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1 Introduction: International policy architecture for global climate change

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Exceptionally diverse aspects of human activity result in greenhouse gas emissions that are the source of anthropogenically induced global climate change. Such emissions occur in every part of the world – a coal-fired power plant in the United States, a diesel bus in Europe, a rice paddy in Asia, and the burning of tropical forest in South America. Today's emissions will affect the global climate beyond our lifetimes – most greenhouse gases reside in the atmosphere for decades to centuries. The impacts of global climate change pose serious, long-term risks. Global climate change is the ultimate global-commons problem, with the relevant greenhouse gases mixing uniformly in the upper atmosphere, so that damages are independent of the location of emissions. Because of this, a multinational response is required. To combat the risks posed by climate change, efforts that draw in most if not all countries over the long term will need to be undertaken. The challenge lies in designing an *international policy architecture* that can guide such efforts.

This focus on climate policy architecture reflects the need to establish a foundation of policy principles and institutional infrastructure to inform and frame multilateral and national actions. Richard Schmalensee highlighted the need for a long-term policy architecture in his 1998 review of the Intergovernmental Panel on Climate Change's assessment of policy instruments. He called for the "establishment of effective institutions for policymaking, as well as a policy architecture that permits efficient transitions between particular policies. When time is measured in centuries, the creation of durable institutions and frameworks seems both logically prior to and more important than choice of a particular policy program that will almost surely be viewed as too strong or too weak within a decade" (Schmalensee 1998: 141).

The current climate policy architecture has evolved since 1992 under the United Nations Framework Convention on Climate Change

(UNFCCC) and the Kyoto Protocol. These agreements have provided several near-term emission goals and commitments for some countries but have failed to set long-term quantitative goals for the entire international community. The Kyoto Protocol is merely a first step, stipulating emission targets for industrialized countries through 2012. Significant interest has focused on designing post-Kyoto policies, either building on the Kyoto framework or transitioning to a different policy approach.

This book addresses this need to design a post-2012 international climate change policy architecture. Building on a May 2006 workshop at Harvard University that brought together the world's leading scholars on climate policy architecture, this volume presents six proposals for successors to the Kyoto Protocol. Some of these proposals clearly build on the foundation established by the Kyoto agreement, while others focus on the need for developing an entirely new policy infrastructure. A dozen commentaries provide critical reviews of the policy designs and political questions raised by the proposals. The book closes with an epilogue by Thomas Schelling plus our synthesis chapter that provide insights both for the international policy community regarding the design of climate policy architecture and for the academic community as it considers how to address unresolved research questions.

The next section briefly surveys the state of climate science to establish the need for policies to mitigate climate change risks. We then describe the evolution of global climate policy architecture from the UNFCCC through the Kyoto Protocol. After describing the current policy architecture, we elaborate on the strengths and weaknesses of the UNFCCC/Kyoto Protocol and look beyond the Kyoto Protocol, with a discussion of post-2012 policy processes. The final part of the chapter provides an overview of the six proposals and their associated commentaries for post-2012 climate policy architectures that serve as the core of this book.

Human activities and the global climate

Over the past several decades, progress in global climate change research has found with increasing levels of confidence that human activities are affecting and will continue to affect the global climate. Over the last century, global anthropogenic emissions of carbon dioxide (CO_2) from fossil fuel combustion increased from 0.5 billion metric tons of carbon to 6.7 billion metric tons annually. Over this same time, the atmospheric concentration of carbon dioxide increased from 295 parts per million (ppm) to 369 ppm. From 1900 to 2000, global average temperatures increased by 0.6°C (1°F), with the 1990s the warmest decade on the instrumental record (dating to 1861), and likely the warmest decade in 1,000 years in the Northern Hemisphere. During the twentieth century, sea levels rose on average 10 to 20 centimeters (Marland, Boden, and Andres 2006; Neftel *et al.* 1994; Keeling and Whorf 2005; IPCC 2001).

The state of knowledge has improved with respect to detection and attribution of the human impact on climate as summarized periodically by the Intergovernmental Panel on Climate Change (IPCC). Established by the World Meteorological Organization and the United Nations Environment Programme in 1988, the IPCC convenes thousands of natural and social scientists periodically to review and synthesize the state of scholarly research on global climate change for the policy community. The IPCC has published four major assessments of the climate change literature, and with each review the IPCC has found stronger evidence of human impacts on the global climate.

In its first assessment, the IPCC (1990) reported that greenhouse gas emissions from human activities were increasing atmospheric concentrations of these gases. Reflecting on the quickly expanding academic literature on climate science, the IPCC concluded in its second assessment report that "the balance of evidence suggests a discernible human influence on global climate" (IPCC 1996: 4). In its third assessment report, the IPCC stated "[M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations. Furthermore, it is very likely that the twentieth-century warming has contributed significantly to the observed sea level rise, through thermal expansion of seawater and widespread loss of land ice" (IPCC 2001: 10).

In response to a request in the United States by the George W. Bush Administration to review the IPCC's conclusions on climate science, a committee of the National Academy of Sciences agreed with the IPCC's general findings. The National Academy committee opened its 2001 report by stating: "Greenhouse gases are accumulating in the Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising" (National Research Council 2001: 1).

The IPCC stated in its fourth assessment report that "warming of the climate system is unequivocal, as is now evident from observations of global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level" (IPCC 2007: 4). Having established that the global climate is warming, the IPCC concluded that "understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report, leading to *very high confidence* that the globally averaged net effect of human activities since 1750 has been one of warming" (IPCC 2007: 3; emphasis in original). With 90 percent confidence, the IPCC attributed most of the warming over the past half-century to the increase in anthropogenic greenhouse gas concentrations.

The IPCC (2007) forecasts accelerated warming under a variety of scenarios. Even if atmospheric concentrations of greenhouse gases could be held constant at the year 2000 levels through the twenty-first century, the global climate would still warm 0.6°C (+/− 0.3°C). Under a variety of long-term emission scenarios, temperature increases could range from 1.1 to 6.4°C by 2100.

The changing climate will result in a myriad of impacts. The sea level will rise, on average globally, about 20 to 60 centimeters through 2100. The severity and frequency of hurricanes, floods, droughts, and other extreme weather events may increase. Heat waves will become more common. Agricultural, fishery, and forest productivity will change, with adverse impacts more likely with higher levels of warming. The ranges of vector-borne diseases such as malaria will expand. Some species of plants and animals, especially those inhabiting unique ecosystems, may be at risk as the climate changes, especially since the rate of change may exceed their capacity to migrate and adapt. The capacity to adapt to such impacts, as evident by endowments of human capital and technology as well as effective government institutions, varies substantially around the world, and such heterogeneity in capacity may persist for some time.

The potential risks from increasing atmospheric greenhouse gas concentrations include potential catastrophic events. A warmer world may weaken the Atlantic Ocean's thermohaline circulation – the Gulf Stream that currently carries warm water from the Caribbean north and east to Europe – resulting in colder temperatures and different precipitation patterns for Europe as the rest of the world warms. A changing climate could also result in relatively rapid and large increases in sea level – on the order of ten or more meters – if Greenland or the West Antarctic ice sheet effectively melts. A warmer climate may induce strong, positive feedbacks, such as through the release of large amounts of methane from thawing of permafrost.

The global, long-term impacts of increasing emissions of greenhouse gases provide some insights about how to design policies to address climate change. A ton of carbon dioxide has the same effect on the global climate regardless of whether it is emitted in Shanghai, Stockholm, or San Francisco. This ton of carbon dioxide could remain in the atmosphere for more than a hundred years. Moreover, most other greenhouse gases are both more potent than and longer lasting in the atmosphere than carbon dioxide. Uncertainty about the effect of a ton of carbon dioxide on the climate and the small probability of major events does not suggest inaction. Rather, such uncertainty commends policy action as a hedging strategy or insurance policy as more information about climate science is developed (Manne and Richels 1992).

These characteristics of the climate change problem, as noted by Lawrence Summers of Harvard University in his Foreword to this book, also provide formidable challenges for effective policy responses. The long-term effects of climate change raise questions about how we weight the welfare of today's generation versus the welfare of future generations in making decisions. The decade- to century-long time frame of climate change does not square well with the shorter political time horizon that most elected officials operate under. The uncertainty about the impacts of climate change requires the pursuit of flexible policy approaches that are robust under a variety of possible climate change scenarios. The global nature of the problem calls for international cooperation, and, as Summers suggests, considerable imagination will be required to design climate policy architectures that can effectively address these challenges.

The evolution of climate change policy architecture

The United Nations Framework Convention on Climate Change (UNFCCC)

The global-commons nature of the climate change problem motivated several international conferences in the 1980s to consider coordinated goals and policies. In 1990, the United Nations General Assembly, based in part on the IPCC's first assessment report, initiated negotiations for a multilateral framework to address the risks posed by global climate change. This negotiation process resulted in the United Nations Framework Convention on Climate Change, signed at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil in 1992. The US Senate voted unanimously to ratify the agreement later that year, and the treaty entered into force in 1994. With 190 countries as parties to the UNFCCC, this treaty enjoys broader participation than nearly any other multilateral agreement.

The UNFCCC created a global policy architecture with four key elements: a general long-term environmental goal; a near-term environmental goal with specific quantitative targets; concerns about equity; and preference for cost-effective implementation.[1] These elements are important because they have largely defined international policy architecture to address climate change since 1992.

The UNFCCC recognized the very long-term impacts of greenhouse gas emissions by setting a long-term environmental goal. The UNFCCC established as the primary objective of climate change policy the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2). Although the world community agreed that climate change policy should strive to maintain atmospheric greenhouse gas concentrations at a "safe level," they did not articulate what this meant. Some suggested quantifying this objective with a long-term greenhouse gas concentration stabilization goal (e.g., 550 parts per million – about double preindustrial carbon dioxide concentrations) or a temperature increase stabilization goal (e.g., 2°C above current levels). However, in the absence of consensus within the scientific, economic, and political communities, negotiators at subsequent Conferences of the Parties (COPs) to the UNFCCC did not agree to specific quantitative expressions of the ultimate objective.

The UNFCCC set a near-term goal for industrialized countries, consisting of most members of the Organisation of Economic Co-operation

[1] The FCCC also initiated, *inter alia*, processes for monitoring greenhouse gas emissions, communicating countries' climate policies, reporting on how climate change may affect parties to the Convention, and financing technology transfer via the Global Environment Facility. Although all play important roles in climate change policy, they are secondary to the four key elements identified in the text above.

and Development (OECD) and most countries with economies in transition (together, forming the so-called Annex I countries in the treaty). These countries agreed to a nonbinding aim to stabilize their greenhouse gas emissions at 1990 levels starting in 2000. This focus on a country's "output" instead of its actions or "inputs" created the precedent that policy commitments would take the form of quantitative emission targets. This approach also created the precedent for country-level discretion about how to implement policies to meet those targets. Compliance with these voluntary goals was not impressive – most countries with year 2000 emissions below their 1990 levels met their goal through substantial economic decline and transformation (e.g., Russia and Germany, the latter because of reunification) or non-climate-related energy sector reforms (e.g., the United Kingdom).

Reflecting concerns about equitable burden sharing, the UNFCCC declared that the principle of "common but differentiated responsibilities" (Articles 3 and 4) should guide climate change policy. This translated into a very clear policy dichotomy between the industrialized countries and the developing countries. Industrialized countries took on emission targets, but developing countries had no quantitative emission goals or any other policy obligations. OECD member countries also had financial and technology transfer obligations to developing countries. The "obligations" of developing countries include occasional reporting on their climate vulnerabilities and climate change policies, monitoring and reporting of greenhouse gas emissions, and accepting financial and technology transfers from OECD countries.

To provide some experience with cost-effective implementation policies, the UNFCCC established a pilot program for so-called "Joint Implementation" (JI). This would allow an industrialized country to invest in an emission-reducing project in a developing country and use the emission reductions toward its 2000 emission goal. It was thought that allowing industrialized and developing countries to implement such projects jointly would exhibit some of the potential for emission trading to lower costs of achieving emission goals. This project-based emission trading draws on the fundamental characteristics of greenhouse gases – they mix globally and reside in the atmosphere for very long periods of time – so the climatic impact of an emission reduction does not vary with location. A broad and efficient emission trading program would have the potential to reduce emissions at lowest possible cost, by providing market-based incentives for emission sources to seek out the least-cost emission abatement opportunities. But the pilot program resulted only in a modest number of jointly implemented emission reduction projects.

The Kyoto Protocol

At the UNFCCC's first Conference of the Parties in Berlin, Germany, in 1995, the international community decided to begin a new round of negotiations for a second set of commitments by industrialized countries. The "Berlin Mandate" called for commitments by industrialized countries after 2000 and reiterated the UNFCCC's "common but differentiated responsibilities" language in effectively exempting developing countries from emission commitments. The following year at the second COP in Geneva, Switzerland, the United States advocated in favor of binding quantitative emission commitments. These two years of negotiations set the stage for the third COP in Kyoto, Japan, in December, 1997.

On the eleventh day of the ten-day Kyoto conference, the parties to the UNFCCC agreed on the terms of what came to be known as the Kyoto Protocol. This agreement built on the foundation laid by the Framework Convention on Climate Change, by serving as the first step toward the UNFCCC's ultimate objective through ambitious, near-term quantitative targets for industrialized countries with policy mechanisms for cost-effective implementation.

The Kyoto Protocol established emission commitments for industrialized countries for the 2008–2012 time frame, the so-called first commitment period. As such, it was intended to be a first step toward a long-term, but still unspecified objective. Several European countries initially advocated much longer-term emissions, concentrations, and temperature goals, but these received limited attention at the Kyoto conference. Instead, industrialized countries agreed to ambitious, binding quantitative emissions targets for the 2008–2012 commitment period. At the time, the agreement was expected to result in industrialized countries' emissions declining in aggregate by 5.2 percent below 1990 levels.

A grand bargain to secure acceptance by countries with concerns about the economic burden of these targets included an array of market-based mechanisms to promote cost-effective implementation. The Kyoto Protocol created tradable emission allowances for industrialized countries with quantitative targets that would serve as the basis for an international emissions market. This same set of countries could also engage in JI projects among each other. The agreement also established the Clean Development Mechanism (CDM), a framework for JI projects to generate emission reductions in developing countries that would be financed and used as credits by industrialized countries to satisfy (partially offset) their targets.

The agreement included other elements of flexibility to promote cost-effectiveness. The five-year commitment period allowed for implicit trading over time – short-term banking and borrowing. A country's annual emissions could fluctuate between 2008 and 2012, for example, because of business-cycle effects or weather variations, as long as that country's aggregate, five-year quantitative emissions did not exceed its five-year emissions budget under the agreement. In addition, creating commitments based on a basket of all six types of greenhouse gases would allow for implicit inter-gas trading. For example, if a country with a 1990 target could abate methane at lower cost than carbon dioxide, then it would have the flexibility to lower its total cost of compliance by reducing methane more than carbon dioxide so long as the carbon equivalent for all greenhouse gases equaled the 1990 level.

The Kyoto Protocol stipulates that industrialized countries' quantitative emission commitments are legally binding. If a country's emissions exceed its target for the 2008–2012 period, then it is obligated to "repay" those tons in the second commitment period plus a 30 percent penalty. For example, if a country had 10 million tons of carbon equivalent in excess of its target over 2008–2012, then it would have to reduce its emissions 13 million tons below its second commitment target. The Protocol, as in most international treaties, also includes a provision for a country to withdraw from the agreement simply by stating its intent to do so and waiting one year after notification of withdrawal.

As in the UNFCCC, the Kyoto Protocol calls only on industrialized countries to limit their emissions, requiring no emission restrictions or other greenhouse gas policies of any kind for developing countries. Developing countries can participate in the global effort to address climate change by cooperating in CDM projects, submitting reports to the United Nations, and benefiting from technology transfer.

The Kyoto Protocol did not settle all climate policy issues; negotiations at the next four COPs addressed a variety of implementation details in the Kyoto agreement. After the 2001 COP in Marrakech, Morocco, industrialized countries began to ratify the Kyoto Protocol. By that time, however, the George W. Bush Administration in the United States had declared that the United States would not ratify the Kyoto Protocol. The Government of Australia soon thereafter echoed its lack of support. Despite the withdrawal of these two countries, the Kyoto Protocol entered into force in 2005, having met the dual requirements that 55 countries had ratified the agreement and jointly accounted for 55 percent of 1990 Annex I emissions.

Strengths and weaknesses of the existing international policy architecture

The international climate policy architecture embodied in the Kyoto Protocol, building on the foundation provided by the UNFCCC, has been both lauded and criticized. To provide context for the most frequently identified strengths and weaknesses of the Kyoto Protocol, we identified six important criteria for evaluating climate policy architectures in previous work with our co-author (and contributor to this volume) Scott Barrett. We employed the following six criteria to frame our assessments of the Kyoto Protocol and alternative climate policy architectures: (1) environmental outcome; (2) dynamic efficiency; (3) dynamic cost-effectiveness; (4) distributional equity; (5) flexibility in the presence of new information; and (6) participation and compliance.

Environmental outcome refers to a policy's time path of emissions or concentrations of greenhouse gases, or the impacts of climate change. A dynamically efficient policy maximizes the aggregate present value of net benefits of taking actions to mitigate climate change impacts. The criterion of dynamic cost-effectiveness refers to the identification of the least costly way to achieve a given environmental outcome. Distributional equity refers to the distribution of both benefits and costs across populations within a generation and across generations, and can account for responsibility for climate change, ability to pay to reduce climate change risks, and other notions of equity. Given the significant uncertainties that characterize climate science, economics, and technology, and the potential for learning in the future, a flexible policy infrastructure built on a sequential decision-making approach that incorporates new information may be preferred to more rigid policy designs. Finally, incentives for participation and compliance are important, since a climate policy