional temperature change and damages because there is no additional abatement taking place, meaning that any reduction in emissions occurs as a result of a general background tendency toward decarbonization. In a pathway with some investment in abatement, the failure of the backstop price to continue declining over time implies less abatement at higher cost, which ultimately translates into a less effective regime.

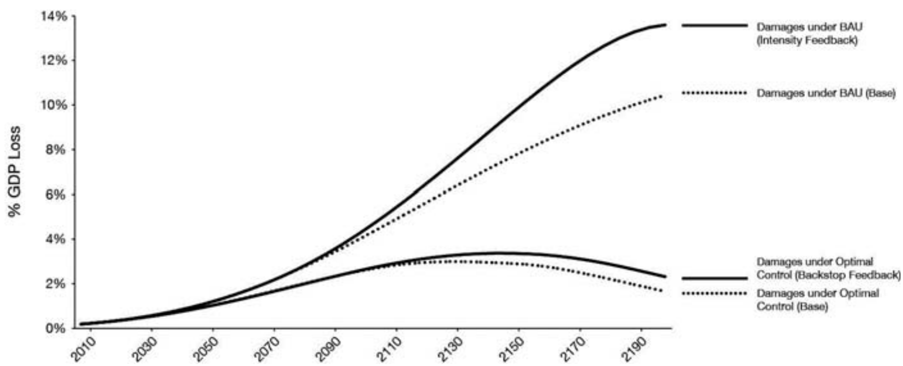

Figure 4. Increased damages from sociopolitical feedback effects on technological development. Over time, predicted damages diverge in both the BAU and Optimal Control scenarios if political feedbacks lead to less rapid technological development in the areas of emissions intensity or zero-carbon energy sources.

C. Regime Failure

Although the path of technological development is at least partially determined by public policy, innovation also occurs as the result of normal market operations: it is possible that general market forces will exert some downward trend on emissions intensity and the backstop price even absent a sustained policy response. Abatement, however, is a decision that requires policy because it amounts to a direct expenditure on a global public good. Some private actors may be willing to incur such costs on moral grounds, but purely self-interested decision-makers will not. Generally speaking, government is needed to generate these types of public goods. Indeed, given the global nature of climate change, cooperation (or altruism) across borders is necessary to arrive at efficient investment in climate stability via mitigation expenditures (i.e., abatement).[153]

Because of the global collective action problem at the heart of climate change, the research reported in Part II is most directly relevant to the long-term prospects of international collaboration on climate change policy. If climate damages increase the risk of civil conflict—of various types—and conflict reduces willingness or ability to cooperate, the stability of a climate change regime is threatened by climate instability. Extrapolating from the relatively *high doses* of conflict found in our dataset—which involves relatively widespread outbreaks of violence—to *lower doses* that are more often experienced in advanced countries, it may be that even mild social discord that is exacerbated by a warming planet may make commitment to climate cooperation difficult. Often, signing environmental treaties is relatively costless, so if even that relatively cheap form of cooperation tends to be abandoned during times of conflict, the costlier steps required of a genuine climate regime may be more quickly abandoned in the face of milder social strife.

To test the potential effect of a widespread cooperation-related sociopolitical feedback on temperature and damage estimates, we model a third *Policy Feedback* case in which an efficient global climate accord partially collapses after the 2° Celsius threshold is passed. Given that this case is only relevant in the optimal setting and not the business-as-usual setting, we only analyze the *Base* and *Policy Feedback* cases for the optimal setting. We model the consequences of the regime falling from 100% participation to two alternative levels: 50% and 25%.

By the end of century, warming in the *Policy Feedback* case with 50% participation is 0.3 degrees higher; with the 25% participation rate, warming is 0.46 degrees higher. By 2200, the effect has become very substantial. Warming in the *Base* case, with full participation in the climate change regime, is predicted to be roughly 2.5 degrees. In the case of a drop of participation to 50%, the amount of warming is predicted to be 4.9 degrees, and for 25% participation, warming grows to 6 degrees. Tracking temperatures, by 2100, the additional lost global GDP in the *Policy Feedback* case is 0.53% and 0.81% for the 50% and 25% participation rates. By 2200, that number jumps to an additional 4.7% and 8% of GDP, compared to the *Base* case. These effects are illustrated in Figure 5. These are extremely large numbers, but they may even underestimate the extent of the harm, given the difficulty of predicting the extent of climate damages associated with such substantial temperature changes.

153. *See generally* William Nordhaus, *Climate Clubs: Overcoming Free-Riding in International Climate Policy*, 105 AM. ECON. REV. 1339 (2015).

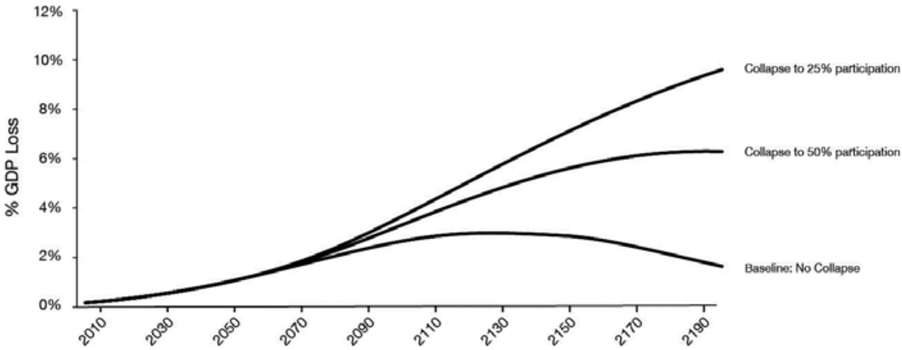

Figure 5. Increased damages from sociopolitical feedback effects on the abatement coalition. Over time, predicted damages diverge from a relatively low baseline in the Optimal Control scenario to reflect a reduction in global participation in the abatement regime.

The outputs of the DICE model are determined by the parameter assumptions that are used as inputs—many of these inputs are contestable. Reasonable and informed people are likely to disagree about both the empirical inputs (such as climate sensitivity) and value inputs (such as the discount rate). The purpose of our modeling exercise is to examine how sociopolitical feedbacks affect model outputs, holding all of the inputs at the level set in DICE-2013R. The parameters of the sociopolitical feedbacks, of course, are also set as assumptions in the model, and we would expect the model outputs to be related to those assumptions. In general, we expect sociopolitical feedbacks to have less of an impact the higher the temperature threshold that triggers the feedback and the smaller the impact from the feedback effect on the relevant variable.

Overall, we find that there is significant potential for sociopolitical feedbacks to contribute to climate damages, especially in the long term. Reasonable policymakers should adjust their policies accordingly; how they might do so is the subject of the following discussion.

IV. Legal and Policy Responses

The preceding Parts argued that sociopolitical feedbacks are a plausible and important category of dynamics in the economy-climate system that have received inadequate attention to date. Here, we will discuss potential responses to sociopolitical feedbacks. We first argue that further emissions limits, although justified, will not be a sufficient policy response. We will then build on existing law literature on climate change concerning policy durability to explore how policies and climate governance can be made more resilient in ways that dampen the downsides of sociopolitical feedbacks and, if possible, take advantage of negative feedbacks to reduce risks within the climate system.

A. The Limitations of Emissions Limits

Perhaps the most obvious policy response to the existence of sociopolitical feedbacks is to further limit greenhouse gas emissions. If the harms of current greenhouse gas emissions are greater than currently anticipated—because they may set off irreversible self-reinforcing sociopolitical feedbacks—then additional steps are justified to invest in conservation and cleaner forms of energy generation. Among the many costs of current emissions is the possibility of disabling future societies from taking efficient measures to mitigate or reduce exposure to climate risk. Additional investments now that can avoid that outcome (or render it less severe) will make climate change overall less damaging.

There are two primary reasons why more stringent emissions limits alone may not be an adequate policy response in the face of the potential for sociopolitical feedbacks. The first is that many political communities have proven themselves inadequate to the task of cutting emissions. Nearly three decades after the first IPCC assessment report, efforts to reduce greenhouse gas emissions across the globe are (with few exceptions) a patchwork of partial or weak policies with only limited efficacy. The worst offender is the United States, where climate policy has become mired in partisan deadlock. Significant legislation at the national level to adopt greenhouse gas limits has been stymied by fierce opposition. Many prominent politicians within the Republican Party continue to question the scientific consensus concerning climate change.[154] Regulatory measures adopted by the Obama Administration under existing statutory authority faced sustained and well-organized opposition.[155] Under the Trump Administration, the prospect of positive executive action is non-existent, and the new EPA has even removed references to climate change from its website.[156] The Trump Administration has officially announced that it is abandoning the country's commitments under the Paris Accord.[157]

That some states, localities, and private actors in the United States have chosen to move forward with emissions limits is a positive development, and these efforts will reduce climate damages on a marginal basis. For that reason alone, they are well worthwhile. State effort may also, over time, help shift the political landscape on climate policy.[158] Nevertheless, the reality is that investment in climate mitigation is woefully inadequate, given the scope of the risks.

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154. *See generally* Hari M. Osofsky & Jacqueline Peel, *Energy Partisanship*, 65 EMORY L.J. 695 (2016).

155. *See generally E&E'S Power Plan Hub*, E&E NEWS, https://perma.cc/6CAG-X2NH.

156. Lisa Friedman, *E.P.A. Scrubs a Climate Website of 'Climate Change'*, N.Y. TIMES (Oct. 20, 2017), https://perma.cc/69CC-L4J4.

157. *See* Jason Bordoff, *Withdrawing from the Paris Climate Agreement Hurts the U.S.*, 2 NATURE ENERGY 1 (2017).

158. *See* Michael A. Livermore, *The Perils of Experimentation*, 126 YALE L.J. 636, 700 (2017).

Outside the United States, the situation is also dire. Several major emitting countries—most notably China and India—argue that their lack of historical contributions and lower per capita emissions imply that they should not have to shoulder the burden of emissions reductions.[159] Although these countries have nevertheless engaged in mitigation policies, their existing commitments are not adequate to actually keep global emissions within the parameters needed to avert significant climate change.[160] Absent the shift in attitudes in the West that would be necessary to allow a transfer of resources in support of additional mitigation efforts in rapidly developing countries, recent trends indicate that emissions will be far above what is needed to avoid substantial climate damages.

A second reason that emissions limits alone are inadequate is that, even if the political landscape shifted tomorrow to facilitate the adoption of efficient emissions limits, momentum in the climate system toward warming may be sufficient to trigger some sociopolitical feedbacks. In a recent paper, two climate scientists found that, even if carbon dioxide immediately ceased, "committed warming" based purely on past emissions is likely to fall in the range of 1–3.6° Celsius.[161] Of course, emissions are exceedingly unlikely to stop altogether in the near future, and so even under the most plausibly aggressive scenarios there is an even larger degree of unavoidable warming.

This momentum in the climate system has important implications for sociopolitical feedbacks. Even if the political will surrounding climate policies shifts in the coming years in favor of more serious action, any commitment to engage in mitigation efforts will exist under the shadow of committed warming. In the face of future climate damages, countries may decide that they no longer wish to remain faithful to their prior commitments and exit from climate agreements. As is made clear by the Trump Administration's actions on the Paris Accord, such reversals are always a possibility. Countries facing conflict or economic dislocations due to climate change may not only be less likely to engage in prospective acts of cooperation, but may also find it impossible or undesirable to keep faith with their earlier efforts. If that is the case, an overhang of

159. *See generally* T. Jayaraman, *India's Carbon Caution in Paris*, THE HINDU (Nov. 24, 2015), https://perma.cc/2ZSE-JXAL (discussing India's strategy in climate negotiations). These claims have some support from moral philosophers. *See, e.g.*, STEVE VANDERHEIDEN, ATMOSPHERIC JUSTICE: A POLITICAL THEORY OF CLIMATE CHANGE 68–71 (2008).

160. *See generally* Glen P. Peters et al., *Measuring a Fair and Ambitious Climate Agreement Using Cumulative Emissions,* 10 ENVTL. RES. LETTERS 105,004 (2015).

161. Thorsten Mauritsen & Robert Pincus, *Committed Warming Inferred from Observations*, 7 NATURE CLIMATE CHANGE 652, 652 (2017). The range of 0.9–3.6 (5th–95th percentile) is the base case; assuming a high degree of ocean carbon uptake after the cessation of emissions lowers the total amount of committed warming. Other factors that affect the estimate include assumptions concerning whether the emission of short-lived climate forcers (such as methane) and aerosols cease along with carbon dioxide emissions. *Id.*

instability exists over every future-oriented climate agreement due to committed warming.

This overhang of instability does not only affect the prospect of future cooperation. If an element of climate agreement involves a substantial intertemporal dimension, the prospect of future instability will undermine current negotiations. A country contemplating whether to agree to some climate-related investment now, with the understanding that a counterparty will engage in a complementary investment at a future time, will have less faith in the ability or willingness of the counterparty to carry out its pledge. From the ex-ante perspective, countries will be necessarily suspicious of any delayed action, which will impede their ability to come to an efficient agreement in a context where long time horizons are centrally important. The inability of any country to make credible long-term commitments at the very least increases the costs of agreement and may make it impossible to arrive at a bargain that is acceptable to all parties.

The combination of unwillingness to adopt sound climate policy and committed warming based on past behavior implies that emissions limits alone will be inadequate to respond to sociopolitical feedbacks. Given that climate change is happening and will worsen in coming years, adaptation investment across a wide variety of domains is justified. Reducing vulnerability to sociopolitical feedbacks is one of the many adaptation measures that societies should take in light of expected climate damages. Just as investment is needed in hardening infrastructure or protecting fragile species and ecosystems, choices now can affect the extent to which climate change endangers the ability of societies to engage in future-oriented climate policymaking.

The following two sections describe steps that can be taken to increase the resilience of institutions and policies to anticipated climate-related shocks.[162] The notion of resilience has, in recent years, taken flight from its descriptive origins within the field of ecology to take on broader normative social meanings.[163] Here, we attempt to hew relatively closely to the original meaning of resilience, which describes "the persistence of systems and of their ability to absorb change and disturbance" while retaining their fundamental characteristics.[164] This concept of resilience is akin to the notion of "robustness" drawn from complexity science, where robustness refers to "the maintenance of some desired system characteristics despite fluctuations in the behavior of its compo-

162. This issue is a facet of a larger set of questions concerning the design of climate policies, including how to ensure their long-term "durability" in the face of a range of potential political risks. *See generally* Carlson & Fri, *supra* note 19.

163. *See generally* Fridolin Simon Brand & Kurt Jax, *Focusing the Meaning(s) of Resilience: Resilience as a Descriptive Concept and a Boundary Object*, 12 ECOLOGY & SOC'Y. 23 (2007).

164. *Id.* at 26. (citing C. S. Holling, *Resilience and Stability of Ecological Systems*, 4 ANN. REV. ECOLOGY & SYSTEMATICS 1, 14 (1973)).

nent parts or its environment."[165] The concept is similar to policy durability as it has been discussed by some environmental law scholars.[166] The question that we will attempt to answer is how governance institutions and policies can be designed to interfere with positive sociopolitical feedbacks and, if possible, accentuate negative sociopolitical feedbacks. These types of resilient policies or institutions would add stability to the economy-climate system by reducing the potential for runaway positive feedbacks and even dampening the long-run response of the climate system to current emissions.

B. Resilient Politics

Resilience in the face of sociopolitical feedbacks would imply a ratchet effect that would increase the stringency of controls when climate damages show the risks to be greater than anticipated while maintaining controls even if climate damages undermine the political will behind mitigation. At the level of policies, however, that kind of two-way resilience is difficult to imagine, and so we focus in this section on the second element of resilience: policy stability in the face of climate damage–induced political opposition. One way to insulate climate policies would be to increase their formal legal status. An economy-wide limit on greenhouse gas emissions or a carbon price could, for example, be placed directly in countries' constitutions, making any revision subject to relatively burdensome amendment procedures. Law-abiding nations would be bound to follow those constitutional provisions, even in the face of climate damages that might otherwise incline them to abandon their prior commitments. At least in theory, the constitutionalization of climate policy would have the beneficial effect of making it extremely difficult to change direction once a course of climate mitigation had been adopted.

There are two major problems with the constitutional approach. Most glaringly, it is unlikely, certainly at the scale necessarily to have any genuine effect. Although many countries have constitutional provisions that make general statements regarding environmental quality,[167] no country has shown an interest in reforming its constitution to include specific mandates on greenhouse gas emissions. In the United States, where constitutionalization would have the most benefits (because the U.S. Constitution is so difficult to amend), prospects for a Climate Amendment to the Constitution are slim. The second problem with the constitutionalization of climate policy is that even these com-

165. J.M. Carlson & John Doyle, *Complexity and Robustness*, 99 PROC. NAT'L. ACAD. SCI. 2538, 2539 (2002).

166. *See* Carlson & Fri, *supra* note 19, at 122–23; Lazarus, *supra* note 19 (suggesting the means of increasing the policy durability of potential climate change legislation and regulation).

167. *See generally* DAVID R. BOYD, THE ENVIRONMENTAL RIGHTS REVOLUTION: A GLOBAL STUDY OF CONSTITUTIONS, HUMAN RIGHTS, AND THE ENVIRONMENT (Audrey McClellan ed., 2012).

mitments can be ignored, given the right circumstances. In some polities, it is relatively easy to amend the constitution, making them only a bit more insulated than regular law.[168] Where formal constitutional amendment is difficult, informal interpretive amendment is possible, as has happened—at least arguably—several times throughout U.S. history.[169] Especially if climate language in a constitution is general rather than specific (as would likely be the case), there would be sufficient interpretive flexibility to formally honor the commitment while abandoning it in practice.

Of course, other things being equal, increasing the formal difficulty of revising climate policies will interfere with sociopolitical feedbacks. To take an obvious recent example, in the United States it has been relatively easy for the Trump Administration to reverse many of the less formal climate polices of the Obama Administration, but undoing climate regulations that were adopted through notice-and-comment rulemaking requires an equivalent amount of process, including opportunities for judicial review.[170] If comprehensive climate legislation had been adopted, it would have proven even more difficult than regulation to reverse. Enshrining climate policy at the highest degree of formality certainly will add to its stability, and there is likely a legitimate tradeoff between formality and stringency if compromises must be made.

At the same time, while the level of formality may affect policy resilience in the face of climate damages and associated political effects, practical factors may be as, or even more, important. Two practical means of heightening the stability of climate policies include increasing the relative size of large, upfront, fixed expenditures compared to marginal costs and creating powerful reliance interests that will resist change. Although not distinct in their level of formal stability, policies that involve upfront costs or reliance interests will nevertheless likely prove more resilient over time.

The logic behind the first, sunk-cost, approach is that economically rational actors will continue operating a facility with low marginal costs, even if, at some later date, that actor comes to regret the initial expenditure. For example, imagine there are two different renewable energy generating technologies, both of which are anticipated to generate electricity over a thirty-year period that is worth $100 million in net present value (NPV) terms, of which $25 million is monetized climate benefits in the form of a renewable energy tax credit. One technology costs $80 million to build and is anticipated to cost roughly $10 million NPV in total operation and maintenance costs, spread out over the life of the facility. The alternative costs only $10 million to build but is

168. *See generally* ZACHARY ELKINS, TOM GINSBURG & JAMES MELTON, THE ENDURANCE OF NATIONAL CONSTITUTIONS 82 (2009).

169. *See id.* at 74.

170. *See generally* ENVIRONMENTAL LAW INSTITUTE, ENVIRONMENTAL PROTECTION IN THE TRUMP ERA (2018), https://perma.cc/4QGB-TKKF.

expected to cost $79 million NPV in operation and maintenance costs. Although the second alternative is preferable from an economic standpoint (generating the same benefits at lower costs), the first alternative is more resistant to change: if the tax credit is eliminated immediately after construction, then the second facility will halt generation, while the first will continue generating over its useful life, even if the owners regret their original investment. The relationship between sunk costs and policy durability would favor a capital-intensive approach to climate policy. Examples of such policies might include tax credits that favor capital expenditures, or the facilitation of permitting for new facilities and infrastructure—anything that makes it easier or more attractive to build. Generally speaking, an approach of this sort is likely to favor clean energy generation compared to conservation.

The sunk-cost strategy works by making the decisions of economically rational actors not depend on the climate policy in question—once behavior has shifted in response to the policy, the maintenance of the policy is no longer needed to ensure that the behavior continues. An opposite approach would be to intentionally create reliance interests that can then be counted on to fight in favor of the continuation of the policy. In the above example, both facilities have reliance interests, as they have expended some amount of capital in anticipation of the renewable tax credit. Even if there is general political displeasure with the continued tax expenditure, the owners of the facilities both have considerable economic value at stake, and can, accordingly, be expected to protect that value through their own lobbying and political efforts.

To maximize the resilience value of reliance interests, a climate policy should create immediate and reliable ongoing benefits for politically powerful interests. One example of such a policy would be a revenue-neutral carbon tax whereby the funds collected were used to reduce the corporate income tax or to subsidize the activities of a concentrated interest group such as clean electricity generators. In either case, efforts to reverse these policies would be met by opposition, not only by those who favor responsible greenhouse gas reduction, but also by the corporate interests that might see a tax increase, or the electricity generators that will lose their subsidies.

Other things being equal, such use of public policy is not normatively attractive. Although public choice theorists might believe that government policies often amount to the doling out of benefits to the already powerful, no political philosopher that we are aware of endorses such action as a legitimate exercise of the state's authority. Nevertheless, if the value of stable climate policy is sufficiently high, it would justify at least some willingness to depart from first-best policy in order to ensure the long-term continuity of a climate regime.

As the preceding discussion makes clear, there are some significant costs involved with designing climate policies that are resistant to change. There may be immediate tradeoffs, such as when a lesser level of stringency is accepted to enshrine a policy in statute rather than in regulation. Or there may be direct economic costs, such as would occur if more expensive but more capital-intensive policies were favored over cheaper approaches that spread costs out over a longer time horizon. There are also normative costs associated with buying off powerful special interests in the hopes that, down the road, they will fight to keep access to the special benefits that they receive from a policy. And most generally, policy stability, by definition, makes it difficult to make changes in light of new information or altered circumstances.[171] The entire goal, after all, is to make it difficult to abandon climate policy when it would be socially undesirable, but politically attractive, to do so. But updated scientific understanding, new technologies, or social changes may create circumstances that demand policy responsiveness. Making policies resistant to change creates a substantial bias in favor of a status quo that may outlive its usefulness.

The following section focuses on institutions as an alternative locus for resilience. Rather than attempting to maintain continuity at the level of policy, with the resultant inflexibility and ossification, this type of resilience seeks institutional arrangements that are both insulated from certain types of influence (i.e., those that lead to positive sociopolitical feedbacks) but are also open to other types of influence (i.e., those that result in negative feedbacks). Not only would these types of institutions reduce the risks that climate damages will undermine future climate policy, they also increase the chances that societies can learn from a changing climate in time to avoid even graver harms in the future.

C. Resilient Governance

Because the climate system is capable of generating so many diverse types of effects that could plausibly interact with sociopolitical decision-making, it is difficult in theory to design systems that are impervious to every possible climate risk, even if such a system were normatively desirable. Even trickier is the question of how to design institutions that achieve two-way resilience by interfering with positive sociopolitical feedbacks while facilitating negative feedbacks. In essence, the challenge is to allow learning to occur while also insulating the policy process from the harmful political consequences of climate change. If climate damages galvanize support for climate policy, that political moment should not be wasted. At the same time, if climate damages cause a bout of short-sightedness or insularity that undermines climate policy, the optimal regime would be able to weather that less favorable political environment, at least for a while.

Broadly speaking, there are two types of relevant institutional questions. The first set of questions concerns how best to allocate authority within existing institutions to promote resilient governance. These questions can be further

171. *Cf.* Carlson & Fri, *supra* note 19, at 122–23.

divided into questions concerning the horizontal allocation of power (i.e., between markets, legislatures, agencies, and courts) and questions concerning the vertical allocation of power (i.e., between international, national, regional, state, and local decision-makers). The second set of questions concerns whether to reform existing institutions to enhance their resilience, and, if so, how. Policymakers consistently make decisions concerning the allocation of power between existing institutions, but only rarely engage in substantial reform of the underlying institutions. For this reason, enhancing resilience by shaping the allocation of authority, rather than through major reform efforts, is likely a more promising route, at least in the short term.

In terms of the horizontal allocation of authority, bodies that are more responsive to climate-exposed constituencies are more likely to facilitate both positive and negative sociopolitical feedbacks. Market actors are likely the most extreme example. Business firms may find it in their reputational interests to voluntarily adopt some level of climate mitigation, for example by engaging in internal carbon pricing or supporting clean energy. If the reputational benefits of such actions increase for whatever reason—for example, if climate change becomes more salient due to major storms or fires—then firms can quickly respond with greater levels of mitigation. On the other hand, if the attention of the relevant constituencies (such as consumers or shareholders) shifts to other matters, perhaps due to a climate-induced economic recession, then firms have the capacity to quickly change course, drop their mitigation plans, and reinvest resources in more profitable ways. The relative flexibility of private actors implies very little rigidity of their policies.

There may be some private law mechanisms to enhance the resilience of the voluntary mitigation actions undertaken by market actors. For example, contracts to engage in long-term purchasing of clean power or easements on private land given over to carbon storage cannot be easily abandoned, even if underlying reputational benefits that supported those investments fail to materialize. In combination with private law commitment measures, voluntary market-based decisions may exhibit exactly the kind of resilience that would best respond to the existence of sociopolitical feedbacks: when climate salience is high, there would be pressure to commit to long-term mitigation (thereby facilitating negative feedbacks), and while salience is low, the commitment devices would prevent easy abandonment (thereby inhibiting positive feedbacks).

Even if voluntary actions could be relatively resilient, there are major incentive issues that make the market a suboptimal policy forum. A non-exhaustive list of these issues includes: inefficiency of reputation as a conduit for public preferences; grossly inegalitarian distribution of influence; monitoring costs; arbitrage opportunities for defectors; and consumer inattentiveness and bias. Although there may be a place for private governance in responding to climate change[172]—and in light of policy failure, it is certainly better than nothing—voluntary actions are very unlikely to deliver a complete solution.

In terms of the horizontal allocation of power within government institutions, the asymmetry of private law (whereby it is easier to commit than to abandon) is not obviously presented. Executives, legislatures, and courts can all reverse course through the same mechanisms (regulation, statutes, decisions) that they adopted the original policy. In this way, however much their control over an issue would interfere with positive feedbacks, it would also inhibit negative feedbacks. If the goal is stability, then a constitutional right declared by the highest court may be relatively difficult to undo. But such rights are rarely announced. Statutes are more stable than regulations and typically more difficult to adopt. For the three branches, there is a somewhat straightforward tradeoff between stability and responsiveness, and so the desirable allocation between the three depends on the relative importance of positive and negative feedbacks.

The vertical allocation of power may be more promising. In federal or other partial decentralized systems, cooperative arrangements may have some of the asymmetric benefits associated with private law. For example, under the U.S. Clean Air Act, the national government sets air quality standards, and states are required to submit plans to come into compliance with those standards over time. Although there are several potential arguments in favor of and against this allocation of authority, resilience may be one less acknowledged benefit. The national government can, with little cost to itself, adopt more stringent standards when the political will to do so materializes. At the same time, states must continually update their plans, and face citizen suits by private actors if they fail to do so, even during times when air pollution is not politically salient. In addition, although more stringent standards are often opposed by affected industries, sometimes with success, efforts to actually reduce the stringency of standards once adopted are typically scattered and ineffective.

Even if the national government suddenly exited the scene and stopped setting air quality standards, state plans would remain in place until statutory or regulatory changes were made at the state level, creating an additional source of inertia. Furthermore, if the national government contemplated such a move, many states would likely oppose its exit because the lack of national standards would allow some states to lower environmental quality to attract business investment—high-environmental-quality states are currently protected against such competition by uniform national standards. These states could be expected to act in ways similar to private entities that are benefited by an environmental regime, by lobbying or using other means at their disposal to protect those benefits.

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172. *See generally* Michael P. Vandenbergh & Jonathan M. Gilligan, Beyond Politics: The Private Governance Response to Climate Change (2017).

With its Clean Power Plan, the Obama Administration adopted a similar cooperative-federalism approach to climate change, in part because that regulation was based on existing authority under the Clean Air Act.[173] This Obama-era regulation of greenhouse gas emissions from power plants began with the national government setting emissions goals, which the states were then charged with meeting. If the Clean Power Plan survives current attempts by the Trump Administration to reverse it,[174] over the long run it may serve to be quite resilient, being open to negative feedbacks if the national government can be fairly responsive to demands to increase stringency, while continuing to operate even during periods of political lulls in support for climate policies.

As the fate of the Clean Power Plan indicates, even relatively decentralized approaches to responding to climate change will still be responsive to political shifts at higher levels. But the Trump Administration's efforts to undo that regulation have been substantially helped by the fact that there was insufficient time for the regulation to weave itself into the fabric of state law and regulation. Because it was stayed by the U.S. Supreme Court, the regulation did not go into effect during the final months of the Obama Administration, making it much more subject to reversal. The current level of instability seen in U.S. climate policy is likely an artifact of a strange series of semi-random political circumstances, rather than a telling indication of the merits of the Clean Power Plan approach.

The final set of questions concerning resilient climate governance involves institutional reforms. Any reform that renders decision-making more responsive to affected constituencies will facilitate negative sociopolitical feedbacks but create risks of positive feedbacks, while less responsive institutions will have the opposite character. As with the choice between legislative, executive, or judicial action, it is not clear that any obvious reforms will dominate, such that positive feedback will be inhibited and negative feedbacks will be encouraged. More likely, institutional reforms will create tradeoffs between the two, with no reform clearly superior to the status quo—at least in this regard.

Of course, it may be possible to engage in institutional reforms such that climate policy becomes more likely overall, for example by shifting power away from regions that will bear the costs of mitigation (e.g., coal mining regions) and toward areas that will bear the costs of climate change (e.g., coastal regions). But although such moves may alter the equilibrium policy in a climate-friendly direction, they may not necessarily result in more stable policy: indeed, because affected communities have more power, there may be greater risk of positive feedbacks. Because investments in mitigation pay off over very long

173. *See* Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64,662 (Oct. 23, 2015).

174. *See* Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units; Revisions to Emission Guideline Implementing Regulations; Revisions to New Source Review Program, 83 Fed. Reg. 44,746 (Aug. 31, 2018).

time-horizons and primarily benefit out-of-jurisdiction parties, even highly impacted groups have few incentives to unilaterally mitigate. When climate damages are heaped on that already highly skewed incentive set, they will often only make matters worse. It is possible that experience with climate change will trigger empathy and altruism sufficient to overcome those incentive problems, but as communities face greater degrees of climate damages, their investments naturally turn to more pressing issues. This is the lesson of Part II of this Article: conflict makes countries less likely to engage in environmental cooperation. One might imagine that, even if the residents of California were placed entirely in charge of U.S. climate policy, if their state were wracked by continuous large-scale wildfires, drought, agricultural disruption, mass immigration, new diseases, and general civil unrest, the appetite to invest in long-term projects like mitigation would subside.[175] Instead, political attention would likely turn to the more immediate demands of maintaining basic protections for life and prosperity in the here and now, leaving the problems of the future to those who will inhabit it.

Conclusion

In this Article, we introduced the concepts of sociopolitical feedbacks and described how they could be incorporated into models of the economy-climate system. We have also offered one plausible positive feedback mechanism: the cooperation pathway. Under the cooperation pathway, climate damages increase civil strife of various forms, which reduces the ability or willingness of countries to cooperate with each other on mitigation or adaptation measures, which then increases the extent of and vulnerability to future climate damages. Our canvas of the literature on climate and conflict leads us to conclude that there is a genuine risk of a connection between the two. We engage in an empirical investigation of the relationship between conflict and environmental cooperation based on newly merged country-level data on conflict and participation in multilateral environmental agreements. We find a consistent, significant, and meaningful negative relationship between civil conflict and international environmental cooperation that is robust to multiple control strategies and specifications. Together, prior work alongside our new analysis provides sound reason to believe that a potential cooperation pathway exists that could lead to a positive sociopolitical feedback in the economy-climate system.

175. It is worth noting that California has already experienced many of these challenges and has continued to be at the political forefront in pursuing emissions limits, despite a lack of cooperation by many other states and the national government. *See generally* Denise Grab & Michael A. Livermore, *Environmental Federalism in a Dark Time*, 79 Ohio St. L.J. (forthcoming 2019). This thought experiment imagines turning the dial up on climate damages so that they reach sufficiently severe levels that long-term problems of any form recede from the public agenda.

We explore the seriousness of this risk with a modeling exercise using one of the most widely respected economy-climate integrated assessment models. We find that, especially where feedbacks undermine international mitigation cooperation, the potential downsides of a sociopolitical feedback are severe. We then explore ways that society can respond to the potential for sociopolitical feedbacks in the design of climate policies and governance mechanisms.

The primary conclusion of this Article is that one of the potential harms associated with climate change is that climate damages earlier on will undermine the capacity for societies to invest in mitigation or adaptation efforts. The result is that over time, damages will become self-reinforcing, threating long-term human well-being and development. These sociopolitical feedbacks may be as important as natural positive feedbacks in the climate system. Given this reality, societies should take additional steps to mitigate climate change and increase the resilience of their existing and planned climate change responses.