Climate Change Politics

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Abstract

Within the past 25 years, climate change has evolved from an issue of interest primarily to some natural scientists into one of the top priorities on the global policy agenda. Research in political science and related fields offers systematic and empirically well-supported explanations for why solving the climate problem has turned out to be more difficult than originally anticipated. After reviewing this research, I focus on four areas in which we know less: (*a*) institutional design features that may help in mitigating or overcoming fundamental problems in the global cooperative effort; (*b*) factors that are driving variation in climate policies at national and subnational levels; (*c*) driving forces of climate policy beyond the state, in particular civil society, the science–policy interface, and public opinion; and (*d*) sociopolitical consequences of failing to avoid major climatic changes. The article concludes by identifying key questions at the micro, meso, and macro levels that should be addressed by political scientists in the coming years. In view of the fact that governance efforts at the global level are progressing very slowly, greater attention to bottom-up dynamics appears useful, both for analytical reasons (there is lots of variation to be explained) and for normative reasons.

INTRODUCTION

GHG: greenhouse gas

A large body of research in the geophysical sciences demonstrates that climatic changes—that is, long-term changes in temperature and precipitation patterns—are common in the Earth's history. It also shows, however, that the human imprint on climatic conditions has grown since the Industrial Revolution began in the late eighteenth century. Climatic changes are driven to a large degree by changes in the composition of the Earth's atmosphere. Vastly increased emissions of so-called greenhouse gases (GHGs), most of all carbon dioxide and methane, which emanate from the burning of fossil fuels and from agriculture and forestry, have led to higher concentrations of these gases in the atmosphere. Higher concentrations of GHGs, in turn, contribute to higher surface temperatures on our planet (**Figure 1**) because GHGs are trapping additional energy within the atmosphere; and higher temperatures tend to have various negative implications for nature and humans, including more severe droughts, floods, extreme weather events, and sea-level rise (IPCC 2007, Smith et al. 2009).

Because climate change is caused to a substantial degree by humanity and also affects humanity (as well as animals, plants, and ecosystems), it raises important questions that are of great interest to social as well as natural scientists. Compared to other social issues (e.g., elections, wars, the welfare state), political scientists have thus far paid only modest attention to the climate change issue. Very few articles on climate politics have appeared in general political science journals, whereas the issue has received strong attention in the leading journals of the natural sciences. Political scientists who have published on the subject have done so mainly in specialized journals of the discipline (e.g., *Global Environmental Politics*), or in multi- and interdisciplinary journals (e.g., *Global Environmental Change*, *Climatic Change*, *Ecological Economics*, *Nature Climate Change*, the *Proceedings of the National Academy of the Sciences*).

As climate politics is now slowly but surely making its way into mainstream political science research, it seems opportune to take stock of existing research. This article identifies areas where progress has been made and areas where gaps remain, and it outlines some ideas on where research in the next few years could be heading.

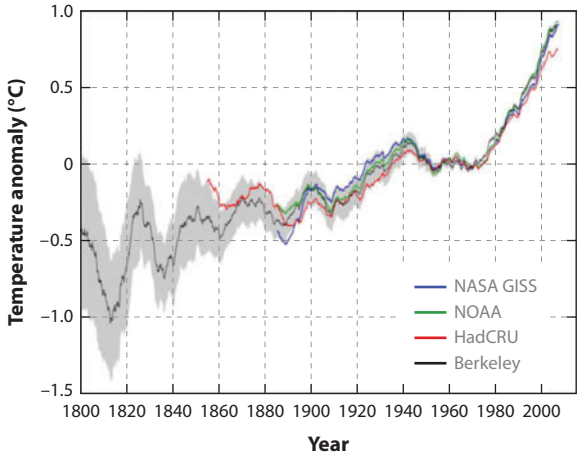

Figure 1

Global temperature changes since 1800. Shows a ten-year moving average of surface temperatures over land. Anomaly is relative to the January 1950–December 1979 mean. The gray band indicates a 95% statistical/spatial uncertainty interval. Source: Berkeley Earth Surface Temperature (2011–2012).

Political efforts to deal with the global climate change problem by means of negotiating and implementing a global treaty are progressing at a pace that is far slower than what the large majority of climate scientists deem necessary for avoiding major climatic changes. I start with a review of research that accounts for difficulties in achieving global climate cooperation. Whereas the reasons for these difficulties are now quite well understood, we know much less about three issues that are also crucial not only from a scientific but also from a practical viewpoint. The first concerns institutional design features that may help in mitigating or overcoming fundamental problems in the global cooperative effort. The second concerns factors that are driving variation in climate policies at national and subnational levels. The third concerns driving forces of climate policy beyond the state, in particular civil society, the science–policy interface, and public opinion. After reviewing the literature on these three issues, the article moves on to a final issue: unless large-scale GHG reduction efforts get under way very soon, major climatic changes are virtually unavoidable. Political scientists have thus explored possible sociopolitical consequences of climate change as well.

In view of the research gaps identified in this article, the final section outlines opportunities for political science research in the coming years. These suggestions are organized from the micro to the macro level. This reversal in perspective, compared to the structure of the previous parts of this article, is motivated by the fact that governance efforts at the global level are progressing very slowly, so it seems worthwhile to focus more strongly, for analytical and normative reasons, on bottom-up dynamics.

UNFCCC: United Nations Framework Convention on Climate Change

KP: Kyoto Protocol

WHY IS GLOBAL PROBLEM SOLVING SO DIFFICULT?

There is strong scientific consensus that the negative consequences of climate change in terms of economic and ecological damages are very serious. Policy makers clearly pay attention to this evidence, but problem solving has turned out to be much harder than many practitioners and scientists initially expected. In the 1980s, a global environmental problem with somewhat similar geophysical properties had appeared on the policy agenda: the depletion of the stratospheric ozone layer (Parson 2003, Mitchell 2006a, Victor 2011). Emissions of ozone-depleting chemicals worldwide had, similar to the climate problem, changed the composition of the atmosphere. In the ozone case, the thinning of the stratospheric ozone layer leads to increased UV radiation, which in turn is detrimental to agricultural production and human health. Within 10 years, an effective global regime was established, and the ozone layer is likely to be back at its preindustrial level within the next few decades. The global ozone regime is based on a framework convention established in 1985, a protocol established in 1987, and a series of amendments to this protocol.

The widespread enthusiasm about this outstanding success in global environmental policy making motivated the international community to use almost the same approach for climate change. The United Nations' 1992 Framework Convention on Climate Change (UNFCCC) sets the general goal, namely "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner." The 1997 Kyoto Protocol (KP) to the UNFCCC defines specific GHG emission limits for 37 industrialized countries and transition economies, and the European Union.

The early enthusiasm has, in the meantime, given way to widespread pessimism (Victor 2001, Barrett 2005, Michaelowa & Michaelowa 2012). Shortly after the KP was concluded, it became evident that the United States, the largest GHG emitter at that time (now it is China), would

not join the agreement. Canada, which ratified the KP in 2002, formally withdrew from it in 2012. Moreover, in contrast to the ozone regime, obtaining specific reduction commitments from emerging economies and developing countries has turned out to be far more difficult than expected. Why is global cooperation to solve the climate problem so difficult? Existing research offers systematic and empirically well supported answers that also point to institutional designs that could help in problem solving.

Climate change mitigation is a global collective good (sometimes also called a global common pool resource) whose "production" requires global collective action. Individuals, firms, and other actors externalize parts of their production and consumption costs by "exporting" emissions into the atmosphere, where they spread around the globe. The resulting increase in GHG concentrations in the atmosphere then harms everyone, albeit to different degrees. Trying to avoid dangerous levels of climatic change involves opportunity costs for GHG emitters and is associated with a free-rider problem. Reducing emissions or avoiding more emissions is costly and, when implemented, generates a positive global externality. The prisoner's dilemma characteristic of the problem, which in the climate case also corresponds to the tragedy-of-the-commons logic, is an impediment to global problem solving, that is, global collective action (Sandler 2004, Thompson 2006).

The organization of the international system into ∼200 sovereign states means that the global collective action problem is structured in terms of a political problem between and within states. Between states, the global collective action problem is exacerbated by strong asymmetry in benefits and costs of problem solving, mainly across richer and poorer countries. GHG emissions are primarily a function of economic output, although the goal is of course to decouple emission trajectories from economic growth. This means that almost automatically, for the time being, large economies are large GHG emitters. And, with the exceptions of China, India, Brazil, and some other emerging economies, these large economies are also the richest and technologically most advanced countries. This asymmetry has adverse effects on the potential for global cooperation (Ward et al. 2001). Large, rich countries with large GHG emissions would have to contribute most to problem solving. Hence they experience the highest opportunity costs, but they are likely to suffer least from climatic changes because they have a high capacity for adaptation. In view of the global free-rider problem (see above), they have an incentive to invest in adaptation measures, rather than in mitigation, because the investing country can directly appropriate the benefits of adaptation. Developing countries, in contrast, are much more likely to suffer from climatic changes because of their smaller capacity for adaptation. Yet, even if they reduced their economic growth to zero, they could not (with the exception of China, India, and Brazil) contribute in a significant way to solving the problem. And those large emerging economies whose commitment to major GHG reductions is essential have a different social rate of time preference (discount rate) than mature industrialized economies: they prefer to grow first and "clean up" later (Spilker 2012a,b).

Within countries, some additional characteristics of the climate issue compound the global collective action problem by making states reluctant to invest in climate change mitigation, irrespective of the global free-rider challenge. The key problem here concerns discounting. Reducing GHG emissions to levels deemed necessary by most climate scientists (approximately 50–80% below 1990 levels by 2050–2100) requires a fundamental conversion of the entire global energy supply system (Victor 2011). It requires large-scale investments in the short to medium term (most notably, a major shift from fossil fuel to renewable energy sources), whereas the main benefits accrue in the long term (avoiding major climatic changes). However, people tend to discount climate change–related damages that occur in the long term, and by implication also the benefits of climate change mitigation (Jacobs & Matthews 2012; we return to public opinion below). Given that investments in climate change mitigation in the short term loom large, this results in a low net present value of climate change mitigation. In view of rather weak public pressure for climate

change mitigation, policy makers are unlikely to assign a high priority to this issue, relative to other issues on domestic and international political agendas.

Another obstacle to climate change mitigation is political uncertainty (Hovi et al. 2009, Victor 2011, Urpelainen 2012a). Political uncertainty, in the climate policy context, means that any given government's incentives and preferences can change over time and that uncertainty about such changes can hamper efforts to establish an effective long-term policy in the first place. Suppose a government wants to introduce incentives to motivate firms and private households to reduce their GHG emissions (e.g., through tax breaks, subsidies, or feed-in tariffs for photovoltaic energy). If firms and households believe, however, that the government could abandon these costly measures once the next economic downturn or change of government arrives, they are less likely to invest in climate change mitigation in the first place. This could undermine efforts to install the policy. This problem materializes within and between countries. It would exist even if one single world government could decide autocratically whether or not to reduce GHG emissions worldwide. Not only the sheer magnitude of the task of having to reduce global emissions by up to 80% within the next 50–70 years would make it extremely hard for a hypothetical world government to firmly and credibly commit to such a course of action. Long-term credible commitment is also made difficult by the fact that the government would change many times over the decades, and political priorities would almost certainly change as well. In other words, any given government and its citizens will wonder whether investing billions into climate change mitigation today is worthwhile if a future government might "drop the ball," causing global warming to happen anyway. This argument presumes, of course, that changing government incentives strongly affects continuing costs, and not just fixed up-front costs when first installing a policy. It also presumes that contemporary investments in climate change mitigation can be undone (in terms of not avoiding global warming) if government turns away from GHG mitigation policy in the future. The political uncertainty problem described here is somewhat similar to the time-inconsistency problem in economic theory.

Yet another obstacle to effective climate change mitigation concerns cost–benefit distributions within countries. As noted by Oye & Maxwell (1994), who draw on theories of collective action and economic regulation, environmental problems are easier to solve when problem solving generates large benefits for a small group of actors (large benefits per actor) and the costs of problem solving can be dispersed over a very large group (small costs per actor). This argument helps explain why the ozone problem was solved rather quickly and effectively, and why the climate problem has turned out to be much harder to deal with. In the ozone case, the benefits of solving the problem were very substantial and easy to communicate to the public (e.g., less skin cancer and less damage to agriculture; see Sprinz & Vaahtoranta 1994); the overall costs of solving the problem were orders of magnitude smaller (a few billion US dollars, compared to hundreds of billions of dollars or more in the climate case). In the ozone case, the problem was solved through a shift to alternative chemicals. This substitution brought some additional economic benefit to a few large firms accounting for a large share of global production of the relevant chemicals. The substitution costs, which per capita were very low, were imposed on consumers. Consequently, the industry concerned eventually welcomed the proposed solution, and the additional per capita costs to consumers were too small to provoke enough opposition to stop the policy (Oye & Maxwell 1994; see also Victor 2011 and Barrett 2005). In the climate case, some industries may benefit from GHG reductions (e.g., producers of climate-friendly technologies), but the substitution costs for the average firm and consumer in most economies are likely to be rather high. This means that neither industry nor consumers (many of whom are also voters) are likely to support strong

climate policies. In other words, the net present value per capita of solving the ozone problem was evidently much higher than the equivalent value of solving the climate problem.

It is not surprising, then, that negotiations on a successor agreement to the KP, whose commitment period ended in 2012, have made very little progress (Michaelowa & Michaelowa 2012). Emission reductions of the 37 industrialized countries and the European Community, which were supposed to be 5.2% on average (by 2012, compared to 1990) will probably remain below target. However, while emissions in industrialized countries are starting to level off, they are growing massively in the emerging economies (**Figure 2**). Pending a formal follow-up agreement to the KP, many industrialized countries have pledged to reduce their GHG emissions (see **http://www.climateactiontracker.org/**). But various studies show that, even with full implementation of these legally nonbinding pledges, there is still a large gap between projected global emissions and the "emissions budget" that would allow the world to keep global average temperature increase within 2° Celcius (Rogelj et al. 2010).

The recent literature on international regime effectiveness tells us that we should not only look at emission data but also ask what the outcome of concern would have looked like in the absence of international cooperation (in this case the KP; see Helm & Sprinz 2000, Siegfried & Bernauer 2007, Breitmeier et al. 2011). Studies taking this into account show that the marginal effect of the KP on global emissions is extremely small. Even if all unilateral reduction pledges pending a follow-up to the KP were implemented, this would add up to no more than an optimistic business-as-usual scenario (Rogelj et al. 2010). They also show that the 1987 Montreal Protocol, which regulates some ozone-depleting substances that also have a global warming effect, is having a larger effect in reducing global warming than the KP (Velders et al. 2007, Victor 2011).

INTERNATIONAL REGIME DESIGN

The previous section has shown that obstacles within countries (mainly discounting, political uncertainty, low net present value of GHG reductions, and unfavorable cost-benefit distribution) coalesce with obstacles between countries (mainly free-riding and enforcement problems and asymmetric interests between richer and poorer countries) to make a global solution extremely difficult. By implication, it also shows that research in political science and related disciplines (e.g., political economy) now offers widely accepted explanations for slow progress in global climate policy. As discussed in this section, however, we need to learn much more about whether and how particular institutional design features affect the global cooperative effort.

Young (2011, p. 19855) notes, "Regime design is often a more significant determinant of effectiveness than some measure of whether the problem is benign (i.e., easy to solve) or malign (i.e., hard to solve)." If one subscribes to this view, research that investigates the determinants and implications of institutional design characteristics can be both intellectually rewarding and useful for policy making (Mitchell 2006b, Victor 2011). Some of the diagnostic arguments, discussed above, on why the climate change problem is so hard to solve also point to potential solutions.

Political Uncertainty and Commitment Mechanisms

Coping with the political uncertainty problem outlined above requires mechanisms through which governments (and ultimately also firms and individuals) can "lock themselves" into commitments that will be difficult and costly to turn away from over the next several decades. As noted by Hovi et al. (2009, p. 23), "Any world government announcing a transition to a low–greenhouse gas economy during the 21st century would face a credibility problem precisely because this investment would not be profitable for several generations and a range of other problems are

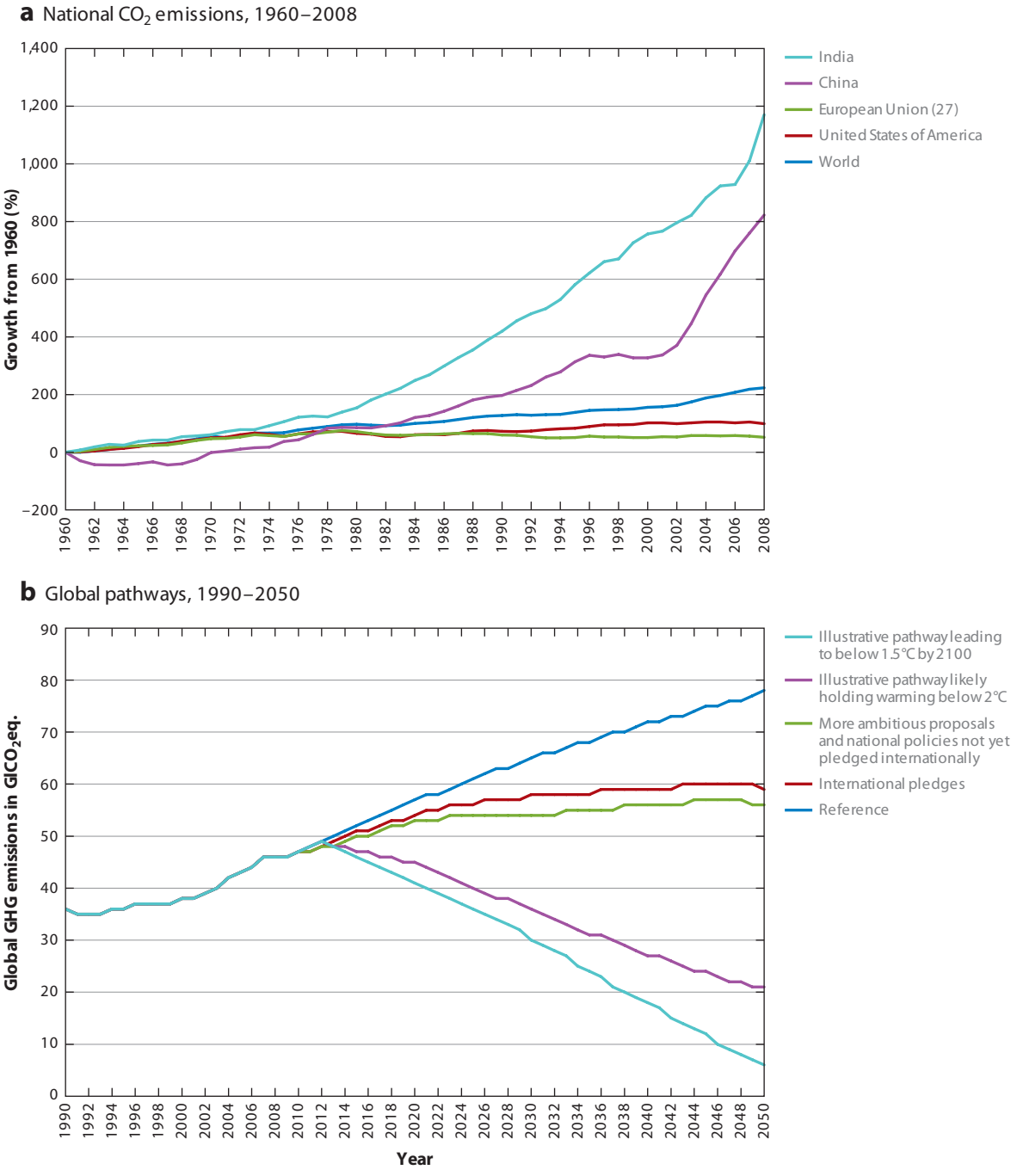

Figure 2

Emissions of greenhouse gases (GHGs) (*a*) and possible future trajectories (*b*). Data sources: (*a*) World Resources Institute (2012), (*b*) **http://www.climateactiontracker.org/**.

likely to arise over time (such as poverty reduction, financial crisis. . .) that will make ex post adherence to the ambitious climate goal unlikely."

Political scientists have recently started to explore this issue in greater depth. Urpelainen (2011), for instance, argues that if climate-friendly governments gain power in the major emitter countries and expect their successors to be less interested in climate policy, they will have an incentive to tie their successors' hands with a legally binding global climate agreement. The same holds for local policy makers vis-à-vis their successors as well as the national government. It remains unclear—and thus worth further analysis—under what conditions climate-friendly governments will have sufficient conviction and capacity to react to the political uncertainty problem by a tying-hands approach. From a normative viewpoint, it also remains open whether such an approach is desirable because it fails to respect the time preferences of future citizens, or because it can lock in policies that may turn out to be suboptimal in cost efficiency and problem-solving effectiveness. In any event, such arguments suggest that a purely economic analysis of whether early GHG mitigation is more (or less) efficient (Stern 2007) must be complemented by positive and normative analysis of political uncertainty and strategies for long-term commitments. Normative analysis, for instance, would have to clarify what reasons for future policy change a contemporary tying-hands approach should safeguard against, and what the trade-offs between policy rigidity and flexibility are in this respect.

Although a tying-hands approach appears to be the obvious solution to the political uncertainty problem, it is much easier said than done, particularly when we consider the international level. Governments frequently use costly signals to demonstrate long-term commitment to a given policy, including climate change policy. For instance, the European Union has explicitly committed itself to reducing its GHG emissions by 20% by the year 2020. It has also expressed strong commitment to further reductions beyond that point in time. These commitments have also found their way into formal EU regulations and programs (the EU's so-called climate and energy package). Nonetheless, even if the EU occupied a hegemonic position in the international system, there are many reasons why, at some point along the way, EU policy makers might change their current position and soften or even withdraw from contemporary commitments.

A similar problem would arise if governments delegated decision-making authority concerning emission levels or quotas to an independent global body, or if they legally bound themselves to specific GHG reduction trajectories for the next few decades. Such approaches would make it more costly for governments to renege later. But government could, in principle, still retract the delegated authority along the way and/or simply renege on reduction commitments issued by the supranational authority.

Another institutional design option, ultimately perhaps the most effective one, could be to promote the transition to new technologies that require massive upfront investment but once in use become very cheap owing to scale economies and network effects (Barrett 2005, Hovi et al. 2009, Victor 2011). For instance, when more and more cars are run on advanced biofuels, hydrogen, or electricity, these cars and fuels might become cheaper and more convenient, relative to fossil fuel–powered cars. Global efforts to protect the stratospheric ozone layer were successful in part because ozone-depleting chemicals were eventually quite easy and comparatively cheap to substitute for (Oye & Maxwell 1994). The challenge in climate policy is orders of magnitude bigger, requiring emission cuts across a large range of economic activities (from transportation and electricity generation to agricultural practices and forestry). Given the scale and complexity of the task, it is hard to see how a technology-driven tipping point in the global energy supply could be reached anytime soon—particularly in view of the discounting problem associated with large up-front investment and long-term benefits.

In the absence of a technological fix that removes the political uncertainty problem, and given that instead of a world government there are ~200 countries participating in global climate policy

making, institutional mechanisms that mitigate the global free-rider problem could also mitigate the political uncertainty problem. We now turn to this issue.

Free Riding and Enforcement

A large amount of research based on laboratory experiments and observational studies shows that monitoring and enforcement mechanisms are essential for effective collective goods provision, from the local to the global level (Axelrod & Keohane 1985, Keohane & Ostrom 1995, Mitchell & Keilbach 2001).

In contrast to many other areas of international cooperation (e.g., trade liberalization, arms control), where specific reciprocity is the principal strategy for solving the free-rider problem, specific reciprocity is not an attractive enforcement device for countries interested in solving the climate change problem. Increasing GHG emissions in response to noncooperation by another country in a tit-for-tat strategy will, in most cases, be at least as damaging to the punisher as to the punished, notably because it may undermine the entire effort of collective goods provision. Moreover, other forms of decentralized enforcement—e.g., imposing trade sanctions or cutting foreign aid—in response to a violation of GHG reduction commitments (usually labeled diffuse or non-issue-specific reciprocity) invokes a second-order collective goods problem. Punishing a violator imposes costs on the punisher but creates a positive externality if punishment or the threat thereof motivates the noncooperator (and potentially others who are deterred from violating the agreement in the future) to comply and reduce GHG emissions.

Conventional wisdom holds that solving this problem requires a powerful centralized enforcement system. Yet, as Hovi et al. (2009, p. 31) observe, "The dismal conclusion is that potent enforcement systems are unlikely to be politically feasible precisely when they are most needed. Conversely, whenever a potent enforcement system is politically feasible, there is likely little need for it." One might object, however, that slow progress in global climate policy making may not primarily be due to an enforcement problem in view of strong free-riding incentives. If insufficient possibilities for enforcement were the key problem, countries could safely engage in more ambitious commitments without having to fear punishment for defection and free riding later on. The fact that many governments (e.g., those of China, India, and the United States) are unwilling to contract any international obligations to cut GHG emissions suggests that noncompliance is regarded as costly (on the issue of noninstitutionalized enforcement, see Victor 2011). The political backlash against Canada's exit from the KP lends some support to this assumption. However, it remains unclear how important the free-riding and enforcement obstacle is, relative to other obstacles such as discounting and political uncertainty. Further research could use content analysis of government justifications for cooperation or noncooperation as well as experiments on collective goods provision.

Irrespective of how strong decentralized enforcement in global climate policy may be, the enforcement instruments of the global climate change regime per se are in fact very weak (UNEP 2010). Only 37 of the 165 countries that have ratified the KP contracted specific GHG emission limits. Those 37 countries in total have to reduce their emissions to 5.2% below 1990 levels. Sanctions in the event of noncompliance (which are relevant only to those 37 countries) include an obligation to reduce emissions by the required amount, plus an additional 30%, in the next commitment period if the country concerned does not meet its targets by the end of the first commitment period. Moreover, countries who fall behind on their obligations are not allowed to sell emission permits in the next period. These provisions are not included in the KP but in the so-called Marrakesh Accord. The first commitment period of the KP ended in late 2012,

and a follow-up period remains to be negotiated. If there is no follow-up period, even the weak sanctioning mechanisms established so far will become irrelevant.

Because participation in the global climate regime is ultimately voluntary, adding stronger enforcement to the regime creates a "screening versus constraining" problem (Downs et al. 1996, Stein 2005). Stronger behavioral constraints on states are likely to screen out those who are unwilling or unable to comply; in this case, adding stronger enforcement will screen out countries that are unable or unwilling to reduce their GHG emissions. The design of the global climate regime reflects this trade-off: it includes so-called flexibility mechanisms. They allow countries with GHG reduction obligations to either invest in reduction measures in other countries or buy emission permits from other countries. The economic rationale is that this reduces mitigation costs because countries with high marginal abatement costs can finance reductions in countries with low marginal abatement costs. And from a geophysical viewpoint, it does not matter where on Earth emissions are reduced. Von Stein (2008) finds that those flexibility mechanisms have contributed to participation in the global climate regime.

Various studies have examined how the free-rider problem in climate change could be addressed. Those examining options for enhancing the enforcement system of the KP almost invariably conclude that this will be next to impossible without weakening reduction commitments and/or reducing participation levels (Hagem et al. 2005, Hovi et al. 2007, Froyn & Hovi 2008, Hovi et al. 2012a). Some researchers advocate replacing absolute GHG reduction targets with GHG intensity targets (GHG/GDP), best available technology approaches, or a more flexible system of "pledge and review" (Barrett 2005, Victor 2011). Critics argue that these approaches would simply result in much lower overall GHG reductions. Such a conclusion is premature, however, because we simply do not know, and much more research is needed to better understand the trade-offs between ambition levels of cooperation, enforcement, and participation. That is, it remains unclear whether climate policy would be better off in the long run by pursuing a strategy of inclusion with softer obligations and enforcement, instead of a strategy focusing on hard targets and strict enforcement. Further research on such trade-offs in other areas of environmental policy, as well as experiments on collective goods provision, could help fill this research gap at least to some extent.

Political efforts to (re)focus international climate governance on technology development and on climate change adaptation must ultimately be viewed as second-best responses because of both the global free-rider problem and the discounting problem. Technology development allows innovators to at least temporarily capture some benefits, even while others may free ride on the positive environmental externalities that also result from innovation (Aldy & Stavins 2010, Victor 2011). The returns on investment in climate change adaptation can even be appropriated almost entirely by the investing country. Conliffe and Jinnah (Conliffe 2011, Jinnah 2011) offer an interesting analysis of how these incentives have shifted attention from mitigation to adaptation in the UNFCCC context.

Asymmetric Interests and Financial and Technology Transfers

Whereas the political uncertainty problem and the free-rider and enforcement problems among the many sovereign countries in the international system are making effective GHG mitigation difficult, strong asymmetries of interest among the participating countries are adding an additional challenge (Victor 2011). Countries are, to vastly different degrees, responsible for global warming today and in the future. Such responsibility shares are changing over time. For instance, from a historical perspective, the accumulated responsibility of the United States for the global warming problem is much larger than the responsibility of China, but the latter has become the largest

emitter globally in recent years. Moreover, per capita emissions differ enormously: the per capita emissions of China have grown to some extent but are still only a fraction of the per capita emissions of the United States [5.4 tons CO2e/cap (carbon dioxide equivalents per capita) in China in 2008 versus 18.6 in the United States and 8.0 in the EU-27]. Finally, sensitivity (potential damage) and vulnerability (damage after adaptation) of countries to climatic changes differ strongly.

Research in political science and related disciplines has contributed to describing the various criteria that have been or could be used to justify particular distributions of the global mitigation burden. The most important criteria include historical responsibility, contemporary economic capacity, social rates of time preferences, and vulnerability (e.g., Wesley & Peterson 1999, Metz et al. 2002, Ringius et al. 2002, Steffek 2003, Den Elzen et al. 2005, Bohringer & Welsch 2006, Rive et al. 2006, Page 2008, Vanderheiden 2008, Roberts & Parks 2009, Parks & Roberts 2010, Paterson 2010, Ekardt 2011, Weiss & Burke 2011). In reality, these criteria line up quite well on a single dimension—income per capita.

As in most other cases of global environmental cooperation, financial transfers (or "green aid") from richer to poorer countries will be required to offset asymmetries of interest. As in the stratospheric ozone case, such transfer payments need to focus on large countries whose emissions are growing rapidly, most notably Brazil, India, and China. But in the climate case the challenge is orders of magnitude bigger than in the ozone case. For instance, a recent estimate that combines liability for climate change–related damages with differences across world regions in social rates of time preferences (which are a function of economic growth prospects) and a global carbon price of $35 per ton of carbon dioxide arrives at $15–48 billion for transfer payments for mitigation from OECD countries to the other countries per year (Landis & Bernauer 2012). Demands for transfer payments voiced by policy makers range from $50 billion to $200 billion per year, but these also include financial transfers for climate change adaptation. At least some of those transfers are likely to be administered by the recently created Green Climate Fund, to be located in South Korea.

The literature in political science offers a wealth of insight into the design and implications of financial transfer mechanisms in a wide range of environmental policy areas (Keohane & Levy 1996, McLean 2006). One theoretical limitation of this literature is that much of it relies on a Coasian framework (Coase 1960). In this framework, transfer payments are meant to motivate a polluter to change its behavior in line with the demands of those who pay to avoid being polluted. To the extent developing countries turn out to be the main victims of climate change, the Coasian solution will not work: those who suffer most from climate change and thus have the strongest interest in solving the problem are least able to pay those countries that are most responsible for the problem (industrialized countries and emerging economies). Further research will have to add to the Coasian framework and develop arguments about noneconomic incentives and motivations for financial transfers.

Empirical research is under severe constraints due to the paucity of reliable data on climate change–related financial transfers. One major challenge is double counting of development aid as climate aid (Michaelowa & Michaelowa 2011). Data problems notwithstanding, recent research is beginning to ask important questions that derive from the large literature on development aid in general. One example is how climate aid is allocated, for instance, whether it is flowing to where it is most needed or most productive, or whether climate aid allocation is politically biased (e.g., Michaelowa & Michaelowa 2007, 2011; Flues et al. 2010).

Technology transfers, another instrument besides financial transfers for reducing asymmetries, are bound to play a major role in the global climate regime as well. Political scientists have contributed to the literature on the causes and implications of particular regime designs in this regard. For instance, Urpelainen (2012b) uses a game-theoretic model to show that a global technology fund should reward both technology development and subsequent adoption in order

to achieve its goals. He also finds that credible commitment to funding rules and a balanced burden-sharing rule are essential.

CDM: Clean Development Mechanism

ETS: Emission Trading System

Technical Uncertainty and Flexibility Mechanisms

Yet another challenge in global climate policy emanates from uncertainty about the costs and benefits of different GHG mitigation options and the effectiveness of (future) technologies and policy instruments in this respect. Although political uncertainty and technical uncertainty are related (governments are more likely to renege on commitments if envisaged policies turn out to be much more costly and/or technically less feasible than anticipated), they are conceptually distinct.

The principal purposes of flexibility mechanisms in the global as well as the EU climate change regime are to direct mitigation efforts to where they are most cost efficient and to efficiently cope with the great uncertainty over how effective and cost efficient future technologies for lowering GHG emissions will be. That is, the purpose of flexibility mechanisms is to lower marginal GHG abatement costs. Flexibility mechanisms are also useful because they are less likely than technology-focused regulation to lock countries into technology choices that turn out to be inefficient for GHG reductions in the long run. To the extent they perform these functions well, governments will be willing to accept more ambitious reduction targets. The global climate regime uses two conceptually similar flexibility mechanisms. One operates among countries that have contracted GHG limits under the KP (it is called Joint Implementation); the other operates between the latter countries and Protocol members with no GHG limits so far (it is called the Clean Development Mechanism). Countries (and also firms) that emit less than permitted can sell excess emission rights to those who exceed their allocation. Countries (firms) investing in emission-reduction projects (e.g., retrofitting of a coal-fired power plant, reforestation) in another country can obtain credits for this and thus obtain additional emission rights at home. Emission allowances or credits can be traded among firms and countries. The most important such trading platform is the European Emission Trading System. Prices on this trading platform indicate at least to some extent how scarce GHG emission rights are and, therefore, how much existing climate policies "bite."

Even though the mentioned motivations for building flexibility mechanisms into the global climate change regime appear intuitive and are also strongly advocated in the environmental economics literature, empirical research has found it surprisingly hard to identify the assumed economic logic in real-world climate policy. Some authors have drawn on rational design of institutions theory to account for why the global climate regime includes flexibility mechanisms. They have found, however, that the negotiation process leading to equilibrium outcomes in this respect does not clearly line up with the rationalistic calculus decision makers are expected to go through in reaching these equilibria (Thompson 2010). Moreover, research by Stein (2008) pointed to above suggests that governments may view flexibility mechanisms as an instrument to soften commitments and as a safety valve protecting against political uncertainty, rather than as a technocratic tool for increasing cost-efficiency in reducing GHG emissions.

A considerable amount of research focuses on particular flexibility mechanisms to assess their design characteristics and performance. Most studies of this kind concentrate on the Clean Development Mechanism (CDM) and the European Emission Trading System (ETS). The CDM is the key institution of the global climate regime through which industrialized countries can fund GHG mitigation projects in developing countries and credit them against their own reduction obligations. Flues et al. (2010), for instance, examine the extent to which the decisions of the executive board of the CDM are politicized. They find support for the politicization hypothesis: developing countries represented on the executive board of the CDM are more likely to get projects in/for their country approved. As to the ETS, Aakre & Hovi (2010), for instance,

compare its enforcement system with the emission trading scheme of the KP and the United States' SO_2 emission trading program. They theorize on whether compliance levels correlate with the relative strength of enforcement mechanisms. Their counterintuitive hypothesis, which remains to be examined empirically, is that the emission trading scheme of the KP may turn out to achieve higher compliance rates because the European Union's ETS is based on mandatory participation, whereas participation in the Kyoto mechanism is voluntary.

While these flexibility mechanisms are widely used by the contracting states, another instrument that could be used to cope with uncertainty, namely geoengineering, remains a hypothetical option. Geoengineering, in the climate context, comprises a variety of techniques that could be used to deflect incoming solar energy from the atmosphere and remove GHGs from the atmosphere. In principle, geoengineering might offer an efficient and flexible solution for coping with scientific uncertainty over how much GHG should be reduced by when to keep global temperature changes within certain limits. In practice, geoengineering proposals remain mired in controversy and are not likely to be implemented on a large scale anytime soon (Victor 2008, Virgoe 2009, Swart & Marinova 2010, Vaughan & Lenton 2011, Gordijn & Have 2012).

A few studies by political scientists have contributed to the debate on how geoengineering could or should be regulated. Victor (2008), for instance, doubts that existing international treaties are sufficient to effectively constrain geoengineers; countries are likely to disagree, and unilateral national geoengineering activities are possible. He advocates open research programs and assessments of geoengineering to facilitate an international norm-building process from the bottom up.

More generally, the combination of strong heterogeneity of interests and the fact that, in comparison to many other global issues, climate change is a rather recent problem, has resulted in a complex patchwork of global policy making and institutions. This is also partly because of "bandwagoning" of preexisting international institutions on the climate issue (Jinnah 2011, Wapner 2011). Some scholars (e.g., Keohane & Victor 2011) argue that the emergence of this "regime complex" is due to functional, strategic, and organizational factors, and that different bargaining dynamics and political coalitions have emerged around different tasks and functional solutions (Bailer 2012). They also claim that, because of high uncertainty and political complexity associated with the climate change issue, a regime complex is more likely to be effective than a single, monolithic regime. These arguments reflect a widely shared presumption that, in most cases, international regime overlap is conducive rather than detrimental to problem solving. As noted by Young (2011, p. 19856), "Regime complexes offer a way forward in situations that do not lend themselves to the creation of a single integrated governance system. . .institutional interplay is just as likely to produce positive or even synergistic results as it is to lead to interference between or among regimes." Other authors are more skeptical with respect to synergies between the different elements of the "climate regime complex" (Axelrod 2011, Jinnah 2011, McDermott et al. 2011, Wapner 2011) and call for reforms and greater centralization of governance structures (Gehring & Oberthur 2009; Biermann et al. 2011, 2012a).

Finally, some recent research is trying to integrate political science concepts and theories on international regime effectiveness into integrated assessment models of climate change policy (de Vos et al. 2013). Hence, it seeks to complement such models, which thus far consist of climate and economic components. This approach could offer an opportunity for more systematically assessing, through computational simulations, the implications of particular institutional design options such as those discussed above.

NATIONAL AND SUBNATIONAL CLIMATE POLICIES

Research that identifies international cooperation problems and possible regime design solutions, as discussed above, focuses primarily on the systemic level (groups of countries or all countries).

This perspective is very fruitful. But it ignores strong variation between political entities in how much they contribute to providing the global collective good of avoiding detrimental climatic changes. Political science research has in recent years contributed to describing and explaining variation in climate policies across countries and, to some extent, also across subnational units. From a normative viewpoint, this research also indicates that the gloomy picture conveyed by the lack of progress at the global level is somewhat misleading. Stalemate at the global level has not prevented some states and/or subnational units from pushing ahead with more ambitious climate policies.

International regimes emerge from complex interactions within and between states. In line with recent research in other empirical areas of political science (Shipan & Volden 2006, Bernauer et al. 2010), research on climate politics started out by explaining national or subnational climate policy behavior as a function of structural characteristics and has recently incorporated interdependent behavior and policy diffusion in empirical models.

Many studies concentrate on describing and assessing individual national or regional (primarily in the case of the European Union) climate policies. These studies are important in informing the academic community and policy makers on what policies are being used for climate change mitigation and adaptation and which policy instruments appear to work better (e.g., Harrison & Sundstrom 2007, Andonova 2008, Selin & VanDeveer 2009, Schreurs et al. 2009, Selin 2011, Steinberg & VanDeveer 2012).

Large-N comparisons of many countries, which are needed to generate more generalizable findings, are still rare. Most of them focus on explaining levels or trends of GHG emissions, with an emphasis on carbon dioxide. That is, they focus on explaining environmental outcomes, rather than policies. The reason is that data on emissions are readily available for many countries and years. The most sophisticated studies use some version of the environmental Kuznets curve (EKC) as the baseline model and then add political determinants.

The EKC has scale, composition, and income components. When a poor society starts to grow economically, industrial production expands, and the average member of that society prioritizes his/her material needs over avoiding environmental damages. Environmental degradation thus increases with economic output and growing incomes. At some point, the pollution curve levels off or (ideally) declines. The point at which this happens depends on a variety of conditions. In essence, it occurs (*a*) when a higher level of income has generated both stronger preferences for postmaterial goods and greater financial, technological, and institutional (state) capacity to address environmental problems, and (*b*) when the services sector expands at the expense of traditional pollution-intensive industries. From that point on, composition and income effects overwhelm scale effects, and pollution declines as income grows further (Dasgupta et al. 2002, Stern 2004, Spilker 2012).

Many studies show that for carbon dioxide the turning point on the EKC materializes only at rather high levels of income (Spilker 2012). The reason is that forms of pollution that exert direct and short-term local damages receive political priority over forms of pollution that can be "exported" into the global atmosphere and have indirect, long-term implications. This is why the turning points of some forms of air and water pollution tend to occur at much lower levels of income than the turning points of GHG emissions. Such studies also show, however, that at any given level of income, countries' GHG emissions still differ greatly.

Political scientists have been interested in explaining the remaining variation in emissions with political factors, most notably democracy and indicators of good governance. Most studies are not able to identify a robust significant effect of such factors (Bättig & Bernauer 2009, Bernauer & Koubi 2009, Spilker 2012). This finding contrasts with other studies that have found a democracy effect on local forms of pollution, such as air pollution (Li & Reuveny 2006, Bernauer & Koubi 2009). The "noneffect" of democracy on GHG emissions suggests that GHG emissions are (so far)

driven primarily by socioeconomic factors, including income levels, population density, industrial structure, past choices in respect to electric and thermal energy supply, historical evolution of public transportation networks, etc. It is also in line with the presumption that, particularly in cases of long-term and large-scale environmental problems, discounting and free rider problems dominate over the democracy effect. To make things worse, this result probably sheds an overly benign light on advanced industrialized democracies because of relocation of pollution-intensive economic activity to poorer countries. Interestingly, however, Spilker (2012) finds that developing countries that are more involved in international organizations (measured by number of memberships) tend to have lower GHG emissions, independently of their democracy level. The causal mechanisms through which such involvement affects GHG emissions remain to be clarified. But Spilker's results suggest that this factor can, independently of country characteristics that may influence membership in international organizations, help in mitigating the "grow rich and clean up later" problem.

Studies explaining climate policies (rather than emissions) arrive at different results with respect to the democracy effect. Most of them concentrate on ratification of the KP, one important expression of policy commitment. McLean & Stone (2012), for instance, consider European leadership in joining the KP as an example of "Europeanization," wherein EU countries ratify in lockstep and leader countries are pulling the laggards along through selective incentives (e.g., the prospect of EU accession; see also Schreurs & Tiberghien 2007). Other studies show that democracies are, *ceteris paribus*, likely to adopt more ambitious climate policy commitments relative to other countries (Neumayer 2002, Stein 2008, Bättig & Bernauer 2009). A study by Hovi et al. (2012b) demonstrates that reconstructing ratification decisions of individual countries can yield useful insights as well. This study, based on interviews, explores the inconsistency between the standard two-level-game argument (negotiators tailor international agreements to be ratifiable domestically) and the failure of the United States to join the KP. Hovi et al. find most support for the argument that the Clinton-Gore administration had already given up on Senate ratification when the KP was finalized but still pushed for the agreement to create a "green legacy" for themselves.

Much research remains to be done in this area to arrive at robust inferences about the factors that cause variation across political units in forms and ambition levels of climate policies. This work will have to take into account interdependent behavior of political units (policy diffusion) as well as characteristics of these units. Such research requires, first and foremost, better data on climate policies, particularly panel data. The latter data format is indispensible for empirical modeling of interdependent decision making among political units. The only two datasets currently in existence for the international level are those by Germanwatch (**http://germanwatch.org/klima/ccpi.htm**) and by Bernauer & Böhmelt (2013). Both datasets offer aggregate measures of ambition levels of climate policies but no information on the adoption of specific climate policy instruments. Panel datasets for subnational climate policies are currently being developed.

Recent research in this area suggests that local and national climate policy is at least partly characterized by interdependent behavior of political units. For instance, Krause (2011) examines the determinants of participation of US cities in the so-called Mayor's Climate Protection Agreement. She finds that these choices are driven primarily by city characteristics (e.g., city population, education level, political orientation, economic structure), but also by whether neighboring cities adopt the agreement. In an attempt to look at different conceptualizations of neighborhood, Schaffer (2011) finds that interdependent decision making does not seem to occur via direct geographical neighborhood relations but through similar population sizes of cities as well as through cities' participation in municipal networks (see also Betsill & Bulkeley 2004, Vasi 2006, Matisoff 2008, Urpelainen 2009, Bulkeley 2010). A recent study by Hsueh & Prakash (2012, p. 445) finds

that federal climate programs in the United States "are likely to emphasize less tangible reputational benefits while state programs are likely to emphasize more tangible benefits, such as access to technical knowledge and capital." This finding raises questions about how horizontal policy diffusion affects vertical policy diffusion, which remain to be addressed. Other studies focus on the international level. They examine, usually by means of qualitative case studies, the diffusion of particular climate policy instruments or technologies across countries (e.g., Ciocirlan 2008, Betsill & Hoffmann 2011, Freitas et al. 2012). Yet other work has illuminated, at the conceptual level, mechanisms of climate policy diffusion within federal systems and internationally (Jänicke 2008, Brown 2012, Ovodenko & Keohane 2012).

Future research will have to show whether and how climate policy diffusion mechanisms within states differ from those between states. It will also have to explore how domestic and international factors interact to influence policy choices. One example of such work—which, however, examines emissions rather than policies—is a study by Perkins & Neumayer (2012). They find that foreign direct investment can, under certain conditions, help reduce the carbon intensity of economic activity in the recipient countries. Another study of this kind by Underdal et al. (2012) examines how a conditional commitment by a major polluter would affect the incentives of other countries to cooperate, via implications for mitigation costs—contingent on domestic politics. Their rather pessimistic findings suggest that Europe's pushing ahead in climate policy is unlikely to motivate the United States to follow suit. One of the still very few studies that examine international climate policy diffusion with respect to one particular policy instrument (taxation) is by Ward & Cao (2012). They examine spatial and temporal variation in "green taxes" as a function of domestic and international determinants, focusing on OECD countries from 1995 to 2004. They find that, domestically, left–right and environmental positions of legislative medians and the power of the energy-producing sector are most influential. At the international level, trade and international environmental governance networks are also influencing national green taxation.

Studies that take into account both domestic and international determinants of climate policy can help answer the puzzling question why, despite the systemic obstacles to climate policy (e.g., the global free-rider problem), some countries or subnational units become frontrunners. They will also help address critics who argue that frontrunning in climate change is primarily a "low-hanging fruit" phenomenon that will last as long as climate policies create direct and easily visible cobenefits for which citizens can reward policy makers—e.g., in the form of reducing local air pollution or creating new jobs in the renewables sector.

In summary, the literature shows that GHG emissions are thus far determined primarily by economic structures and processes rather than by political factors such as democracy and good governance. Forms and ambition levels of climate policy, however, which may serve as lead indicators for future emissions behavior, are influenced also by political system characteristics as well as interdependent behavior and political network effects.

Finally, the construction of much more detailed and comprehensive datasets on climate policies worldwide and the analysis of these data using advanced spatial statistics will always remain incomplete. Numerical coding of forms and ambition levels of climate policies will miss many nuances that are interesting and important; and statistical techniques cannot reconstruct dynamic decision-making processes that ultimately generate the observable variation in policy choices. Consequently, qualitative case studies based on "thick description" of climate policy making will remain crucial. It is worth noting, in this context, that the political science literature is currently witnessing a (still rather small) surge in quantitative work on climate change policy—not because such work is necessarily superior but simply because the qualitative work is more voluminous and there is an obvious need to probe into the generalizability of some of those findings by means of large-N statistical work.

BEYOND THE STATE

Political science research on the climate change issue has, thus far, focused heavily on government behavior and institutional aspects of climate politics. However, because an effective solution will ultimately require a comprehensive transformation of the global carbon-based energy system, with obvious implications at individual and firm levels, public support for climate policy is essential. Research focusing on civil society involvement in climate governance, on the science–policy interface, and on public opinion is motivated by this consideration. The presumption here is that traditional state consent to international treaties has become insufficient as a legitimating device in the case of complex global policy problems that are negotiated and regulated far away from the domestic demos (Bodansky 1999, 2010).

IPCC: Intergovernmental Panel on Climate Change

Civil Society

Climate politics is characterized by an unprecedented amount of civil society involvement (Raustiala 1997). At recent UNFCCC Conferences of the Parties, about half of the accredited conference participants were from nongovernmental organizations (e.g., environmental groups, business groups, scientific institutions). Even more surprising, ~70% of all national delegations included nongovernmental representatives, and ~18% of all national delegation members were from nongovernmental organizations (Bernauer & Betzold 2012, Böhmelt et al. 2012).

The literature on civil society involvement in global climate governance offers very useful descriptions, typologies, and interpretations of this phenomenon (Wapner 1995, Betsill & Corell 2008, Dryzek & Stevenson 2011). But it does not yet provide systematic answers to some fundamental questions. For instance, why do governments involve civil society in particular forms (there is strong variation in practices across governments), and under what conditions does civil society involvement have particular types of effects on governance efforts?

Science–Policy Interface

Global climate governance is characterized by interaction on a large scale between scientific activity and governmental policy making. The most important expression of this interaction is the assessment process under the auspices of the Intergovernmental Panel on Climate Change (IPCC). Public policy scholars have examined how independent science has been from governments and their policy making in this area, as well as the IPCC's response when scientific evidence was evidently misinterpreted or wrongly communicated. Recent examples include the so-called Climategate episode and premature conclusions about the melting of glaciers in the Himalayas. By and large, such studies find that the IPCC assessment process functions quite well in terms of synthesizing the best available scientific evidence (e.g., Edenhofer 2011).

Political scientists have also contributed to an interdisciplinary literature that examines how (changing) scientific evidence on global warming and ways and means to address it have affected policy making (e.g., Clark et al. 2001). This research offers valuable insights into when and how new scientific evidence can foster learning and thus affect policy making in global to local arenas of climate politics. Research in this area suggests that preexisting stakeholder interests and political system characteristics moderate the effect of scientific findings on domestic climate policy making. The observation that the same scientific evidence seems to have contributed to political polarization over the issue in the United States, whereas it appears to have generated a political

drive for finding joint solutions in Europe, can be interpreted in this light (Bang & Skjærseth 2012).

Public Opinion

As noted above, two of the key obstacles in climate politics are high discounting of future benefits of adopting stricter climate policies today, and the distribution of costs and benefits of climate policy within and across countries. Public opinion plays a crucial role in climate politics in this context.

Research on public opinion with respect to climate policy is still in its infancy (e.g., Marquart-Pyatt et al. 2011), although such research can build on prior work on environmental attitudes and climate risk perceptions (e.g., Ivanova & Tranter 2008, Franzen & Meyer 2010, Kvaloy et al. 2012) in sociology and psychology. Interesting contributions to recent research address general issues, for instance, the impact of weather on people's climate risk perceptions and the impact of framing on policy preferences, as well as specific facets of climate politics, such as questions of reciprocity and civil society involvement.

With respect to more general issues, Egan & Mullin (2012) examine whether above-normal temperatures influence people's views on global warming. In line with common knowledge among climate scientists that people tend to confuse the concepts of weather and climate, the two authors find that above-normal temperatures make people more likely to believe that there is solid evidence for global warming. This effect is short-lived, however, and it is stronger among less educated persons. The analysis is based on data for the United States. This finding is congruent with other research on climate change attitudes in the United States. Brulle et al. (2012), for instance, find that economic conditions and elite cues have larger effects on climate policy preferences than other factors, such as scientific risk communication. They conclude, "The implication would seem to be that information-based science advocacy has had only a minor effect on public concern, while political mobilization by elites and advocacy groups is critical in influencing climate change concern" (p. 169). In another interesting contribution, Bain et al. (2012) examine how framing policy choices could affect support for stricter policies among climate change skeptics in Australia. They find that climate change skeptics become more supportive when climate policies are framed as fostering economic progress and/or creating a stronger sense of community. In contrast, framing in terms of the risks of climatic changes has no effect.

There have also been studies of specific facets of global climate politics. Tingley & Tomz (2012) use survey experiments to examine whether global climate cooperation could be fostered through strategies of reciprocity. They find that individuals do not view climate politics in tit-for-tat terms. This finding lines up with the widely shared view, discussed above, that climate governance based on strict reciprocity is unlikely. Tingley & Tomz find, however, that respondents support economic sanctions against states that violate an international climate agreement. They conclude that "cooperation could, therefore, emerge from efforts to link climate with other issues and to embed climate commitments in international law" (Tingley & Tomz 2012, p. 1). Bernauer & Gampfer (2013) also use survey experiments to find out whether more involvement of civil society could increase public support for climate policy. They find that people generally support the inclusion of civil society representatives in the climate policy-making process. They also observe that adding civil society leads to more positive, and exclusion of civil society to more negative, assessments of global climate policy-making. These findings provide an indirect answer to the aforementioned question of why governments involve civil society in global climate policy making.

It is worth noting in conclusion that the largest part of the literature on public opinion concerning climate change seeks to account for risk or problem perceptions, including those few papers

that have been published in political science journals or have been written by political scientists. With very few exceptions (e.g., the two papers referred to above; see also Ding et al. 2011, Klinsky et al. 2012, Krosnick & MacInnis 2012), studies have not explained individual attitudes or behavior vis-à-vis forms and ambition levels of climate policy.

CLIMATE CHANGE, POLITICAL VIOLENCE, AND HUMAN SECURITY

The preceding sections have shown that stabilizing GHG emissions at a level that avoids major changes in the Earth's climate system will be extremely challenging. What could happen if political efforts fail? Social scientists have shown that climatic changes can have very serious implications for national economies and people's livelihoods. The most negative consequences are to be expected in poor countries, primarily those in arid or semiarid zones and those with large, low-level, high-population coastal areas (IPCC 2007, Stern 2007). The Stern Report, a large effort to estimate the costs and benefits of climate change mitigation, concludes that severe climate change (3–6° temperature increase) could cause annual economic losses on the order of 5–20% of GDP (Stern 2007). Other economic assessments have arrived at smaller numbers (Tol & Yohe 2009).

Many policy makers and some scientists have jumped to the conclusion that severe climatic changes, because they can have massive implications for economic systems and people's livelihoods, increase the risk of political violence, in the extreme case war. For instance, former UN Secretary General Kofi Annan (2006) argued, "climate change also is a threat to peace and security." The IPCC, which summarizes and assesses at regular intervals the scientific knowledge on the causes and consequences of climate change as well as mitigation and adaptation options and involves thousands of scientists worldwide, has echoed such claims (IPCC 2007).

Concerns about the potential political fallout of unmitigated climate change have provoked an innovative research effort that has brought together conflict researchers and environmental policy specialists. Already in the 1980s and 1990s, following the "limits to growth" debate (Meadows et al. 2004), some scholars revived an argument made by Thomas Malthus back in 1798. They claimed that environmental degradation contributed to political violence (Homer-Dixon 1991, 1999; Spillmann & Baechler 1995). This research identified, at the conceptual level, a variety of causal pathways through which environmental degradation may generate violent conflict (Hauge & Ellingsen 1998). A considerable number of qualitative case studies offered support for these arguments (Homer-Dixon 1999).

Although this literature showed that environmental degradation can contribute to conflict, in the extreme case even violent conflict, it has several limitations (Gleditsch 1998, Bernauer et al. 2012b). For instance, the cases that were studied were not randomly chosen and tended to focus on small-scale conflicts. These features make it hard to draw robust conclusions about when and why environmental degradation leads to violent conflict of particular types, and when and why it does not. Large-N quantitative studies on the subject, which have been undertaken in the past few years, have addressed some of these limitations. A growing number of studies have focused on whether climatic changes (rather than environmental degradation more broadly) increase the risk of violent conflict (Homer-Dixon 1991, Hendrix & Glaser 2007, Buhaug 2010b, Raleigh 2010, Theisen et al. 2011, Gartzke 2012, Hendrix & Salehyan 2012, Koubi et al. 2012). They have addressed the climate-conflict claim mainly along three lines.

First, they have examined whether there is a direct relationship between climatic changes (or climate variability) and large-scale political violence measured in terms of civil or interstate war (Zhang et al. 2007, Buhaug 2010a, Hsiang et al. 2011, Gartzke 2012). Second, they have studied potential indirect effects in an effort to bring empirical testing more closely in line with theoretical arguments. These arguments hold, for instance, that climate change may influence the

risk of violence through its effects on economic activity. For instance, recent studies have examined whether climate change increases the risk of political violence via its presumably negative impact on economic performance (Koubi et al. 2012). On both accounts, and despite some initial claims to the contrary (Miguel et al. 2004), the results have been overwhelmingly negative; that is, there is no robust evidence that climatic changes are systematically associated with large-scale violent conflict (a milestone in this research is the special issue of the *Journal of Peace Research* 49/1, 2012). This "nonresult" is important, for it challenges a very prominent political claim that has frequently been voiced and has implicitly served to legitimize stronger climate policies (I return to this point below). Third, whereas the older environment-conflict literature was rather ambiguous in its definitions of conflict, quantitative work has forced researchers to be more explicit about the outcome to be explained. This applies both to scale and intensity. The first and second lines of research, noted above, find that the risk of climatic changes leading to large-scale political violence involving the state (civil war, interstate war) is insignificant. This general finding also holds when spatially disaggregated data on civil war are used (Theisen et al. 2011). It does not, however, tell us whether climatic changes have resulted in conflict on a smaller and/or less intense scale.

Interestingly, recent studies using new event datasets arrive at contradictory findings for lower-intensity conflict. For instance, Hendrix & Salehyan (2012) find that in Africa, rainfall variability correlates with political conflict. Yet, in contrast to the scarcity argument, violent events are more likely in wetter years, though extreme deviations in rainfall in both directions (drier, wetter) generate more violent and nonviolent political conflict. A recent study on water-related conflicts (the most likely manifestation of climate change–related conflicts) shows, however, that violent water-related conflicts, even at very local scales, are extremely rare, and that water cooperation is much more frequent. It also shows that water conflicts result primarily from expanding water demand rather than climate-related reductions in water supply (Bernauer et al. 2012a, Böhmelt et al. 2012). This research, which is informed by a wealth of case studies on local resources management (Ostrom 2009), suggests that institutionalized mechanisms for adaptation and conflict resolution are the most likely reason why violent water-related conflicts are rare.

The research discussed here provides clarification in respect to potential motivations for climate change mitigation policies. It cannot show, of course, what would happen under extreme climate change scenarios. It suggests, however, that other types of negative implications of climate change that cause other forms of human suffering should constitute the dominant justifications for GHG mitigation policies. This means that justifications based on human security and economic damages (Barnett & Adger 2007, Raleigh 2011) should provide the basis for policy making. The concept of human security became politically prominent with the United Nations Development Programme's 1994 Human Development Report. It emphasizes the well-being of the individual, rather than the state, and relates to a wide range of components of human welfare, ranging from employment, food security, and health to human rights (Adger 2010). Although political science research appears to be moving toward closure of the climate-war debate, major research opportunities remain with respect to the effects of climatic changes on low-intensity political violence and instability (e.g., Benjaminsen et al. 2012), migration, and adaptation strategies, as well as other facets of human security.

CONCLUSION

The political science literature on climate change issues is very diverse, both in its substantive questions and its methodology. Its topics range from global regime formation to public opinion to the sociopolitical implications of climate change. It relies on the entire spectrum of modern

social science methods, ranging from verbal and formal theory to case studies, statistical work, and experimental approaches.

This diversity implies that, in contrast to some other research areas in political science (e.g., electoral behavior, democratization, war), political science research on climate change does not concentrate on a narrowly defined set of outcome variables. Rather, climate change is viewed as a large-scale problem whose political dimensions political scientists—in addition to scholars from many other scientific disciplines—are trying to understand with whatever analytical tools they can muster. This problem-oriented nature of political science research on climate change makes many of its results policy relevant. But it has not yet enabled the emergence of a cohesive research community. As a result, much of the most innovative political science work on climate politics has, thus far, appeared in non–political science journals. Although policy makers may not care much about this, the discipline of political science should.

As discussed above, many challenging and interesting research questions remain to be addressed. In view of the fact that governance efforts at the global level are progressing very slowly, greater attention to "lower-level" dynamics appears useful, both for analytical (there is much variation to be explained) and normative reasons.

At the micro level, one of the most fundamental obstacles in climate policy is the combination of strong emphasis on current mitigation costs and strong discounting of future benefits of avoiding climate change–related damages. More research is needed on how particular ways of framing potential solutions could reduce discounting and increase public support for climate change mitigation policies. Experience with earlier environmental problems, such as leaded gasoline, ozone layer depletion, and water quality, suggests that such policies can be successful when policy makers succeed in focusing the attention of electorates on important medium- to long-term benefits of a policy and are thus able to mobilize politically influential stakeholder groups (see Victor et al. 2012 for a specific proposal). Research in social psychology also suggests that effective framing may rely not only on rationalistic arguments (e.g., risk reduction, cobenefits of mitigation policies) but also on sense-of-community and identity frames.

At the meso level, questions about civil society involvement and the science–policy interface loom large. We need more research on the conditions under which more civil society involvement in local to global climate governance affects, or could affect, the process and outcome qualities of these efforts. The conventional wisdom is that involving civil society is beneficial because it adds expertise and increases popular legitimacy. However, systematic research on the conditions under which this is indeed the case remains to be done. Similarly, we observe that the same scientific evidence on climate risks and mitigation options is processed and debated differently in different political systems. We need to know more about the conditions that influence the political processing of scientific information and the behavioral conclusions policy makers draw from such information. Yet another important question, to which we currently have no systematic answer, concerns the conditions under which climate-friendly local to national governments have sufficient will and capacity to react to the political uncertainty problem by installing policies that later, potentially less climate-friendly governments cannot easily retract. The recent literature on environmental innovation and target group influence (Jänicke 2012, Skodvin et al. 2010) offers a very promising starting point for such research. It directs our attention to processes through which climate-friendly policy instruments and policies spread among cities and other subnational units, as well as among states, and how subnational policy diffusion processes interact with international governance efforts in this field. Because, unlike in the ozone case, it will probably be impossible to mobilize sufficient transfer payments to simply buy off emerging economies, research at the micro and meso levels in these countries is particularly important.

At the macro level, one key question that remains unresolved is how strong the free-rider and enforcement problems in global climate governance really are. From this follows the crucial question of what the trade-offs are between softer, technology-oriented solutions and harder obligations focusing on emission targets and backed by stronger enforcement mechanisms, notably in view of their effects on participation. Moreover, we still know little about whether and how the flexibility mechanisms built into global and regional climate governance systems can actually help reduce mitigation costs and thus make states more willing to engage in more ambitious commitments—or whether these mechanisms are primarily devices to soften seemingly hard obligations and thus increase participation. Yet another important issue, on which there is virtually no political science research to date, concerns the effects of unilateral measures on international climate governance. There are several cases of regional or global governance in other environmental areas where green jurisdictions have moved ahead and have, usually via a combination of positive and negative incentives, "dragged" other jurisdictions along (Vogel 1995, DeSombre 2000, Victor 2011). In climate policy, the European Union has recently subjected all airlines operating flights in, from, and to Europe to its "cap and trade" system. Several non-EU governments, such as those of China, India, and the United States, have protested but not yet retaliated against this measure. It will be interesting to study whether this new EU policy can motivate non-EU airlines to reduce their emissions. The same holds for border carbon adjustment tariffs, which have been proposed but not yet implemented. And finally, research is needed on the effects of climatic changes on low-intensity political violence and instability, migration, adaptation strategies, and other aspects of human security.

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