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FORGING

A More Effective

Global Climate Treaty

Can the next treaty be based on sound science, rational economics, and pragmatic politics?

by Robert N. Stavins

After seven years of uncertainty, the Kyoto Protocol to the United Nations Framework Convention on Climate Change (FCCC) will come into force early next year—despite the lack of participation by the United States. With Russian ratification on 4 November, 127 countries have now ratified, accepted, or otherwise approved the treaty—and more than 40 others are at least talking about it. The key requirement for implementation is that a minimum of 55 nations, including Annex I (industrialized) countries representing 55 percent of 1990 industrialized world emissions of carbon dioxide (CO_2) must ratify the agreement; thus, because the 127 nations include industrialized countries accounting for 62 percent of 1990 Annex I emissions, the numerical requirements will now be met.[1]

If all countries except the United States were to ratify the Kyoto Protocol, approximately 64 percent of 1990 industrialized world emissions would be represented. However, in addition to the United States, Australia also indicated that it will not ratify the agreement. Removing Australia drops the relevant share of 1990 emissions to about 62 percent.[2] If the United States, Australia, and Japan had all failed to ratify, however, then the emissions share covered would have fallen to less than 53 percent, below the 55 percent threshold. Likewise, if all countries except the United States, Australia, and Russia had failed to ratify, then the total share of 1990 industrialized world emissions accounted for by ratifying countries would have been only about 44 percent.[3]

These numbers are important, because they explain why the rules of the agreement were rewritten at the Conferences of the Parties (COPs) of the Framework Convention on Climate Change in ways that lowered the costs for Canada, Japan, and Russia to ratify

BEYOND KYOTO

The dilemma: The Kyoto Protocol will come into force without U.S. participation; its effects on climate change will be trivial to nonexistent; and yet, the economic and scientific consensus points to the need for a credible international approach.

the protocol. In the process, the environmental integrity of the agreement was compromised; that is, the overall target was substantially decreased.[4]

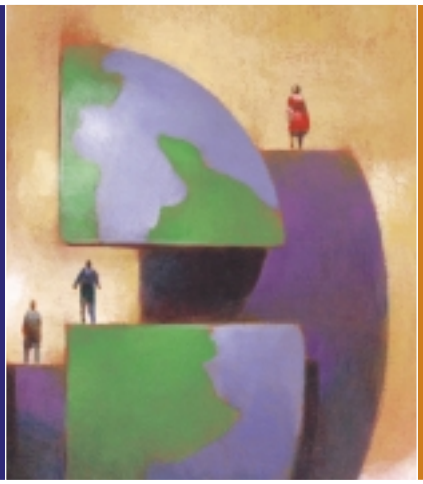
The impacts of the Kyoto Protocol on emissions of greenhouse gases,[5] targeted exclusively for the compliance period 2008–2012, will be much less than originally anticipated. Nonparticipation by the United States will be highly significant—it is the largest emitter—and, as indicated above, the rules written at the COPs in Bonn and Marakesh in 2001 had the effect of significantly relaxing the aggregate target.[6] Yet a scientific consensus is steadily forming regarding the likelihood of future climate change due to anthropogenic emissions of carbon dioxide, methane, and other greenhouse gases.[7] And economic analysis increasingly points to the wisdom of some kind of policy action.[8] Here is the current dilemma: The Kyoto Protocol will come into force without U.S. participation; its effects on climate change will be trivial to virtually nonexistent; and yet, the economic and scientific consensus points to the need for a credible international approach.[9] What can be done?

A reasonable starting point is FCCC, which was signed by 161 nations and ratified by 50—including the United States—and which entered into force in 1994. Among other things, FCCC established the principle of "common but differentiated responsibilities," meaning that all nations should engage in the solution (because of the global-commons nature of the problem) but that different countries could participate in different ways.[10]

If FCCC provides a reasonable starting point, can the Kyoto Protocol provide the way forward? To consider this question, it is helpful to examine the protocol in terms of its major architectural elements:[11] Its targets apply only to industrialized nations; it contains ambitious, short-term emissions-reduction targets but no long-term targets; and it provides flexibility through market-based mechanisms, such as tradable permits. This architecture has been widely criticized, chiefly because it would impose high costs, fail to provide for full participation by developing countries, and generate modest short-term climate benefits while failing to provide a long-term solution.[12] On the other hand, the argument has been made that the Kyoto Protocol is essentially "the only game in town," and "instead of suggesting alternatives, economists should concentrate on convincing policymakers how to get the long-term climate policy instruments right that build on Kyoto's foundations."[13]

Even if the Kyoto Protocol were an ideal policy in abstract theoretical terms, its failure—for the last seven years—to generate support sufficient for it to come into force is significant. A policy that appears perfectly efficient in theory but cannot be implemented is, in reality, high-

ly inefficient, because all net benefits are foregone.[14] Some have expressed the sentiment that given the tremendous amount of work that went into crafting the Kyoto Protocol, it should be kept and strengthened, not abandoned. Of course, from an economic perspective, the previous investments are sunk costs, and the relevant question becomes the likelihood—going forward—that incremental improvements in the protocol will yield greater net benefits than efforts dedicated to developing an alternative framework.



Given its limitations—but also its possibilities as a starting point—it may be that the best perspective is to remain agnostic on the question of the Kyoto Protocol's viability. Some analysts see the agreement as "deeply flawed,"[15] while others see it as an acceptable first step.[16] But virtually everyone agrees that the Kyoto Protocol is not sufficient to the overall challenge and that further steps will be required.[17] Therefore, the policy architecture outlined below may be thought of either as a substitute for the Kyoto Protocol or as a post-Kyoto framework.

A Three-Part Policy Architecture

To be effective, a post-Kyoto framework must be based on fundamental aspects of the science, economics, and politics of global climate change policy. In addition, it is crucial that the architecture of such an alternative approach includes three chief components: a means to ensure that key nations—industrialized and developing—are eventually involved; an emphasis on an extended time path of targets (employing a cost-effective pattern over time); and market-based policy instruments.

Expanding Participation

Broad participation—by major industrialized nations and by key developing countries—is essential to effectively and efficiently address the global commons problem of climate change. The share of global emissions attributable to developing countries is significant and growing. In fact, developing countries may account for more than half of global emissions by the year 2020, if not before.[18] A frequently voiced response to this assertion is that—on an ethical basis—industrialized countries should take the initial steps on their own to make serious emissions reductions. But the simple reality is that developing countries provide the greatest opportunities now for relatively low-cost emissions reductions.[19] Hence, it would be excessively and unnecessarily costly to focus emissions-reductions activities exclusively in the developed world.

A reasonable response to this observation about cost-effectiveness is that industrialized countries are solely responsible for the bulk of anthropogenic concentrations of greenhouse gases in the atmosphere. Hence, industrialized countries should go first with emissions reductions, and developing countries should take on such efforts only later. Although sensible arguments can be made in support of this position on grounds of distributional equity, there is a serious problem.

If developing countries are not included in an initial agreement, then comparative advantage in the production of carbon-intensive goods and services will shift outside the coalition of participating countries, making developing countries' economies more carbon intensive than they otherwise would be (through so-called "emissions leakage"[20]). Rather than helping developing countries move onto less carbon-intensive paths of economic development, the industrialized world would actually be pushing them onto more carbon-intensive growth paths.[21] This would increase their cost of joining the coalition later. Still, on equity grounds, it is unreasonable to expect developing nations to incur significant emissions-reduction costs in the short term. It would retard their economic development.

There is thus a policy conundrum. On the one hand, for purposes of environmental effectiveness and economic efficiency, key developing countries must be participants in an international effort to reduce greenhouse gas emissions. On the other hand, for purposes of distributional equity, they cannot be expected to incur the consequent costs. The solution: These countries must get on the "global climate poli-

cy train" without necessarily paying full fare. How can this be accomplished?

Four key elements of this first architectural component—expanding participation—can provide incentives for developing countries. First, a mechanism is needed for voluntary accession of developing countries into the group of nations that takes on binding commitments. Examples exist for such voluntary accession in the case of the sulfur dioxide (SO_2) allowance trading program in the United States under the Clean Air Act amendments of 1990.[22] Second, and much more important, a trigger mechanism is required whereby developing countries would be obligated to take on binding commitments once their per capita gross domestic product (GDP) reached agreed levels.

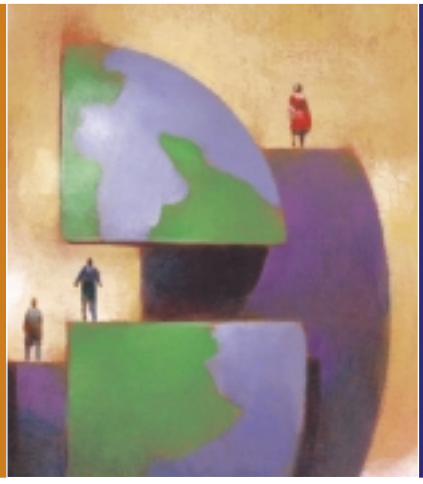
Third, an even better approach would be "growth targets" that would become more stringent for individual developing counties as they become more wealthy.[23] In the short term, such indexed targets could be set at business-as-usual (BAU) emissions levels[24] but would become more stringent over time if the countries in question became wealthier. In other words, a growth target is not a number but an equation that relates targeted emissions to per-capita income and possibly other variables. Thus, if a developing country was doing particularly well economically, its target would become proportionately more stringent, but if it was doing worse economically than anticipated, its target would be less stringent than otherwise.

It should be noted that the degree of abatement (percentage reduction below BAU emissions) depends upon a number of factors, including the specific formula employed in the growth target equation, the affected country's rate of economic growth, and the make-up of the country's economy. A target such as that proposed in 1999 by Argentina—for emissions growth to be proportional to the square root of GDP—would have the effect of setting more stringent abatement targets when economic growth is more rapid than anticipated and less stringent targets when economic growth is slower than anticipated. In any event, two necessary characteristics of a growth target formulation are that it not create perverse incentives that would encourage nations to increase their emissions and that it should be relatively simple, so as not to create impediments to negotiation.[25]

Fourth, by combining growth targets with a well-designed international tradable-permit program (discussed below), developing countries can fully participate without incurring prohibitive costs (or even any costs in the short term). That is, cost-effectiveness and distributional equity can both be addressed.[26]

An Extended Time Path of Targets

Global climate change is a long-term problem. The relevant greenhouse gases remain in the atmosphere for time spans ranging from decades to centuries. The Kyoto Protocol does not sufficiently reflect this fundamentally important reality—that is, the cumulative, stock-pollutant nature of the problem. The protocol has only short-term targets, an average 5 percent reduction from 1990 levels by the 2008–2012 compliance period. That may sound like a modest reduction, but it translates into a severe 25–30 percent reduction for the United States from its BAU emissions path.[27] The reason for this is that the United States economy grew at an exceptionally rapid rate during the 1990s, exhibiting a remarkable 37 percent increase in real GDP from 1990 to 2000.[28]



Key developing countries must get on the "global climate policy train" without necessarily paying full fare.

Thus, the Kyoto Protocol's targets are too little, too fast: They do little about the problem but are unreasonable for countries that enjoyed significant economic growth after 1990. Two elements are needed to ameliorate this problem: firm but moderate targets in the short term to avoid rendering large parts of the capital stock prematurely obsolete[29] and flexible but more stringent targets for the long term[30] to motivate (now and in the future) technological change, which in turn is needed to bring down costs over time.[31] Specifically, emissions targets ought to start out at BAU levels, then gradually depart from these, so that emissions targets in the short term would, in fact, be increasing over time but at rates below the rate of increase exhibited by BAU levels. Importantly, these intertemporal emissions targets should not be monotonically increasing but should reach a maximum level and

then begin to decrease—eventually becoming substantially more severe than the constraints implied by the Kyoto Protocol's short-term targets.[32]

This pattern would be consistent with estimates of the least-cost time path of emissions for achieving long-term greenhouse-gas concentration targets: short-term increases in emissions—just slightly below the BAU path—and subsequent emission reductions.[33] Such a time path of future targets, put in place now, would be consistent with what is often denigrated as "politics as usual." Politicians are frequently condemned for the fact that in representative democracies there are strong incentives to place costs on future, not current voters and, if possible, future generations. It is typically the politically pragmatic strategy. In the case of global climate policy, it is also the scientifically correct and economically rational approach.

Market-Based Policy Instruments

The final component of the three-part policy architecture is—in principle—part of the Kyoto Protocol: working through the market rather than against it. There is widespread agreement that conventional regulatory approaches—which many critics call "command-and-control" policies—cannot do the job, certainly not at acceptable costs. To keep costs down in the short term and bring them down even lower in the long term through technological change, it is essential to embrace market-based instruments as the chief means of reducing greenhouse gas emissions.[34]

On a domestic level for some countries, systems of tradable permits might be used to achieve national targets. This is the same mechanism that was used in the United States to eliminate leaded gasoline from the market in the 1980s at a savings of more than $250 million per year.[35] It is also the same mechanism now being used to cut sulfur dioxide (SO_2) emissions as a precursor of acid rain in the United States by 50 percent, at a savings estimated to be $1 billion per year.[36] Of the two systems, the better model for climate change policy is the upstream lead-rights system (analogous to trading based on the carbon content of fossil fuels) rather than the downstream SO_2 emissions-trading system.[37] For some countries, systems of domestic carbon taxes may be more attractive.[38] Another promising market-based approach is a hybrid of tax and tradable-permit systems—that is, an ordinary tradable permit system, plus a government promise to sell additional permits at a stated price.[39] This creates a price (and thereby cost) ceiling and has hence been labeled a safety-valve system.[40]

International policy instruments are also required to solve this fundamentally international—indeed global—problem. The Kyoto Protocol includes in Article 17 a system whereby the parties to the agreement can engage in trading their "assigned amounts," that is, their reduction targets, translated into quantitative terms of emissions.[41]

In theory, such a system of international tradable permits—if implemented only for the industrialized countries (as directly regulated under the Kyoto Protocol)—could reduce costs by 50 percent; and if such a system included major developing countries, costs could be lowered to 25 percent of what they otherwise would be.[42] In an emissions permit–trading system, sources that have low costs of control have an incentive to take on added reductions, so that they can sell their excess permits to sources that face relatively high control costs and would hence wish to reduce their control efforts.[43] An undisputed attraction—in theory—of an international trading approach is that the equilibrium allocation of permits (that is, the post-trading permit allocation), the market-determined permit price, and the aggregate costs of abatement are independent of the initial allocation of permits among countries. However, this is only true as long as particularly perverse types of transaction costs are not prevalent[44] and individual parties—be they nations or firms—do not have market power. The latter concern is a significant and real one in the Kyoto context.[45] In any event, the initial allocation can be highly significant distributionally, implying possibly massive wealth transfers. Essentially, it is in this way that a permit system can be used to address cost-effectiveness and distributional equity.

If an international trading system is used, it must be designed to facilitate integration with domestic policies that nations use to achieve their respective domestic targets.[46] In the extreme, if all countries use domestic tradable permit systems to meet their national targets (that is, allocate shares from the international permit system to private domestic parties), then an international system can—in theory—be cost-effective. But if some countries use nontrading approaches, such as greenhouse gas taxes or fixed-quantity standards—which seems likely—cost minimization is not ensured.[47] Thus, individual nations' choices of domestic policy instruments to meet their targets can substantially limit the cost-saving potential of an international trading program. In this realm, a trade-off exists between the degree of domestic sovereignty and the degree of cost-effectiveness.

Not long ago, most observers would have predicted that few, if any, European countries would employ tradable permit systems, given the European Union's strenuous opposition to such approaches dating to back to the time of the Kyoto Protocol. But the EU has now launched its own continent-wide trading system.[48] Furthermore, by the time of the COPs in Bonn (summer 2001) and Marrakech (fall 2001**)**, China and the G-77 (the coalition of developing nations) had, in effect, dropped their opposition to international emissions trading. Combined with the strong U.S. preference for trading, these realities represent important political arguments for this element of a future international climate policy architecture.

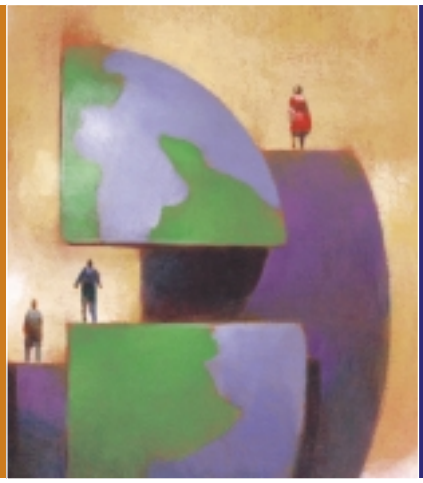
International permit trading thus remains a promising approach to achieving global greenhouse targets, despite the challenge that any program must be integrated carefully with domestic policies. It is probably fair to state that the more one studies international tradable permit systems to address global climate change, the more one comes to believe that this is the worst possible approach—except, of course, for all the others. This conundrum brings to mind Winston Churchill's famous observation: "It has been said that

democracy is the worst form of government, except all those other forms that have been tried from time to time."[49]

Conclusion

The three-part global climate policy architecture outlined above can be viewed either as a follow-up to or as a substitute for the Kyoto Protocol and builds upon the UN Framework Convention on Climate Change. For such an approach to work, key nations have to be involved, including major developing countries through the use of economic trigger mechanisms such as growth targets. In addition, cost-effective time paths of targets are required: firm, but moderate in the short term, and in the long term, much more stringent and flexible. Finally, market-based policy instruments ought to be part of the package, whether emissions trading, carbon taxes, or hybrids of the two.

This overall approach can be made scientifically sound, economically rational, and politically pragmatic. There is no denying that the challenges facing adoption and successful implementation of this type of climate policy architecture are significant, but they need not be insurmountable, and they are not necessarily any greater than the challenges facing other approaches to the threat of global climate change.



The challenges facing successful implementation are significant, but they need not be insurmountable.

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NOTES

1. Article 25 of the Kyoto Protocol states that the agreement will enter into force 90 days after the date on which it has been ratified by at least 55 Parties to the Framework Convention on Climate Change, including Annex I countries accounting for at least 55 percent of total 1990 carbon dioxide emissions by that set of countries. Annex I (to the Framework Convention) is a list of industrialized nations plus economies in transition. The Kyoto Protocol designates the countries with emissions commitments as Annex B countries. With only a few exceptions, the set of countries with Annex B commitments is identical to the set of Annex I countries in the Framework Convention. United Nations, "The Kyoto Protocol to the Convention on Climate Change," 1997; and United Nations, "United Nations Framework Convention on Climate Change," 1992.

2. Previously, there was some question whether Canada would decline to ratify the agreement. This would have cut the emissions share to less than 59 percent.

3. On 29 September 2003, Russian President Vladimir Putin refused to commit his country to ratification of the Kyoto Protocol. S. B. Glasser, "Russian Stance Leaves Fate of Global Warming Pact in Doubt," The Washington Post, 30 September 2003. On 2 December 2003, senior Russian officials indicated that Russia was unlikely to ratify the agreement. S. L. Myers and A. C. Revkin, "Russian to Reject Pact on Climate, Putin Aide Says," The New York Times, 3 December 2003. However, in May 2004, Putin changed tack and said Russia might approve it—and by late September he and the appropriate ministers had indeed approved it and sent it to the Duma (Russia's lower house) for ratification. Russia officially ratified 4 November. "Putin Clears Way for Kyoto Treaty," BBC News, 8 November 2004, http://news.bbc.co.uk/1/hi/world/europe/3985669.stm.

4. W. J. McKibbin and P. J. Wilcoxen, "Estimates of the Costs of Kyoto: Marrakesh versus the McKibbin-Wilcoxen Blueprint," *Energy Policy* 32, no. 4 (2004): 467–79.

5. Carbon dioxide (CO_2) is the primary anthropogenic driver of climate change. Other important anthropogenic greenhouse gases are methane (CH_4), nitrous oxide (N_2O), and various halocarbons. R. T. Watson, ed., *Climate Change 2001: Synthesis Report. Contributions of Working Group I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK: Cambridge University Press, 2001).

6. The original Kyoto Protocol—if extended to the year 2050—would lead to a 13 percent emissions reduction by that year, relative to 1990 emissions. Without the United States, this version would have led to a 3–5 percent emissions reduction worldwide. With the new rules, the anticipated aggregate emissions reduction for the year 2050 will be only 1–2 percent, well within the bounds of prediction error. See, for example C. Böhringer, "Climate Policies from Kyoto to Bonn: From Little to Nothing?" *The Energy Journal* 23, no. 2 (2002): 61–71.

7. Watson, note 5 above. Also, for a survey of the risks of global climate change, see J. P. Holdren, "Environmental Change and the Human Condition," *Bulletin of the American Academy of Arts and Sciences*, Fall 2003, 24–31.

8. J. F. Shogren and M. A. Toman, "Climate Change Policy," in P. R. Portney and R. N. Stavins, eds., *Public Policies for Environmental Protection, Second Edition* (Washington, DC: Resources for the Future (RFF), 2000), 125–68; and C. D. Kolstad and M. Toman, "The Economics of Climate Policy," Discussion Paper 00-40REV (Washington, DC: RFF, 2001), forthcoming in K-G. Mäler and J. Vincent, *Handbook of Environmental Economics, Volume II* (Amsterdam: Elsevier Science). For examinations of dynamically efficient policies (which maximize present value net benefits), see J. Hammitt, "Evaluating Endpoints and Climate Policy: Atmospheric Stabilization, Benefit-Cost Analysis, and Near-Term Greenhouse Gas Emissions," *Climatic Change* 41, no. 3–4 (1999): 447–68; and W. McKibbin and P. Wilcoxen, "The Role of Economics in Climate Change Policy," *Journal of Economic Perspectives* 16, no. 2

(2002): 107–29.

9. Given the global commons nature of the climate problem, a multinational—if not fully global—approach is required. A truly efficient climate change agreement would secure full participation by all countries, with each and every country mitigating its emissions to the point where its own marginal abatement costs equaled the sum of marginal benefits globally. But taking the behavior of other countries as given, each country can do better by mitigating only up to the point where its own marginal benefit equals its marginal cost. As long as global marginal benefits exceed every nation's own marginal benefits, countries will either want to avoid participating or avoid complying fully if they do participate. Successful international cooperation must change these incentives. See S. Barrett and R. N. Stavins, "Increasing Participation and Compliance in International Climate Change Agreements," *International Environmental Agreements: Politics, Law and Economics* 3, no. 4 (2003): 349–76.

10. United Nations (1992), note 1 above, Article 3, "Principles," page 9.

11. The general importance of focusing on policy "architecture" and institutions in the global climate domain was first noted in R. Schmalensee, "Greenhouse Policy Architecture and Institutions," in W. D. Nordhaus, ed., *Economics and Policy Issues in Climate Change* (Washington, DC: RFF, 1998), 137–58. See also D. G. Victor and J. E. Salt, "Keeping the Climate Treaty Relevant," *Nature*, 26 January 1995, 280–82; R. N. Stavins, "Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?" *The University of Chicago Legal Forum* 1997: 293–329; and D. B. Sandalow and I. A. Bowles, "Fundamentals of Treaty-Making on Climate Change," *Science*, 8 June 2001, 1839–40.

12. For a summary of critiques of the Kyoto Protocol and alternatives that have been proposed, see J. E. Aldy, S. Barrett, and R. N. Stavins, "Thirteen Plus One: A Comparison of Global Climate Policy Architectures," *Climate Policy* 3, no. 4 (2003): 373–97.

13. A. Michaelowa, "Global Warming Policy," *Journal of Economic Perspectives* 17, no. 3 (2003): 204–05.

14. McKibbin and Wilcoxen, note 8 above; and Barrett and Stavins, note 9 above.

15. See, for example D. G. Victor, *The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming* (Princeton, NJ: Princeton University Press, 2001); R. Cooper, "The Kyoto Protocol: A Flawed Concept," FEEM Working Paper No. 52.2001, July 2001, http://ssrn.com/abstract=278536; McKibbin and Wilcoxen, note 8 above; and McKibbin and Wilcoxen, note 4 above.

16. See, for example M. Grubb, "The Economics of the Kyoto Protocol," *World Economics* 4, no. 3 (2003): 143–89; and Michaelowa, note 13 above.

17. Eileen Claussen, president of the Pew Center on Global Climate Change, wrote, "Yet whether or not the Protocol enters into force, the same fundamental challenge remains: engaging all countries that are major emitters of greenhouse gases in a common long-term effort. We need a durable strategy that can take us beyond Kyoto." E. Claussen, "Forward," in E. Diringer, ed., *Beyond Kyoto: Advancing the International Effort Against Climate Change*, (Arlington, VA: Pew Center on Global Climate Change, December 2003), ii.

18. See for example N. Nakićenović and R. Swart, eds., *Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios* (Cambridge, UK: Cambridge University Press, 2000); and I. Pies and G. Schröder, *Causes and Consequences of Global Warming: How Rational is Our Policy on Climate Change?* (Munich: Policy Consult, 2002).

19. Watson, note 5 above.

20. As the comparative advantage in the production of carbon-intensive goods and services increases outside the coalition of participating countries, then production of such goods and services increases in those non-coalition countries, thereby increasing carbon dioxide emissions. This is the well-known phenomenon of "emissions leakage," brought about through international market forces. Even if an agreement were restricted to the industrialized counties, as under the Kyoto Protocol, such emissions leakage can be significant, with rates ranging from 5 percent to 34 percent for individual countries if they were required to meet their targets domestically; international emissions trading might reduce the leakage rates by half. S. V. Paltsev, "The Kyoto Protocol: Regional and Sectoral Contributions to the Carbon Leakage," *The Energy Journal* 22, no. 4 (2001): 53–79.

21. It is an empirical reality that with most pollutants, as countries become more wealthy beyond some threshold level of wealth, their pollution emissions cease to increase and instead decrease, partly as a function of endogenous domestic environmental policy initiatives, exhibiting the so-called environmental Kuznets curve, which economists Gene Grossman and Alan Krueger found peaked at per capita income levels below $8,000 (G. Grossman and A. Krueger, "Economic Growth and the Environment," *Quarterly Journal of Economics* 110, no. 2 (1995): 353–77). Grossman and Krueger did not examine CO_2 emissions. Subsequent studies that did so estimated turning points of $10,000 per capita income (R. Schmalensee, T. M. Stoker, and R. A. Judson, "World Carbon Dioxide Emissions: 1950–2050," *Review of Economics and Statistics* 80, no. 1 (1998): 15–27); $14,000 (L. A. Cave, and G. C. Blomquist, "The Environmental Kuznets Curve and the Kyoto Protocol: A Study of Greenhouse Gases and Economic Development," paper presented at the annual meeting of the Southern Economic Association, San Antonio, Texas, 21–23 November 2003); $25,000 (M. A. Cole, A. J. Rayner, and J. M. Bates, "The Environmental Kuznets Curve: An Empirical Analysis," *Environment and Development Economics* 2, no. 4 (1997): 401–16); or higher, but the focus in each of those studies was per capita CO_2 emissions, not aggregate emissions.

22. *Clean Air Act of 1990*, Public Law 101-549, 15 November 1990, 101st Congress, 2nd session. Accessible via http://www.epa.gov/oar/caa/contents.html.

23. This is a natural extension of the pattern of target allocation present in the Kyoto Protocol. The extension is from the industrialized world to the developing world and from the cross-sectional dimension to the temporal dimension. The Kyoto Protocol's targets already exhibit some degree of positive correlation between national wealth (in particular, gross domestic product (GDP) per capita) and the degree of targeted emissions reduction. A Brookings Institution report found that the Kyoto targets exhibit an "income elasticity of reductions" of 0.10, that is, for a 10 percent increase in per-capita GDP, the targets—on average—become about one percent more stringent. On this, and other aspects of growth targets, see J. Frankel, "Greenhouse Gas Emissions," *Policy Brief No. 52* (Washington, DC: Brookings Institution, June 1999); and J. Frankel, "You're Getting Warmer: The Most Feasible Path for Addressing Global Climate Change Does Run Through Kyoto," working paper, 25 June 2002, prepared for M. Tamborra and J. Maxwell, eds., *Trade and the Environment in the Perspective of the EU Enlargement* (Cheltenham, UK: Edward Elgar Publishers, forthcoming). In 1999, the Argentine government offered to take on an emissions commitment indexed to its economic growth. An analysis is provided in R. Lutter, "Developing Countries' Greenhouse Emissions: Uncertainty and Implications for Participation in the Kyoto Protocol," *The Energy Journal* 21, no. 4 (2000): 93–120.

24. For that matter, the short-term targets for developing countries could be set at emissions levels that are above business-as-usual (BAU) levels, although such headroom has been denigrated as "hot air" in the case of Russia's target in the Kyoto Protocol. If combined with an international trading program (see page 27), this would provide a direct economic incentive (subsidy) for developing-country participation.

25. J. E. Aldy, R. Baron, and L. Tubiana. "Addressing Cost: The Political Economy of Climate Change,"

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in Elliot Diringer, ed., *Beyond Kyoto: Advancing the International Effort Against Climate Change* (Arlington, VA: Pew Center on Global Climate Change, December 2003) 85–110.

26. If provision is not made for growth targets or some other mechanism that includes developing countries at low or no cost to them, then analysis inevitably points to a trade-off between cost-effectiveness (or efficiency) and distributional equity. For a recent example of this phenomenon, see T. Sugiyama and L. Deshun, "Must Developing Countries Commit [to] Quantified Targets? Time Flexibility and Equity in Climate Change Mitigation," *Energy Policy* 32, no. 5 (2004): 697–704.

27. This contrasts dramatically with the situation in Europe and elsewhere. Emissions of CO_2 from the United Kingdom, Germany, and Russia fell significantly subsequent to 1990 (the Kyoto Protocol's baseline year) and for reasons having nothing to do with climate change or other environmental policy. It is well known that emissions fell in the United Kingdom because of structural changes in the domestic coal industry initiated by Prime Minister Margaret Thatcher's government (1979–1990), that emissions fell in Germany because reunification led to the closure of energy-inefficient plants in the former East Germany, and that emissions fell in Russia because its economic collapse in the 1990s. McKibbin and Wilcoxen, note 8 above. Importantly, it has been estimated that 80 percent of the European Union's CO_2 reductions under the Kyoto Protocol will be achieved by two countries—Germany and the United Kingdom, facilitated via the EU bubble that is part of the protocol. See M. S. Andersen, "Regulation or Coordination: European Climate Policy Between Scylla and Charybdis," paper presented at 10th Symposium of the Egon Sohmen Foundation, "Climate Protection and Emissions Trading—U.S. and European Views," Dresden, Germany, 25–26 October 2002. These factors help to explain the very different perspectives on the Kyoto Protocol held by Europeans and Americans, but other historical phenomena are also at work. On this, see for example R. Kagan, "Power and Weakness," *PolicyReview Online*, June/July 2002, http://www.policyreview.org/JUN02/kagan.html (accessed 12 October 2004).

28. Real U.S. GDP increased from $6.71 trillion in 1990 to $9.19 trillion in 2000. U.S. Council of Economic Advisers, *Economic Report of the President* (Washington, DC: U.S. Government Printing Office, 2003). U.S. carbon emissions increased by 12 percent (165 million metric tons) between 1990 and 1999, whereas Western European emissions increased by 1 percent (9 million metric tons) over the same period. McKibbin and Wilcoxen, note 8 above.

29. See Frankel (2002), note 23 above.

30. L. H. Goulder and S. H. Schneider, "Induced Technological Change and the Attractiveness of CO_2 Abatement Policies," *Resource and Energy Economics* 21, no. 3–4 (1999): 211–53; A. B. Jaffe, R. G. Newell, and R. N. Stavins, "Energy-Efficient Technologies and Climate Change Policies: Issues and Evidence," *Climate Issue Brief No. 19* (Washington, DC: RFF, December 1999), reprinted in M. A. Toman, ed., *Climate Change Economics and Policy* (Washington, DC: RFF, 2001), 171–81; and J. Pershing and F. Tudela, "A Long-Term Target: Framing the Climate Effort," in E. Diringer, ed., *Beyond Kyoto: Advancing the International Effort Against Climate Change* (Arlington, VA: Pew Center on Global Climate Change, December 2003), 11–36. The longer-term targets should be flexible, because there is considerable uncertainty throughout the policy- economics-biophysical system, some of which will be resolved over time. See, for example R. G. Richels, A. S. Manne, and T. M. L. Wigley, "Moving Beyond Concentrations—The Challenge of Limiting Temperature Change," AEI-Brookings Joint Center working paper no. 04-11 (AEI-Brookings Joint Center, Washington, DC, 2004).

31. For a broader survey of the relationship between technological change and the environment, see A. B. Jaffe, R. G. Newell, and R. N. Stavins, "Technological Change and the Environment," in K-G. Mäler and J. Vincent, eds., *Handbook of Environmental Economics, Volume I*, 461–516 (Amsterdam: Elsevier Science, 2003).

32. For an analysis of the implications of combining such an intertemporal pattern of targets with gradual expansion of the coalition of nations that take on targets, see M. G. J. Den Elzen, "Exploring Climate Regimes for Differentiation of Future Commitments to Stabilise Greenhouse Gas Concentrations," *Integrated Assessment* 3, no. 2 (2002): 343–59.

33. T. Wigley, R. Richels, and J. Edmonds, "Economic and Environmental Choices in the Stabilization of Atmospheric CO_2 Concentrations," *Nature*, 18 January 1996, 240–43; and A. Manne and R. Richels, *On Stabilizing CO_2 Concentrations—Cost-Effective Emission Reduction Strategies* (Stanford, CA: Stanford University and Electric Power Research Institute, April 1997). For the global goal—often discussed—of stabilizing atmospheric concentrations of CO_2 at twice preindustrial levels (that is, approximately 550 parts per million), in Wigley, Richels, and Edmonds, it was estimated that the cost-effective time path of emissions would involve global emissions peaking in 2030. In Manne and Richels, it was found that severe emission reductions should take place only in the second half of the twenty-first century.

34. Stavins, note 11 above.

35. R. N. Stavins, "Experience with Market-Based Environmental Policy Instruments," in K-G. Mäler and J. Vincent, *Handbook of Environmental Economics, Volume I*, (Amsterdam: Elsevier Science, 2003), 355–435.

36. R. Schmalensee, P. L. Joskow, D. Ellerman, J-P. Montero, and E. M. Bailey, "An Interim Evaluation of Sulfur Dioxide Emissions Trading," *Journal of Economic Perspectives* 12, no. 3 (1998): 53–68; R. N. Stavins, "What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading," *Journal of Economic Perspectives*, 12, no. 3 (1998): 69–88; and D. Ellerman, P. Joskow, R. Schmalensee, J-P. Montero, and E. Bailey, *Markets for Clean Air: The U.S. Acid Rain Program* (New York: Cambridge University Press, 2000).

37. It is not necessary that the (upstream) level of compliance be the same as the (possibly downstream) level of initial allocation.

38. Kolstad and Toman, note 8 above; and McKibbin and Wilcoxen, note 8 above. Norway introduced a carbon tax in 1991. Despite its considerable magnitude and consequent induced increases in fuel prices, impacts on CO_2 emissions were modest, in part because of extensive tax exemptions. A. Bruvoll and B. M. Larsen, "Greenhouse Gas Emissions in Norway: Do Carbon Taxes Work?" *Energy Policy* 32, no. 4 (2004): 493–505.

39. M. J. Roberts and M. Spence, "Effluent Charges and Licenses under Uncertainty," *Journal of Public Economics* 5, no. 3–4 (1976): 193–208; R. J. Kopp, R. D. Morgenstern, W. A. Pizer, and M. A. Toman, "A Proposal for Credible Early Action in US Climate Policy," in K. L. Brockmann and M. Stonzik, eds., *Flexible Mechanisms for Efficient Climate Policy: Cost Saving Policies and Business Opportunities* (Heidelberg, Germany: Physica-Verlag, 2000); W. A. Pizer, "Combining Price and Quantity Controls to Mitigate Global Climate Change," *Journal of Public Economics* 85, no. 3 (2002): 409–34; and McKibbin and Wilcoxen, note 8 above.

40. For a description of the origin and evolution of the concept in climate policy deliberations, an assessment of its potential application as a domestic policy instrument and an evaluation of potential problems it would present if adopted as an international policy instrument, see H. D. Jacoby and A. D. Ellerman, "The Safety Valve and Climate Policy," *Energy Policy* 32, no. 4 (2004): 481–91.

41. United Nations (1997), note 1 above, Article 17.

42. J. Edmonds, S. H. Kim, C. N. McCracken, R. D. Sands, and M. A. Wise, *Return to 1990: The Cost of Mitigating United States Carbon Emissions in the Post-2000 Period* (Washington, DC: Pacific Northwest National Laboratory, operated by Battelle Memorial Institute, October 1997). Others have argued in favor of an international tax regime. See for example R. Cooper, "Toward a Real Treaty on Global Warming," *Foreign Affairs* 77, no. 2 (1998): 66–79; McKibbin and Wilcoxen, note 8 above; 2004; Pizer, note 39 above; and R. G. Newell and W. A. Pizer, "Regulating Stock Externalities Under Uncertainty," *Journal of Environmental Economics and Management* 45, no. 2, supplement 1 (2003): 416–32.

43. For more information on tradable permit systems, see for example, J. B. Hockenstein, R. N. Stavins, and B. W. Whitehead, "Crafting the Next Generation of Market-Based Environmental Tools," *Environment*, May 1997, 12–20 and 30–33.

44. R. N. Stavins, "Transaction Costs and Tradeable Permits," *Journal of Environmental Economics and Management* 29, no. 2 (1995): 133–48.

45. If, for example, the majority of excess permits (allowable emissions in excess of BAU emissions, or so-called "hot air") is found in a relatively small number of nations in Central and Eastern Europe and the former Soviet Union, then the possibility of collusion among such sellers becomes quite likely. A. Manne and R. Richels, "U.S. Rejection of the Kyoto Protocol: The Impact on Compliance Costs and CO_2 Emissions." *Energy Policy* 32, no. 4 (2004): 447–54. Also see U. Springer and M. Varilek, "Estimating the Price of Tradable Permits for Greenhouse Gas Emissions in 2008–12," *Energy Policy* 32, no. 5 (2004): 611–21.

46. Note that the Kyoto Protocol explicitly provides for national sovereignty regarding domestic instrument choice.

47. R. W. Hahn and R. N. Stavins, *What Has the Kyoto Protocol Wrought? The Real Architecture of International Tradable Permit Markets* (Washington, DC: American Enterprise Institute Press, 1999). In such cases, achieving the potential cost savings of international trading would require some form of project-by-project credit program, such as the Kyoto Protocol's Clean Development Mechanism (CDM). But theory and experience with such credit programs suggest that they are less likely to facilitate major cost savings because of large transaction costs, likely government participation, and the absence of a well-functioning market. For a review of the anticipated transaction costs associated with CDM and other "flexibility mechanisms" in the Kyoto Protocol, see A. Michaelowa, M. Stronzik, F. Eckermann, and A. Hunt, "Transaction Costs of the Kyoto Mechanisms," *Climate Policy* 3, no. 3 (2003): 261–78.

48. For more information on the European Union's emission trading system, see J. A. Kruger and W. A. Pizer, "Greenhouse Gas Trading In Europe: The New Grand Policy Experiment," *Environment*, November 2004, 8–23.

49. This is the most common form of the quotation. Reproduced from the House of Commons, 11 November 1947, in R. R. James, ed., *Winston S. Churchill: His Complete Speeches, 1897–1963, Volume 7* (New York: Chelsea House, 1974).

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