Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?

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Concerns about global climate change due to the greenhouse effect have led policymakers from many countries to consider ways of limiting emissions of greenhouse gases, particularly carbon dioxide (CO_2) emissions associated with the generation of energy from fossil fuels.[1] Although there still is much debate about the desirability of limiting CO_2 and other greenhouse gas emissions, it is important to consider policy instruments that may be able to meet forthcoming targets.[2] In a recent essay, Professor Schmalensee convincingly argues that "the creation of durable institutions and frameworks seems both logically prior to and more important than the choice of a particular policy program that will almost surely be viewed as too strong or too weak within a decade."[3] My primary purpose in this Article is to ex-

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[1] Since pre-industrial times, CO_2 has been the most important anthropogenic source of radiative forcing (the so-called "greenhouse effect"), accounting for about 60 percent of the forcing. Anthropogenic emissions of methane and nitrous oxide account for 15 percent and 5 percent, respectively. Other, less important greenhouse gases include tropospheric ozone (whose chemical precursors include nitrogen oxides, non-methane hydrocarbons, and carbon monoxide), halocarbons (including HCFC's and HFC's), and sulfate aerosols. J.T. Houghton, et al, eds, *Climate Change 1995: The Science of Climate Change* 1-7 (Cambridge 1996).

[2] In May 1992, at the "Earth Summit" in Rio de Janeiro, 154 nations agreed to adopt the Framework Convention on Climate Change. For a comprehensive review of the Convention, see Daniel Bodansky, *The United Nations Framework Convention on Climate Change: A Commentary*, 18 Yale J Intl L 451 (1993). In July 1996, the Undersecretary of State for Global Affairs, Timothy E. Wirth, stated at United Nations-sponsored talks in Geneva that the Clinton Administration was committed to seeking binding international limits on greenhouse gas emissions. John H. Cushman, Jr., *In Shift, U.S. Will Seek Binding World Pact to Combat Global Warming*, NY Times A6 (July 17, 1996).

[3] Richard Schmalensee, *Greenhouse Policy Architecture and Institutions* 8 (Paper Presented for NBER Conference "Economics and Policy Issues in Global Warming: An

plore frameworks and instruments that individual nations and groups of nations can adopt and to achieve goals that may be specified by future "policy programs." This exploration strongly reaffirms that institutional dimensions of the global climate change policy problem are exceptionally important.

I begin—in Part I of this Article—by considering some criteria for assessing policy instruments and by describing the major alternative instruments available. In Parts II and III, respectively, I review conventional regulatory and market-based instruments. In Part IV, I focus on implementation issues; in Part V, I provide a comparative assessment of instruments; and in Part VI, I offer some conclusions.

I. THE MENU OF POLICY INSTRUMENTS

Two distinct categories of policy instruments are pertinent to global climate change. First, domestic policy instruments seek to enable individual nations to achieve their specific targets or goals. Second, international (bilateral, multilateral, or global) instruments can be employed jointly by groups of nations.

By necessity, I investigate both domestic and international instruments. While national environmental policy actions are prevalent, we are much less familiar with successful environmental initiatives at the international level. The "exceptions that may prove the rule" include the successful agreements for stratospheric ozone and the somewhat less successful international whaling agreements. In the case of global climate change, the challenges are significantly greater than either of those experiences might suggest.

Stringent climate change policies will be adopted by individual nations only insofar as those nations perceive that positive net benefits—including international transfers—will be forthcoming.[4] This general point has been made in the starkest terms by Professors Nordhaus and Yang: "It is single nations, not the United Nations, that determine energy and environmental policy, so any grand design to slow global warming must be translated into national measures."[5] On the other hand, there is little doubt

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Assessment of the Intergovernmental Panel Report," 1996).

[4] Geoffrey Heal, *Formation of International Environmental Agreements*, in Carlo Carraro, ed, *Trade, Innovation, Environment* 301 (Kluwer 1994); Carlo Carraro and Domenico Siniscalco, *Strategies for the International Protection of the Environment*, 52 J Pub Econ 309, 323-28 (1993).

[5] William D. Nordhaus and Zili Yang, *A Regional Dynamic General-Equilibrium*

that successful policies to address this truly global environmental problem will require the adoption of international agreements. Hence, both domestic and international policy instruments must be considered.

A. Criteria for Instrument Choice

From an economic perspective, the first candidate criterion for instrument assessment should probably be relative *efficiency*, or the degree to which instruments are capable of maximizing net benefits.[6] But the efficiency criterion can be problematic, because it requires not only knowledge of the costs of abatement, but knowledge of the benefits of abatement. And the latter requires an understanding of both the physical consequences of climate change and the economic valuation of those consequences. This information burden is overwhelming in many circumstances, as it surely is in the current global climate context. Instead, the less ambitious criterion of *cost-effectiveness* has often been used. This criterion entails seeking a policy instrument to achieve a given target or goal (which may or may not represent the efficient level of control) at minimum aggregate cost of abatement.[7]

Regardless of whether one employs the efficiency criterion or the cost-effectiveness criterion, costs must be measured correctly. This is easier said than done, since the full costs of environmental regulation are mutifaceted (see Table 1).[8] Many policymakers and much of the general public would identify the on-budget costs to government of administering environmental laws and regulations as *the* cost of environmental regulation. Most analysts, however, would consider the direct capital and operating

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Model of Alternative Climate-Change Strategies, 86 Am Econ Rev 741, 742 (1996).

[6] The "efficient" level of abatement is the level at which the difference between benefits and costs is maximized. If the benefit and cost functions are shaped as they are typically believed to be, then this efficient level occurs at the point where marginal benefits equal marginal costs. William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy* 35-56 (Cambridge 1988).

[7] The "cost-effective" allocation of the pollution-control burden among sources is that allocation for which all sources are controlling at the same marginal abatement cost. Id.

[8] For a useful decomposition and analysis of the full costs of environmental regulation, see Richard Schmalensee, *The Costs of Environmental Protection*, in American Council for Capital Formation Center for Policy Research, *Balancing Economic Growth & Environmental Goals* 55 (ACCF 1994). Conceptually, the cost of an environmental regulation is equal to the change in consumer and producer surpluses due directly to the regulation and due to any price or income changes that also result from the regulation. Maureen L. Cropper and Wallace E. Oates, *Environmental Economics: A Survey*, 30 J Econ Literature 675, 721 (1992).

expenditure associated with regulatory compliance to be the fundamental element of the overall cost of regulation.[9] Additional direct costs include legal and other transaction costs, the effects of refocused management attention, and disrupted production. "Negative costs" (in other words, non-environmental benefits) of environmental regulation, including the productivity impacts of a cleaner environment and the potential effects on innovations of regulation should, in theory, also be considered. General equilibrium effects associated with product substitution, discouraged investment, and retarded innovation constitute another important layer of costs, as do the transition costs of real-world economies responding over time to regulatory changes. Finally, some social impacts are given substantial weight in political forums, including those on local employment levels and economic security.[10] Thus, correctly assessing cost effectiveness is by no means a trivial task.

Other criteria can also be very important in comparing policy instruments. Individual nations will inevitably choose their own sets of criteria (explicitly or implicitly) to distinguish among alternative policy instruments. Although these chosen criteria will reflect individual socioeconomic and cultural contexts, in many cases, nations will consider such factors as the probability that their environmental goal will be achieved; efficiency or cost-effectiveness; dynamic incentives for innovation and the diffusion of improved technologies; flexibility and adaptability to exogenous changes in technology, resource use, and consumer tastes; distributional equity;[11] and feasibility in terms of political imple-

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[9] These direct costs are typically borne by the private sector, although a substantial share of compliance costs for a minority of environmental regulations falls on government rather than on private firms. An example of the latter is the regulation of contaminants in drinking water under the U.S. Safe Drinking Water Act. 42 USC § 300f et seq (1994 & Supp 1996).

[10] For a fuller explanation of these different categories of the costs of environmental protection, see Adam B. Jaffe, et al, *Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?*, 33 J Econ Literature 132 (1995).

[11] It is widely recognized that issues of distributional equity—both among nations and intertemporally—are central concerns affecting the identification of the time path of appropriate aggregate levels of greenhouse policy action and the appropriate distribution of that burden among the nations of the world. In particular, because of the significant coal resources of China and India and because of their relatively high rates of economic and population growth, it is frequently suggested that massive resource transfers from the industrialized countries to some developing nations will be a necessary ingredient for a successful global greenhouse agreement. Hence, in the present context, the use of a distributional equity criterion essentially means that we need to ask to what degree alternative policy instruments can facilitate such transfers. I address this in the case of "international policy instruments" below, in Part II.C. The evidence from existing institu-

mentation and administration. Several of these criteria—including efficiency, cost-effectiveness, dynamic effects on technological change, distributional equity, and political feasibility—are particularly important in the climate change context.

B. Domestic Policy Instruments

The most common approach, which virtually all countries of the world use to address environmental problems, has been to set standards and to directly regulate the activities of firms and individuals. This approach involves so-called *command-and-control* instruments (see Table 2). Conceivably, such an approach could be used in the greenhouse context as well. By mandating standards, governments could ban or attempt to alter the use of materials and equipment considered harmful. For example, governments could apply standards to the energy efficiency of buildings, to fuel use by motor vehicles, to the energy efficiency of household durables, and to fuel content.

In contrast, *market-based* instruments have recently been employed by governments to alter price signals in order to ensure that polluters face direct cost incentives to control emissions. The primary market-based instruments to be considered for greenhouse management are taxes and tradeable permits. Under a true emissions tax, a charge is imposed per unit of pollutant discharge.[12] A closely related application would be to tax the carbon content of fossil fuels. As an alternative, under an emission trading scheme, sources receive permits to emit, and can then buy and sell these permits among one another.[13] Because these market-based instruments induce decisionmaking units (typically firms) to choose control levels at which their marginal abatement costs are the same, overall pollution abatement costs

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tional experience is not promising. Barbara Connolly, *Increments for the Earth: The Politics of Environmental Aid*, in Robert O. Keohane and Marc A. Levy, eds, *Institutions for Environmental Aid: Pitfalls and Promise* 327 (MIT 1996).

[12] The development of the notion of a corrective tax on pollution is generally credited to Arthur C. Pigou, *The Economics of Welfare* 28-30 (Macmillan 4th ed 1938).

[13] The initial proposal for a system of tradeable permits to control pollution was by John H. Dales, *Pollution, Property, and Prices* 77-100 (Toronto 1968), and first formalized by W. David Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J Econ Theory 395 (1972), although much of the literature can be traced back to R.H. Coase, *The Problem of Social Cost*, 3 J L & Econ 1, 41-44 (1960).

will, in theory, be minimized.[14] That is, market-based instruments can, in principle, be cost effective.

C. International Policy Instruments

Climate change is truly a global commons problem. Because the location of greenhouse gas emissions does not affect the global distribution of damages, free-riding problems plague unilateral or multilateral "solutions." Further, nations will not benefit proportionately from greenhouse-gas abatement policies. In fact, some countries—such as Canada and Russia—might experience no benefits from control, since they actually stand to gain from global climate change (due to the effects of increased temperatures and precipitation on agricultural production). Thus, for some countries, costs of control may exceed benefits. This means that for a voluntary international agreement to be successful, it must include a mechanism for transferring gains to countries that would otherwise not benefit from joining an agreement. This is a central challenge for any international policy instrument that seeks to allocate responsibility among nations.

It may be possible to impose uniform standards on countries participating in an international emissions-reduction agreement. It would be difficult, however, to achieve wide agreement about any large set of specific instruments, because such approaches would place severe limits on individual countries' domestic policy choices. An alternative regulatory approach would require countries to agree on fixed national emission levels. But marginal abatement costs would then vary greatly among participating countries, and total global abatement costs would thus be much greater than necessary.

Instead, some degree of aggregate cost-effectiveness could be achieved if market-based instruments were employed internationally. Four possibilities stand out. First, if countries agreed to

[14] Because the costs of controlling pollution vary greatly among and within firms, any given aggregate pollution control level can be met at minimum aggregate control cost only if pollution sources control at the same *marginal cost*, as opposed to the same *emission level*. Indeed, depending on the age and location of emission sources and available technologies, the cost of controlling a unit of a given pollutant may vary by a factor of one hundred or more among sources. Robert W. Crandall, *The Political Economy of Clean Air: Practical Constraints on White House Review*, in V. Kerry Smith, ed, *Environmental Policy under Reagan's Executive Order: The Role of Benefit-Cost Analysis* 205, 209-19 (North Carolina 1984). Such cost heterogeneity is characteristic of carbon abatement linked with fuel switching and energy-efficiency enhancement as well as carbon sequestration linked with changes in land use.

apply the same level of domestic greenhouse taxes (*harmonized domestic taxes*), marginal abatement costs would tend to be equalized among countries. Second, a *uniform international tax* on greenhouse emissions could be imposed, with total tax revenue allocated among participating countries according to a given set of rules.

A third potentially cost-effective approach would be a system of *international tradeable permits*, in particular, a system of tradeable carbon rights, the total allocation of which would reflect the overall emissions target. International permit trade would establish a market price—an implicit international tax rate—that would equate marginal abatement costs among countries. Theoretically, such permits would lead to a cost-effective solution. In the context of such an international tradeable permit scheme, participating countries would be free to choose any domestic policy instruments that could achieve their permit-determined targets. For example, they might employ domestic tradeable permits, domestic taxes, or conventional regulations.[15]

A fourth market-based instrument, closely related to the concept of international tradeable permits, is *joint implementation*, which is essentially bilateral trading arranged on an ad hoc basis. This policy mechanism, which I also consider below, has received considerable attention in recent years from policy makers and others.

All of these international instruments require us to remember that no world government—or any other institution—appears capable of administering, monitoring, and enforcing truly international instruments.[16] We return to that critical issue later.

II. REGULATIONS, VOLUNTARY AGREEMENTS, AND OTHER NON-MARKET-BASED INSTRUMENTS

The conventional approach to environmental policy in virtually all countries has been to employ policy instruments in the form of uniform standards or voluntary programs to improve the environment.[17] Both approaches are prominent in both current

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[15] As I discuss later, with a domestic tax there is uncertainty regarding the quantity of emissions reductions that will be induced. Given this caveat, any of a variety of price or quantity instruments can be used domestically if a tradeable permit system is used to allocate targets internationally.

[16] Richard Schmalensee, *Greenhouse Policy Architecture and Institutions* (Paper Presented for NBER Conference "Economics and Policy Issues in Global Warming: An Assessment of the Intergovernmental Panel Report," 1996).

[17] Organization for Economic Cooperation and Development, *Economic Instruments*

and proposed policy measures to address global climate change.[18]

A. Uniform Technology and Performance Standards

Conventional regulatory standards (often described as "command-and-control" regulations) can loosely be categorized as either *technology-based* or *performance-based*, although the distinction is often not clear. Technology-based (or design) standards typically require specified equipment, processes, or procedures. In the context of climate change policy, such standards might require, for example, that firms use particular types of energy-efficient motors, combustion processes, or landfill gas collection technologies.

Performance-based standards are more flexible than technology-based standards in that they specify allowable levels of pollutant emissions or polluting activities but permit regulated entities to choose the way in which they will achieve these levels. Examples of uniform performance standards for greenhouse gas abatement include maximum allowable levels of CO_2 emissions from combustion or maximum levels of methane emissions from landfills. Uniform standards can also take the form of outright bans of certain products or processes, such as the banning of aerosol sprays that contain ozone-depleting substances.[19]

Although uniform technology and performance standards can be effective in achieving established environmental goals and standards, they tend to lead to non-cost-effective outcomes in which firms use unduly expensive means to control pollution.[20] Nonetheless, because performance standards give economic

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for Environmental Protection 31-33 (OECD 1989); Robert W. Hahn and Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea?*, 18 Ecol L Q 1, 5-7 (1991); William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy* 15a (Cambridge 1988).

[18] In the case of the United States, for example, see U.S. Environmental Protection Agency, *Policy Options for Stabilizing Global Climate* (Draft Report to Congress VIII-1-87, February 1989); National Academy of Sciences, et al, *Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base* 73-83 (National Academy 1992); and William J. Clinton and Albert Gore, Jr., *The Climate Change Action Plan* (EPA 1993).

[19] Although prohibitions may be the least flexible form of regulation, if low-cost substitutes for targeted products are available, bans can turn out to be a relatively cost-effective policy instrument.

[20] Thomas H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* 14-16 (Resources for the Future 1985); Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders*, 3 J Econ Persp 95, 96-97 (Spring 1989); Hahn and Stavins, 18 Ecol L Q at 5-7 (cited in note 17).

agents flexibility to make choices based partly on economic criteria, performance-based standards will generally be more cost-effective than technology-based standards. On the other hand, if there essentially is only one way to achieve a particular performance standard, a technology-based standard may help conserve information and administration costs.

In theory, the government could achieve a cost-effective allocation of pollution control responsibility among sources if it assigned source-specific control levels that equated marginal costs of control. But this approach would require information about the pollution control cost functions of individual firms and sources—information that governments usually lack and could obtain only at great cost, if at all.[21]

Even if the government could use conventional technology or uniform performance standards to achieve a cost-effective allocation of pollution control at present, such standards would not provide *dynamic* incentives for the development, adoption, and diffusion of environmentally and economically superior control technologies.[22] Once a performance standard has been satisfied, an individual firm can gain little from developing or adopting cleaner technology. In addition, regulated firms may fear that adopting a superior technology will cause performance standards to be tightened. Technology standards are even worse than performance standards in inhibiting innovation, since, by their very

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[21] Source-specific or firm-specific permit programs are one approach traditionally taken to adjust regulatory standards to individual circumstances. If pollutants exhibit highly localized effects, such an approach can have distinct advantages over a tax or permit system, but global climate change is obviously *not* a localized problem.

[22] Performance and technology standards can be designed to be "technology forcing," mandating performance levels that are not currently viewed as technologically feasible or mandating technologies that are not fully developed. Eberhard Jochem and Edelgard Gruber, *Obstacles to Rational Electricity Use and Measures to Alleviate Them*, Energy Pol 340, 348 (May 1990). But while regulators can typically assume that *some* amount of improvement over existing technology will always be feasible, it is impossible to know just how much. Standards must either be made unambitious or run the risk of being unachievable. A. Myrick Freeman III and Robert H. Haveman, *Water Pollution Control, River Basin Authorities, and Economic Incentives: Some Current Policy Issues*, 19 Pub Pol 53 (1971). See also Adam B. Jaffe and Robert N. Stavins, *Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion*, 29 J Envir Econ & Mgmt S-43 (1995); Peter Bohm and Clifford S. Russell, *Comparative Analysis of Alternative Policy Instruments*, in Allen V. Kneese and James L. Sweeney, eds, *Handbook of Natural Resource and Energy Economics* 395 (Elsevier Science 1985); Richard G. Newell, Adam B. Jaffe and Robert N. Stavins, *Environmental Policy and Technology Change: The Effect of Economic Incentives on Direct Regulation on Energy-Saving Innovation* (working paper, John F. Kennedy School of Government, Harvard University, 1996).

nature, they constrain the technological choices available, and may thereby remove all incentives to develop environmentally beneficial technologies.[23] Finally, although technology-based standards may seem to be the least cost-effective of policy instruments, alternative instruments can be relatively attractive if monitoring costs are sufficiently high.[24]

B. Voluntary Agreements

In addition to mandatory policy instruments, voluntary agreements can play significant roles in greenhouse gas reduction strategies, and the threat of mandatory government intervention may sometimes be enough to encourage voluntary agreements. Firms may try to control greenhouse gas emissions if they fear more costly mandatory controls in the absence of these voluntary reductions. This may help explain why voluntary agreements have already arisen. The vast majority of planned greenhouse gas reductions from the actions announced or expanded through the U.S. *Climate Change Action Plan*[25] were associated with voluntary initiatives aimed at increasing energy efficiency.[26]

III. MARKET BASED POLICY INSTRUMENTS

Because of the great potential costs of meeting greenhouse gas emission targets,[27] considerable attention has been given to the possible use of market-based instruments, which can offer cost-effective alternatives, provide dynamic incentives for technological change, and address concerns about distributional equity.[28] At the greatest level of abstraction, in a perfectly competi-

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[23] Under some circumstances, however, a performance standard may provide greater incentives for technological adoption than a market-based system. David A. Malueg, *Welfare Consequences of Emission Credit Trading Programs*, 18 J Envir Econ & Mgmt 66, 72-73 (1990). See also Wesley A. Magat, *The Effects of Environmental Regulation on Innovation*, 43 L & Contemp Probs 4, 17-20 (Winter-Spring 1979).

[24] For discussions of relevant enforcement issues, see Jon D. Harford, *Firm Behavior Under Imperfectly Enforceable Pollution Standards and Taxes*, 5 J Envir Econ & Mgmt 26 (1978); Hirofumi Shibata and J. Steven Winrich, *Control of Pollution when the Offended Defend Themselves*, 50 Economica 425 (1983); A. Mitchell Polinsky and Steven Shavell, *The Optimal Tradeoff between the Probability and Magnitude of Fines*, 69 Am Econ Rev 880 (1979).

[25] Clinton and Gore, *The Climate Change Action Plan* (cited in note 18).

[26] Significantly, it is now recognized that this diverse set of voluntary programs will fail to enable the United States to meet its announced targets.

[27] John P. Weyant, *Costs of Reducing Global Carbon Emissions*, 7 J Econ Persp 27, 42-43 (Fall 1993).

[28] There is extensive literature on the principles underlying the use of market-based

tive market place, an emissions tax or tradeable permit scheme would allow polluters to reduce emissions up to the point where the marginal cost of control equals the emissions tax rate or the equilibrium price of an emissions permit. Both instruments would promote dynamic efficiency, as each provides a continuous incentive for adopting better abatement technologies. This Article will consider five market-based instruments. Two are in the domestic context: carbon taxes and tradeable carbon rights. Three are international: carbon taxes, tradeable permits, and joint implementation.

A. Domestic Carbon Taxes

A carbon tax is not a perfect proxy for a tax on CO_2 emissions, because a carbon tax on fossil fuels provides an incentive to reduce the use of carbon-based fuels, but not to reduce CO_2 emissions by chemical fixation (scrubbing) and disposal. Since feasible means of the latter are severely limited,[29] however, this is not a significant defect of a carbon tax. Hence, the carbon content of primary fossil fuels would be the most practicable base for a CO_2 tax system.[30] In addition, one form of atmospheric car-

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policy instruments for greenhouse management. See, for example, Peter Bohm and Clifford S. Russell, *Comparative Analysis of Alternative Policy Instruments*, in Allen V. Kneese and James L. Sweeney, eds, *Handbook of Natural Resource and Energy Economics* 395 (Elsevier Science 1985); William J. Baumol and Wallace E. Oates, *The Theory of Environmental Policy* 177-89 (Cambridge 1988).; Robert N. Stavins, ed, *Project 88—Harnessing Market Forces to Protect Our Environment: Initiatives for the New President* (Public Policy Study Sponsored by Senators Timothy E. Wirth and John Heinz, 1988); Organization for Economic Cooperation and Development, *Economic Instruments for Environmental Protection* 88-101 (OECD 1989); Thomas H. Tietenberg, *Economic Instruments for Environmental Regulation* 6 Oxford Rev Econ Pol 17 (Spring 1990); Joshua M. Epstein and Raj Gupta, *Controlling the Greenhouse Effect: Five Global Regimes Compared* 18-32 (Brookings 1990); Rudiger Dornbusch and James M. Poterba, eds, *Global Warming: Economic Policy Responses* 52-54 (MIT 1991); Robert N. Stavins, *Project 88—Round II, Incentives for Action: Designing Market-Based Environmental Strategies* (Public Policy Study sponsored by Senators Timothy E. Wirth and John Heinz, 1991); Maureen L. Cropper and Wallace E. Oates, *Environmental Economics: A Survey*, 30 J Econ Literature 675, 689-92 (1992); and Robert W. Hahn and Robert N. Stavins, *Trading in Greenhouse Permits: A Critical Examination of Design and Implementation Issues*, in Henry Lee, ed, *Shaping National Responses to Climate Change* 177 (Island 1995).

29 C.J. Jepma, et al, *A Generic Assessment of Response Options*, in James P. Bruce, Hoesung Lee, and Erik F. Haites, eds, *Climate Change 1995: Economic and Social Dimensions of Climate Change* 225 (Cambridge 1996).

30 For further commentary on the appropriate base of a CO_2 tax, see David Pearce, *The Role of Carbon Taxes in Adjusting to Global Warming*, 101 Econ J 938, 945 (1991); Dale W. Jorgenson and Peter J. Wilcoxen, *The Economic Effects of a Carbon Tax*, in Akihivo Amano, et al, eds, *Climate Change: Policy Instruments and Their Implications* 60 (Intergovernmental Panel on Climate Change 1994); Robert Repetto, et al, *Green Fees:*

bon *removal* is quite feasible technologically: carbon sequestration through forestation and retarded deforestation. Since this approach may be competitive (on a marginal cost basis) with emissions abatement in some countries, at least at low levels of aggregate abatement,[31] policy instruments that will provide appropriate incentives for adoption of a cost-effective portfolio of both emissions reductions and sequestration increases are desirable. Carbon taxes could hence be combined with sequestration tax credits.[32]

There are a significant number of points in the "product cycle" of fossil fuels at which a carbon tax could conceivably be applied, ranging from primary fuel extraction to product and service end use. Energy generation from fossil fuels is obviously the point at which emissions occur, but there would be far fewer monitoring points and hence lower implementation costs if carbon contents were measured and if the carbon tax were applied to wholesale use. A carbon tax would reduce energy-sector CO_2 emissions more efficiently than would taxes levied on some other basis, such as energy content of fuels or the value of energy products. Indeed, simulations indicate that an energy (BTU) tax could be between 20 and 40 percent more costly, and an *ad valorem* tax two to three times more costly, than a carbon tax for equivalent reductions in emissions.[33]

The abatement achieved by a carbon tax and the economic effect of the tax will depend partly on what is done with the tax revenue. There is widespread agreement that revenue recycling

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How a Tax Shift Can Work for the Environment and the Environment 54 (World Research Institute 1992); Organization for Economic Cooperation and Development, *Climate Change: Designing a Practical Tax System* 127 (OECD 1992); Organization for Economic Cooperation and Development, *Climate Change: Designing a Tradeable Permit System* (OECD 1992); Organization for Economic Cooperation and Development, *International Economic Instruments and Climate Change* 56 (OECD 1993); Roy Boyd, Kerry Krutilla, and W. Kip Viscusi, *Energy Taxation as a Policy Instrument to Reduce CO_2 Emissions: A Net Benefit Analysis*, 29 J Envir Econ & Mgmt 1, 10-12 (1995).

[31] Robert N. Stavins, *Correlated Uncertainty and Policy Instrument Choice*, 30 J Envir Econ & Mgmt 218 (1996); Kenneth R. Richards, Robert J. Moulton, and Richard A. Birdsey, *Costs of Creating Carbon Sinks in the U.S.*, 34 Energy Conservation Mgmt 905 (1993); J.M. Callaway and Bruce McCarl, *The Economic Consequences of Substituting Carbon Payments for Crop Subsidies in U.S. Agriculture*, 7 Envir & Resource Econ 15 (1996).

[32] For economic efficiency reasons, these sequestration tax credits might take the form of a combination of taxes on deforestation and tax credits or subsidies for forestation (land-use changes). See Robert N. Stavins, *The Costs of Carbon Sequestration: A Revealed Preference Approach* 9 (Resources for the Future 1995).

[33] Jorgenson and Wilcoxen, *The Economic Effects of a Carbon Tax* (cited in note 30); Joel D. Scheraga and Neil A. Leary, *Improving the Efficiency of Policies to Reduce CO_2 Emissions*, Energy Pol 394, 397-99 (May 1992).

(that is, using revenues to lower other taxes) can significantly lower the costs of a carbon tax.[34] Some researchers have suggested, moreover, that all of the abatement costs associated with a carbon tax can be eliminated through revenue recycling in the form of cuts in taxes on labor.[35] There is an emerging consensus, however, that rejects this stronger claim.[36] Indeed, carbon and other energy-related taxes can exacerbate distortions associated with remaining taxes on investment or labor.

B. Domestic Tradeable Permits

An important theoretical attribute of a domestic tradeable permit scheme is that whatever the initial permit allocation, the final allocation after trading will be the one that minimizes the cost of reducing emissions.[37] Firms will want to buy permits if abatement costs exceed the permit price; in the opposite case, they will want to sell permits. In this way, trade will continue until all firms are indifferent between buying and selling permits, that is, between marginal abatement and additional fossil fuel use. When this state is reached, marginal abatement costs are equated, and an *ex post* allocation of permits that minimizes the costs of reducing emissions is achieved.

The most reasonable basis for a domestic tradeable permit system to control CO_2 emissions would be parallel to the carbon tax system already discussed, that is, a system of tradeable carbon rights not unlike the tradeable lead rights used in the United States in the 1980s to phase down the lead content of gasoline. A national government could issue permits to wholesale dealers in fossil fuels or producers and importers of fossil fuels and allow them to trade in a national permit market.[38] Also, as

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[34] Jorgenson and Wilcoxen, *The Economic Effects of a Carbon Tax* (cited in note 30); Lawrence H. Goulder, *Effects on Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis*, 29 J Envir Econ & Mgmt 271, 292-95 (1995).

[35] Repetto, *Green Fees* at 59-60 (cited in note 30).

[36] A. Lans Bovenberg and Ruud A. de Mooij, *Environmental Levies and Distortionary Taxation*, 84 Am Econ Rev 1085 (1994); A. Lans Bovenberg and Lawrence H. Goulder, *Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses*, 86 Am Econ Rev 985 (1996).

[37] As I discuss later, transaction costs reduce trading levels and increase abatement costs. In some cases, equilibrium permit allocations and hence aggregate control costs will be sensitive to initial permit distributions. Thus, in the presence of transaction costs, the initial distribution of permits can matter in terms of efficiency, not only in terms of equity. Robert N. Stavins, *Transaction Costs and Tradeable Permits*, 29 J Envir Econ & Mgmt 133, 146 (1995).

[38] The government could also allow permit holders to trade directly on an existing in-

with carbon tax/credit programs, tradeable permit programs could—in theory—be designed to give appropriate credit to carbon sequestration through forestation.[39]

A government might choose one of two ways to distribute permits to individual firms. First, firms can be given shares of the total permit volume, based on some historical record ("grandfathering") such as recent fossil fuel sales. Second, the government can auction permits. It is also possible to combine these two approaches. Grandfathering involves a transfer of wealth, equal to the value of the permits, to existing firms, whereas with an auction, this wealth is transferred to the government. In fact, the government would—in theory—collect revenue identical with that from a domestic tax producing the same volume of emissions abatement.

As with tax receipts, auction revenues could be used to reduce pre-existing distortionary taxes. In principle, the same issues apply, regardless of whether one uses a tax or tradeable permit scheme.[40] Like pollution taxes, tradeable permits raise the costs of produced goods relative to labor, and thereby introduce efficiency costs in labor markets.[41] This is the case for both grandfathered and auctioned permits. Some of these costs, however, can be offset when permits are auctioned and when revenues are used to reduce pre-existing distortionary taxes. When costs are offset by using revenues in this way, the government takes the rents generated by the permit program and—rather than leaving those rents in private hands—devotes them to reducing distortionary taxes.[42]

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ternational market. Alternatively, to the extent that both international permit and domestic permit markets existed for a particular country, the government could trade on the international market and set a definite or preliminary domestic limit on the volume of domestic permits for some period ahead.

[39] An interesting attribute of a tradeable permit system—whether domestic or international—is that the market prices of permits that emerge can provide exceptionally useful feedback to policymakers, since these market prices will reflect the underlying marginal abatement/sequestration cost functions of sources. Gary W. Yohe, *Personal Position on the Appropriate Policy Response to Global Change* (Prepared for ACCF Symposium at the National Press Club, Sept 11, 1996).

[40] Peter Bohm, *Government Revenue Implications of Carbon Taxes and Tradeable Carbon Permits: Efficiency Aspects* (paper presented at IIPF, 50th Congress, Cambridge, Massachusetts, Aug 22-25, 1994) ("*Government Revenue Implications*").

[41] Lawrence H. Goulder, Ian W.H. Parry, and Dallas Burtraw, *Environmental Controls, Scarcity Rents, and Pre-Existing Distributions* (paper presented at the NBER Workshop, "Public Policy.and the Environment," Cambridge, Massachusetts, July 31, 1996).

[42] Don Fullerton and Gilbert Metcalf, *A Second-Best Problem for Environmental Taxation* (paper presented at NBER workshop, "Public Policy and the Environment," Cambridge, Massachusetts, July 31, 1996).

To date, most tradeable permit systems have used perpetuities, but there are several reasons why a system of time-limited permits could be used for climate change. First, if permits are initially grandfathered, time-limited permits can reduce the anti-competitive effects of entry barriers. Second, time-limited permits can facilitate any potential future changes of emissions targets in response to new information. The government can retain ownership of permits, leasing them to firms for fixed periods.[43] Allowing permits to be banked, or allowing permits for emissions during a given period to be used at a later date, is important for both the efficiency and political acceptability of tradeable permit schemes.

In contrast with other market-based environmental policy instruments, tradeable permit schemes have been used, particularly in the United States.[44] Beginning in the 1970s, the U.S. Environmental Protection Agency (EPA) offered the option of employing variants of tradeable permits to control localized, criteria air pollutants.[45] More significantly, tradeable permit systems were used in the 1980s to accomplish the phasedown of lead in gasoline[46] and to facilitate the phasedown of ozone-depleting chlorofluorocarbons.[47] In the 1990s, they are being used to cut nationwide sulfur dioxide (SO_2) emissions by 50 percent by the year 2005,[48] to achieve ambient ozone reductions in the Northeast, and to implement stricter local air pollution controls in the Los Angeles metropolitan region.

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[43] When permits are leased by the government or when time-limited permits are auctioned by the government, the revenue implications of permit schemes approach those of taxes. This is not the case where eternal permits are auctioned by government. Bohm, *Government Revenue Implications* (cited in note 40).

[44] This is not to suggest that taxes have never been utilized in the context of environmental policies. The Superfund program, for example, is financed primarily through a tax on petroleum and chemical feedstocks. Since 1990, the United States has also levied a tax on stratospheric ozone-depleting chemicals. J. Andrew Hoerner, *Taxing Pollution*, in Elizabeth Cook, ed, *Ozone Protection in the United States* 39 (World Resources Institute 1996). For a comprehensive review of "environmental taxes" (broadly defined), see Thomas A. Barthold, *Issues in the Design of Environmental Excise Taxes*, 8 J Econ Persp 133 (Winter 1994).

[45] Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders*, 3 J Econ Persp 95, 106 (Spring 1989).

[46] Suzi Kerr and David Mare, *Efficient Regulation through Tradeable Permit Markets: The United States Lead Phasedown* (University of Maryland Working Paper 96-06, 1997).

[47] David Lee, *Trading Pollution*, in Cook, ed, *Ozone Protection in the United States* 31 (cited in note 44).

[48] U.S. Environmental Protection Agency, *1995 Compliance Results: Acid Rain Program* (Report No 430-R-96-012, 1996).

C. International Carbon Taxes

Because international action will be necessary to meet any significant global emissions target, it is important to consider international policy instruments that groups of nations (or the entire globe) can employ. One possibility is for an international agency to impose a carbon tax. The supporting agreement would have to specify tax rates as well as a formula for allocating the tax revenues. Cost-effectiveness would demand a uniform tax rate applied across all countries (assuming full participation). Reallocation of revenues need not hamper cost-effectiveness. It is unclear, however, what international agency could actually impose and enforce such a tax. A set of harmonized domestic carbon taxes offers an alternative to an international carbon tax. In this case, an agreement would stipulate that all countries should levy the same domestic carbon taxes. In either case, some experimentation could be required to set the tax rate to achieve the coalition's emissions target. The tax rate would also need to be adjusted over time as economic conditions change.

The uniformity of tax rates is necessary for cost-effectiveness, but the resulting distribution of costs may certainly not conform with principles of distributional equity. As a result, there may be calls for significant resource transfers. Under a harmonized tax system, an agreement could include fixed lump-sum payments from rich to poor countries, and under an international tax system, an agreement could specify shares of the total international tax revenues that go to participating countries.[49]

D. International Tradeable Permits

Under an international tradeable permit scheme, all coalition countries would be allocated permits for "net emissions," that is, emissions minus sequestration. A permit could define a right to a perpetuity or a right to emit a given volume over some time period. In each period, countries would be free to buy and sell permits on an international exchange. Limiting the temporal duration of permits could help lend credibility to the system by decreasing the possibility that governments would sell permits (part of a nation's wealth) to a degree that would not be honored by future governments in those same countries. Time-limited

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[49] Michael Hoel, *Harmonzization of Carbon Taxes in International Climate Agreements*, 3 Envir & Resource Econ 221 (1993).

permits could also reduce the risk of large countries gaining market power on the permit market.

Negotiations on initial permit allocations are likely to involve such criteria as gross national product (GNP), real GNP, population, land area, and dependence on fossil fuel production.[50] All criteria will have adherents, especially those with larger allocations under those criteria,[51] and several criteria may therefore need to be blended to create international consensus on emissions allocations.[52] Whatever the initial allocation, subsequent trading can lead to a cost-effective outcome if transaction costs are not significant. This potential for pursuing distributional objectives while assuring cost-effectiveness is an important attribute of the tradeable permit approach.

Countries allocated permits greater than their emission requirements could use revenue from the sale of permits to increase their imports relative to their exports,[53] while countries allocated permits less than their requirements would have to reduce imports relative to exports. In this way, a tradeable permit scheme would tend to reallocate world production; the allocation of tax revenue from an international carbon tax scheme would have similar effects.

Providing large initial permits to poor countries (for reasons of distributional equity) suggests that they would be selling permits primarily to rich countries. Because permit prices represent an implicit or explicit tax on all participating countries, the terms of trade within the coalition for countries with the same carbon intensities in production would remain unaffected. From a

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[50] For an overview, see Scott Barrett, *"Acceptable" Allocations of Tradeable Carbon Emission Entitlements in a Global Warming Treaty*, in United Nations Conference on Trade and Development, *Combating Global Warming: Study on a Global System of Tradeable Carbon Emission Entitlements* 85 (United Nations 1992); Geoffrey Bertram, *Tradeable Emission Permits and the Control of Greenhouse Gases*, 28 J Dev Stud 324 (1992); Peter Bohm and Bjorn Larsen, *Fairness in a Tradeable-Permit Treaty for Carbon Emissions Reductions in Europe and the Former Soviet Union*, 4 Envir & Resource Econ 219 (1994).

[51] For example, under an allocation system related to population levels, the big players in the market would likely be India and China, as permit sellers, and the United States and perhaps the former Soviet Union, as buyers. See Joshua M. Epstein and Raj Gupta, *Controlling the Greenhouse Effect: Five Global Regimes Compared* 20 (Brookings 1990).

[52] For example, the Canadians proposed using population and GNP combined as allocation criteria when chlorofluorocarbon ("CFC") reduction obligations were being considered in the development of the Montreal Protocol.

[53] Graciela Chichilinsky, Geoffrey Heal, and David Starrett, *International Emission Permits: Equity and Efficiency* (mimeograph, Columbia University, Nov 1993) (on file with author).

distributional point of view, poor countries would receive compensation, whereas rich countries would have to pay, first for their own emission reductions as called for by the permit price and second for permit purchases from abroad.

Inevitably, the institutional question of who would monitor and enforce such an international program seems paramount. Here it is useful to decompose the "monitoring and enforcement problem" among coalition countries into three separate issues: monitoring, enforcing violations at the margin, and maintaining an enforcing coalition.[54] First, the monitoring problem is really quite similar for different policy instruments, and it may not even be necessary to monitor. This is because an international tradeable permit system—and some other instruments—could be based on an *ex ante* demonstration of likely compliance, rather than *ex post* validation,[55] an approach that has been used successfully in the past in international economic agreements, if not environmental ones. This is not to suggest that compliance problems are trivial, only that they are not necessarily insoluble.

Thus, monitoring *per se* need not be a great obstacle, but we are still faced with the enforcement problem. Here, the tradeable permit mechanism itself can help address the challenge, since permits initially can be allocated to favor low-cost abaters, that is, permit sellers. Such an allocation can reduce the probability of marginal violations because it makes sellers vulnerable to enforcement actions by the (enforcing) coalition of countries.[56] On the other hand, under such an initial allocation (of permits to low-cost controllers, which may largely be developing countries), the incentives for the high-cost controllers (the buyers, most likely the industrialized countries) to maintain the enforcing coalition (the original agreement) are reduced. In the past, this factor has contributed to the collapse of international agreements.[57]

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[54] I am grateful to Bob Keohane for having pointed out the importance of this decomposition.

[55] David G. Victor and Julian E. Salt, *Keeping the Climate Treaty Relevant*, 373 Nature 280 (1995); Richard Schmalensee, *Greenhouse Policy Architecture and Institutions* (Paper Presented for NBER Conference "Economics and Policy Issues in Global Warming: An Assessment of the Intergovernmental Panel Report," 1996).

[56] Robert O. Keohane and Joseph S. Nye, *Power and Interdependence: World Politics in Transition* 19-22 (Little, Brown 1977).

[57] Da-Hsiang Donald Lien and Robert H. Bates, *Political Behavior in the Coffee Agreement*, 35 Econ Dev & Cultural Change 629 (1987).

E. Joint Implementation

Joint implementation ("JI"), provided for in the Framework Convention on Climate Change, involves cooperation between two countries, with one funding emission reduction in the other to help the first meet its reduction commitments.[58] A number of countries are already undertaking joint implementation projects.[59] While many of these involve intergovernmental agreements, the private sector can be involved directly. The U.S. Initiative on Joint Implementation provides for governmental approval of private-sector proposals.[60]

The potential economic merits and demerits of joint implementation have been widely discussed.[61] Joint implementation has been promoted as potentially serving three related purposes: (1) a first step toward establishing an international tradeable permit system; (2) a cost-effective option for industrialized countries to finance emission reductions in developing countries; and (3) an activity to identify when it is cost effective to bring new emissions sources or sinks into an existing international greenhouse management scheme.

Joint implementation also raises many concerns. When applications are between developed and developing countries, where only the former commit to binding targets and the latter do not, it will be difficult to determine the emission-reduction effects of a specific joint-implementation project.[62] The effects of low-cost abatement projects are particularly difficult to estimate because

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[58] For a comprehensive review of the legal and practical aspects of joint implementation, see Onno Kuik, Paul Peters, and Nico Schrijver, eds, *Joint Implementation to Curb Climate Change: Legal and Economic Aspects* (Kluwer 1994).

[59] JI has taken on a significant "life of its own," including the creation of a number of institutions that have been developed purely for the purpose of furthering JI projects. See various issues of the periodical, *Joint Implementation Quarterly*, now in its third year of publication (in the Netherlands).

[60] For a recent summary of joint implementation projects, see Alan Zollinger and Roger Dower, *Private Financing for Global Environmental Initiatives: Can the Climate Convention's "Joint Implementation" Pave the Way?*, Issues and Ideas (Oct 1996).

[61] See, for example, Scott Barrett, *The Strategy of Joint Implementation in the Framework Convention on Climate Change* (United Nations 1995); Peter Bohm, *On the Feasibility of Joint Implementation of Carbon Emissions Reductions* in *Climate Changes: Policy Instruments and Their Implications, Proceedings of the Tsukuba Workshop of IPCC Workshop Group III* 181 (1994); Reinhard Loske and Sebastian Oberthür, *Joint Implementation under the Climate Change Convention*, 6 Intl Envir Aff 45 (1994); Catrinus J. Jepma, ed, *The Feasibility of Joint Implementation* (Kluwer 1995).

[62] Thomas H. Tietenberg and David G. Victor, *Implementation Issues for a Tradeable Permit Approach to Controlling Global Warming*, in *Climate Changes: Policy Instruments and Their Implications, Proceedings of the Tsukuba Workshop of IPCC Workshop Group III* 155 (1994).

such projects may be nearly profitable in the absence of the JI arrangement and hence may be carried out without any policy intervention. In general, bilateral JI efforts are hampered by significant transaction costs and poorly defined property rights.[63] Furthermore, there are significant incentives for parties to a joint-implementation project to exaggerate a project's net emission reduction effects. Lastly, a system of JI agreements—on its own—would be invariably inefficient since countries would ignore benefits to third-party nations. In other words, it would be impossible to overcome the free-rider problem.

Although the Climate Action Plan includes an Initiative on Joint Implementation, relatively little action has occurred in the United States, principally because there has been no binding emissions cap on domestic sources and thus no credit incentive in place.[64]

IV. IMPLEMENTATION ISSUES

Assessing alternative instruments for global climate change requires us to consider implementation issues, since they can greatly affect real world outcomes. With market-based instruments, the claims made for their cost-effectiveness have in some cases exceeded what can reasonably be anticipated. Professor Tietenberg assimilated the results from ten analyses of the costs of air-pollution control, and, in a frequently cited table, he indicated the ratio of cost of actual regulatory programs to least-cost benchmarks.[65] Unfortunately, other people have sometimes taken the resulting ratios (which range from 22.0 to 1.1) as direct evidence of the potential gains from adopting specific market-based instruments. A more realistic and appropriate comparison would be between actual regulatory policies and either actual market-based programs or *reasonably constrained* theoretical programs.[66]

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[63] This also suggests that current efforts to better define property rights and reduce transaction costs in joint implementation programs are well placed. Schmalensee, *Greenhouse Policy Architecture* (cited in note 55). See also Kenneth R. Richards, *Joint Implementation in the Framework Convention on Climate Change: Opportunities and Pitfalls*, in Charles E. Walker, Mark A. Bloomfield, and Margo Thorning, eds, *An Economic Perspective on Climate Change Policies* 171-93 (American Council for Capital Formation Center for Policy Research 1996).

[64] Heidi Yanulis, *Enviro Lauds New US Climate Change Stance*, Greenwire (Oct 18, 1996).

[65] Thomas H. Teitenberg, *Transferable Discharge Permits and the Control of Stationary Source Air Pollution: A Survey and Synthesis*, 56 Land Econ 391, 411-14 (1980).

[66] Robert W. Hahn and Robert N. Stavins, *Economic Incentives for Environmental*

Several factors can adversely affect the performance of market-based systems: concentration in the permit market;[67] concentration in the output market;[68] transaction costs;[69] non-profit-maximizing behavior, such as sales or staff maximization;[70] the pre-existing regulatory environment;[71] the degree of monitoring;[72] the degree of enforcement;[73] and administrative costs.[74]

In the following sections, I review some of the most prominent issues regarding the implementation of carbon taxes and tradeable permit systems.

A. The Effects of Uncertainty on the Choice of Policy Instrument

In the absence of uncertainty, price instruments (such as emission taxes) and quantity controls (such as tradeable permit systems) are—to a large degree—equivalent in their ability to achieve the efficient level of control. Climate change involves many uncertainties, however. We are not yet able to determine climate changes given different emission trajectories or the costs and benefits of abating emissions. Hence, alternative instruments must be compared under conditions of uncertainty.

Perhaps surprisingly, uncertainty about the benefits of abatement does not affect the choice between a price and a quantity instrument. If the marginal abatement cost function is known, then both instruments will be equal in achieving a target level of emission. While uncertainty about the benefits of abatement will make it very difficult to choose the efficient target, one

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Protection: Integrating Theory and Practice, 82 Am Econ Rev 464, 465-66 (1992).

67 Robert W. Hahn, *Market Power and Transferable Property Rights*, 99 Q J Econ 753 (1984); Walter S. Misiolek and Harold W. Elder, *Exclusionary Manipulation of Markets for Pollution Rights*, 16 J Envir Econ & Mgmt 156, 164-65 (1989).

68 David A. Malueg, *Welfare Consequences of Emission Credit Trading Programs*, 18 J Envir Econ & Mgmt 66, 68-72 (1990)

69 Robert N. Stavins, *Transaction Costs and Tradeable Permits*, 29 J Envir Econ & Mgmt 133, 137-43 (1995).

70 John T. Tschirhart, *Transferable Discharge Permits and Profit-Maximizing Behavior*, in Thomas D. Crocker, ed, *Economic Perspectives on Acid Deposition Control* 157, 168 (Butterworth 1984).

71 Douglas P. Bohi and Dallas Burtraw, *Utility Investment Behavior and the Emission Trading Market*, 14 Resource Engineering 129 (1992).

72 Clifford S. Russell, *Monitoring and Enforcement*, in Paul R. Portney, ed, *Public Policies for Environmental Protection* 243 (Resources for the Future 1990).

73 Clifford S. Russell, Winston Harrington and William J. Vaughn, *Enforcing Pollution Control Laws* 16-44 (Resources for the Future 1986); Andrew G. Keeler, *Non-Compliant Firms in Transferable Discharge Permit Markets: Some Extensions*, 21 J Envir Econ & Mgmt 180, 188-89 (1991).

74 A. Mitchell Polinsky and Steven Shavell, *Pigouvian Taxation with Administrative Costs*, 19 J Pub Econ 385 (1982).

instrument will work as well as the other in achieving the chosen target. Hence, the deadweight losses associated with having chosen an inefficient target will be the same with either type of instrument.

In contrast with such instrument symmetry in the presence of benefit uncertainty, the difference between price and quantity instruments can be significant when the costs of abatement are uncertain.[75] If the marginal benefit and marginal cost functions are linear, the two instruments will be equally efficient only if their slopes are identical (in absolute value). If the marginal cost function is steeper than the marginal benefit function, emission taxes will result in a more efficient outcome. Conversely, if the slope of the marginal cost function is less than the slope of the marginal benefit function, then tradeable permits would be preferred.[76]

In the case of global climate change, the available evidence seems to indicate that marginal abatement costs will be relatively flat over some range, then steep once some abatement level is exceeded.[77] By contrast, little is known about how marginal benefits will vary with the level of abatement. There is concern, however, that at some level a threshold may exist in the damages associated with greenhouse gas concentrations. Hence, the effects of uncertainty on optimal (efficient) greenhouse instrument

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[75] A substantial literature in the context of environmental policy has followed, including major works by Zvi Adar and James M. Griffin, *Uncertainty and the Choice of Pollution Control Instruments*, 3 J Envir Econ & Mgmt 178 (1976); Gary W. Yohe, *Comparisons of Price and Quantity Controls: A Survey* 1 J Comp Econ 213 (1977); William D. Watson and Ronald G. Ridker, *Losses from Effluent Taxes and Quotas under Uncertainty*, 11 J Envir Econ & Mgmt 310 (1984). In theory, if a non-linear tax (equal to expected marginal damages at each level of emissions or concentration) is feasible, then a tax (price) instrument dominates a quantity instrument. Marc J. Roberts and Michael Spence, *Effluent Charges and Licenses under Uncertainty* 5 J Pub Econ 193, 202-04 (1976); Louis Kaplow and Steven Shavell, *On the Superiority of Corrective Taxes to Quantity Regulation* (Working Paper, Harvard Law School, 1996). Martin L. Weitzman, *Prices vs. Quantities*, 41 Rev Econ Stud 477, 485-87 (1974).

[76] Although benefit uncertainty on its own has no effect on the identity of the efficient instrument, in the presence of simultaneous uncertainty in both marginal benefits and marginal costs and with some statistical dependence between them, the usual "Weitzman result" can be reversed, depending on the magnitudes of benefit and cost uncertainty and the degree and sign of the correlation between them. Robert N. Stavins, *Correlated Uncertainty and Policy Instrument Choice*, 30 J Envir Econ & Mgmt 218, 229-30 (1996). A positive correlation will always tend to favor a quantity instrument, and a negative correlation will tend to favor a price instrument.

[77] William D. Nordhaus, *The Cost of Slowing Climate Changes: A Survey*, 12 Energy J 37, 61-63 (1991).

choice will vary, depending critically on the level of national and global targets.

B. The Currency of Regulation

Because of the monitoring and enforcement costs associated with regulating actual carbon dioxide emissions, the most reasonable "currency" for a tax or tradeable permit system is likely to be the carbon content of fossil fuels. Given the proportional relationship between carbon content and CO_2 emissions and the lack of a practical way to sequester these stack gases, this seems to be the right approach. Monitoring could rely mainly on self-reporting, supplemented by international access to fossil fuel inventories. Under an international carbon tax or tradeable permit scheme, a system of credible sanctions would presumably be required to make any enforcement system effective. There is little doubt, as I emphasize below, that in the international domain satisfactory solutions to these monitoring and enforcement problems will be preconditions for successfully implementing any policy instrument, be it market-based or otherwise. From this perspective, the central challenge is to understand how a credible and effective system of monitoring and enforcement can be established (at reasonable cost) in the absence of a centralized authority.[78]

C. Market Power

Tradeable permit systems raise two potential market power problems: the potential for some economic agents to influence permit price[79] and the potential for some economic agents to use permits to exercise market power in the output (product) market.[80] Thus, the extent of competition in a tradeable permit market will affect the degree to which potential control cost savings are realized. A monopsonist may force the permit price below the competitive level; or a monopolist may force the permit price above the competitive level.[81] To the extent that market power derives from the initial allocation of permits, one solution would

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[78] Robert O. Keohane, *Reciprocity in International Relations*, 40 Intl Org 1 (1986).

[79] Hahn, 99 Q J Econ 753 (cited in note 67).

[80] Malueg, 18 J Envir Econ & Mgmt at 68-72 (cited in note 68).

[81] Misiolek and Elder, 16 J Envir Econ & Mgmt at 157-64 (cited in note 67).

be to limit the share of permits held by any one participant.[82] One way to do this might be to adopt temporally limited permits.

Emissions taxes can also be problematic when emitters have monopoly power.[83] In principle, a monopolist in an output market for an emissions-intensive commodity would tend to reduce output below the competitive level in order to raise its profits. Hence, welfare gains from reduced emissions must more than offset welfare losses from reduced output for an emissions tax to be worthwhile.[84] Which effect dominates is an empirical issue.[85]

D. Transaction Costs

Transaction costs can affect the performance of tradeable permit markets. Three possible sources of transaction costs in tradeable permit markets can be identified:[86] research and information; bargaining and decision; and monitoring and enforcement.[87]

There is abundant anecdotal evidence that some trading programs involve significant transaction costs. Professors Atkinson and Tietenberg surveyed six empirical studies that found trading levels—and hence cost savings—in permit markets to be lower than theoretical models had anticipated.[88] Professor Liroff suggests that this experience with permit systems "demonstrates the need for . . . recognition of the administrative and related transaction costs associated with transfer systems."[89]

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[82] Thomas H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* 125-47 (Resources for the Future 1985).

[83] James M. Buchanan, *External Diseconomies, Corrective Taxes, and Market Structure*, 59 Am Econ Rev 174, 176 (1969).

[84] Maureen L. Cropper and Wallace E. Oates, *Environmental Economics: A Survey*, 30 J Econ Literature 675, 700-22 (1992).

[85] Although there is no cutoff point, it is unlikely that firms or nations could engage in price-setting behavior if they controlled less than 10 percent of the market. Frederick M. Scherer, *Industrial Market Structure and Economic Performance* 282-85 (Rand McNally 2d ed 1980). Ultimately, the question is whether other firms present credible threats of entry to the market—that is, whether the market is "contestable." William J. Baumol, John C. Panzar, and Robert D. Willig, *Contestable Markets and the theory of Industry Structure* 191-242 (Harcourt Brace Jovanovich 1982).

[86] Stavins, 29 J Envir Econ & Mgmt at 134 (cited in note 69).

[87] The third source of transaction costs—monitoring and enforcement—can be significant, but these costs are typically borne by the responsible government authority and not by trading partners, and hence do not fall within the conventional notion of transaction costs incurred by firms.

[88] Scott Atkinson and Thomas H. Tietenberg, *Market Failure in Incentive-Based Regulation: The Case of Emissions Trading*, 21 J Envir Econ & Mgmt 17, 28-29 (1991).

[89] Richard A. Liroff, *The Evolution of Transferable Emission Privileges in the Untied States*, (paper presented at The Workshop on Economic Mechanisms for Environmental

For example, under the EPA's emissions trading program for "criteria air pollutants," there is no ready means for buyers and sellers to identify one another, and—as a result—buyers have frequently paid substantial fees to consultants to assist in the search for available permits.[90] At the other extreme, the high level of trading that took place under the program of lead rights trading among refineries as part of the EPA's leaded gasoline phasedown in the 1980s has been attributed to the program's minimal administrative requirements and the fact that the potential trading partners (refineries) already had experience in striking deals with one another.[91] Hence, transaction costs were kept to a minimum and there was little need for intermediaries.[92] Likewise, the apparent success of the new SO_2 allowance trading program for acid rain control can be attributed partly to the program's very low transaction costs.[93] The obvious lesson from these experiences for global climate policy is simply that one aim of trading regimes should be to keep transaction costs low.

E. Free-Riding and Emissions Leakage Problems

Can a unilateral policy by one country alone or by a group of cooperating countries prove effective in abating global greenhouse gas emissions? The answer depends on how the other (non-cooperating) countries respond to the policies adopted by the cooperating countries. These responses in turn reflect two phenomena—free riding and leakage—that can undermine any international greenhouse management initiatives, whether they be market-based or conventional.[94] Free riding arises when countries that benefit from global abatement do not contribute toward its provision; and leakage arises when abatement by cooperating

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Protection, Jelenia Gora, Poland, 1989).

[90] Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders*, 3 J Econ Persp 95, 97-104 (Spring 1989).

[91] Robert W. Hahn and Gordon L. Hester, *Marketable Permits: Lessons for Theory and Practice*, 16 Ecol L Q 361, 380-91 (1989).

[92] Suzi Kerr and David Mare, *Efficient Regulation through Tradeable Permit Markets: The United States Lead Phasedown* (University of Maryland Working Paper 96-06, 1997).

[93] Juan Pablo Montero, A. Denny Ellerman, and Richard Schmalensee, *The U.S. Allowance Trading Program for Sulfur Dioxide: An Update After the First Year of Compliance* (paper presented for the Proceedings of the Second Workshop on Energy Externalities, Brussels, Belgium, October 1996).

[94] Scott Barrett, *Climate Change Policy and International Trade*, in *Climate Change: Policy Instruments and Their Implications, Proceedings of the Tsukuba Workshop of IPCC Working Group III* 15 (1994).

countries alters world relative prices in ways that lead non-cooperating countries to increase their emissions.

As long as participation in an international greenhouse policy is voluntary, countries will have incentives to free ride, leading to a less than optimal level of aggregate abatement.[95] The threat of a ban on trade between cooperating and non-cooperating countries in carbon-based fuels and products could work to support full participation in a greenhouse management scheme.[96] Of course, a ban on trade introduces distortions in the global economy. On the other hand, free riding is itself a distortion, and if trade restrictions reduce free-riding, they may yield positive net benefits. This issue, like so many others, invites empirical inquiry.

There are two main channels for emissions leakage. First, since a carbon abatement policy by cooperating countries may shift comparative advantage in carbon-intensive goods toward non-cooperating countries, production of such goods and emissions may rise outside the coalition. Second, a unilateral policy may lower world demand for carbon-intensive fuels and thereby reduce the world price for such fuels traded in international markets. As a result, demands for such fuels (and emissions) can rise outside the coalition.[97]

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[95] A number of studies have examined this issue, including Scott Barrett, *Negotiating a Framework Convention on Climate Change: Economic Considerations*, in *Convention on Climate Change: Economic Aspects of Negotiations* 9, 73-94 (OECD 1992); Scott Barrett, *Reaching a CO_2 Emission Limitation Agreement for the Community: Implications for Equity and Cost-Effectiveness*, VOL European Econ 3, 20-22 (1992); Scott Barrett, *"Acceptable" Allocations of Tradeable Carbon Emission Entitlements in a Global Warming Treaty*, in United Nations Conference on Trade and Development, *Combating Global Warming: Study on a Global System of Tradeable Carbon Emission Entitlements* 85 (United Nations 1992); Peter Bohm and Bjorn Larsen, *Fairness in a Tradeable-Permit Treaty for Carbon Emissions Reductions in Europe and the Former Soviet Union*, 4 Envir & Resource Econ 219 (1994).; Michael Hoel, *International Environment Conventions: The Case of Uniform Reductions of Emissions*; J Envir & Resource Econ 141 (1992); Edward A. Parson and Richard J. Zeckhauser, *Cooperation in the Unbalanced Commons*, in Kenneth J. Arrow, et al, eds, *Barriers to Conflict Resolution* 212-34 (Norton 1995). In spite of free-rider incentives, a stable coalition of cooperating countries may exist. See Michael Hoel, *Harmonization of Carbon Taxes in International Climate Agreements*, 3 Envir & Resource Econ 221 (1993); Carlo Carraro and Domenico Siniscalco, *Strategies for the International Protection of the Environment*, 52 J Pub Econ 309, 323-28 (1993). The size of the coalition depends on the ability of cooperating countries to punish countries that would withdraw.

[96] Barrett, *Climate Change Policy and International Trade* (cited in note 94).

[97] There is a third possible channel for leakage transmission. Under certain conditions, non-cooperating countries will abate their emissions up to the point where their own marginal benefit of abatement equals their own marginal cost of abatement. Scott Barrett, *The Strategy of Joint Implementation in the Framework Convention on Climate Change* (United Nations 1995). Non-cooperating countries will abate their emissions by

What can be done to reduce emissions leakage? If the coalition is a net importer (exporter) of carbon-intensive products in the absence of a carbon tax, then a tariff (subsidy) imposed on these net imports (exports) can reduce emissions leakage through the terms of trade. But the tariff (subsidy) would have to be set proportionately to the carbon-intensity of *every* product, a clearly impractical approach. Further, whether the welfare losses (distortions) caused by the tariffs would be greater or less than the welfare losses reduced by cutting emissions leakage remains an open empirical question. Finally, such border tax adjustments pose a number of other problems, not the least of which is possible conflict with existing multilateral trading rules.[98]

In general, the potential problems of free-riding and emissions leakage are reminders of the importance of compliance issues and of expanding membership in the active coalition in any international agreement, whether political, economic, or environmental. More broadly, these problems are yet another example of the centrality of institutional issues in the global climate policy domain, a point to which I return below.

V. COMPARATIVE ASSESSMENT OF GREENHOUSE POLICY INSTRUMENTS

This section begins by comparing conventional regulations and market-based systems for addressing global climate change. I find that market-based systems are particularly well adapted to the problems that climate change presents, but they raise two further questions. How do domestic tradeable permit systems compare with domestic tax systems? And how do international tradeable permit systems compare with international tax systems?

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less than they would if they cooperated. Where non-cooperating countries undertake positive unilateral abatement, and where the marginal benefit of abatement to non-cooperating countries decreases with the level of global abatement, an increase in abatement by cooperating countries will create an incentive for non-cooperating countries to reduce their abatement. Hence, leakage may occur even in the absence of trade.

[98] World Trade Organization ("WTO") rules allow for border tax adjustments where the taxed or controlled inputs are physically incorporated in the final product, but in the case of greenhouse gases, the concern is with the carbon emitted in the process of manufacturing. The Uruguay Round allows energy taxes to be remitted on exports of manufactured goods, although there is some question about the generality of this provision and whether it could be extended to include imports.

A. Comparing Regulatory Systems and Market-Based Instruments

Even the most optimistic estimates indicate that the cost of addressing the threat of global climate change will be exceptionally great.[99] Hence, the relative cost-effectiveness of alternative policy instruments is of central importance. If governments had complete information about the marginal costs of abatement at each and every source, they could employ conventional regulatory policies to minimize total abatement costs. But since governments do not have such information and can acquire it only at great cost, if at all, regulatory approaches will generally not be cost-effective. In contrast, market-based policy instruments—such as charges and tradeable permits—will, in theory, be cost-effective.

Despite the fairly clear abatement-cost advantages of market-based instruments, we should not neglect the public as well as the private costs of control. That is, the total costs minimized by a truly cost-effective environmental policy instrument should include both the costs of abatement (typically borne by private industry and including transaction costs) and the costs of administration (typically borne by government in the form of monitoring and enforcement costs). When monitoring and enforcement needs are particularly burdensome, performance-based standards—whether market-based or command-and-control—may not be cost-effective. In addition to such concerns about static or allocative cost-effectiveness, it is important to consider how alternative policy instruments may affect the invention, innovation, and diffusion of new technologies. That is, in the long term, the dynamic efficiency properties of environmental policy instruments are likely to be the most important.

In the international context, monitoring and enforcement requirements would hardly differ among major instruments since fossil-fuel output plus imports minus exports would have to be reported for each participating country under any system. In terms of dynamic efficiency—as well as static cost-effectiveness—the advantages of market-based instruments are striking. Additionally, taxes and, to some degree, auctioned permits will make the costs of climate-change protection more visible to private industry and thus to the general public. For political rea-

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[99] John P. Weyant, *Costs of Reducing Global Carbon Emissions*, 7 J Econ Persp 27, 42-43 (Fall 1993).

sons, this awareness may be strategically problematic in the short term, but in the long term it has the advantage of clearly signaling and educating the public about the real tradeoffs associated with various levels of greenhouse control.

B. Comparing Domestic Tradeable Permits and Domestic Taxes

If market-based instruments are indeed preferable in the domestic context because they are cost-effective, then charge systems must be compared with tradeable permit instruments. In principle, with no uncertainty, no fundamental difference exists between domestic carbon taxes and tradeable carbon permits from an aggregate cost-effectiveness or distributional point of view. Auctioned permits are virtually identical in those regards with a proportional tax; and grandfathered permits are identical with a tax linked with particular lump-sum refunds to regulated firms. This symmetry between taxes and permits begins to break down, however, in the presence of uncertainty, transaction costs, and other market imperfections, as well as when political feasibility is seriously considered. In particular, the lack of control over emission levels with taxes could be a distinct disadvantage in an international agreement. Taxes would have to be varied because of inadequate information to determine the appropriate tax level. Furthermore, adjustments would need to respond to changes in economic activity and relative price levels. Finally, although permit systems are more compatible with quantity-based targets, they may be more susceptible than tax systems to strategic behavior. As indicated above, however, tradeable permit schemes can be designed to reduce these effects.

The final choice will likely depend on political factors. And here, the political system in the United States, at least, has revealed its strong preferences for quantity instruments in their grandfathered form.[100] As indicated previously, however, these instruments distribute scarcity rents to the private sector and hence exacerbate pre-existing distortions in the economy. Ironically, it is precisely because of this rent distribution that grandfathered permits have found political favor. Thus, the preferred domestic greenhouse instrument in the United States in the short run may be grandfathered tradeable permits and, in the long run, revenue-neutral carbon taxes.

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[100] Robert W. Hahn and Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea?*, 18 Ecol L Q 1, 5-7 (1991).

C. Comparing International Tradeable Permits and International Tax Systems

In the international context, market-based systems are clearly superior. Which incentive-based instrument is most effective, however, will depend on a number of factors.

A system of harmonized domestic carbon taxes would require an agreement about compensatory international financial transfers as well as the pre-carbon-tax net tax rates on fossil fuels. At best, internationally acceptable estimates of these basic tax levels would be difficult to establish. Moreover, no design seems feasible and generally acceptable when its participants are not allowed to undertake policies on their own that affect fossil fuel use such as levying a tax on substitutes to carbon and subsidizing complements to carbon. Thus, there is some likelihood that a tax harmonization agreement would either fail to be adopted or fail after implementation.

A system of international taxes where all participating countries were liable for a given carbon tax could include an agreement on how tax receipts would be shared among the participants. Under such a system countries might retain all or part of the taxes raised domestically, and some participants (low income countries) might receive a transfer. Although each country would know the amount of tax revenue likely to be raised internally, less information would be available about other countries' tax revenues. Hence, there would be uncertainty about the size of net transfers among countries. Most important, it is difficult to imagine what existing international institution could impose and enforce such as system.

Some of these same institutional barriers would face an international tradeable permit scheme, but such an approach—if implemented—could allow each participating country to decide what domestic policy to use.[101] Such a scheme, moreover, would not require any ongoing side payments. Instead, the initial allocation of permits among countries would reflect distributional considerations. On the other hand, endogenous future prices in international permit trade would be unknown at the time an agreement on the allocation was reached. Hence, the distributional implications could not be fully known beforehand.

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[101] Strictly speaking, only domestic quantity instruments could guarantee that some quantity goal would be met. The point is that a system of international tradeable permits gives individual nations more leeway in choosing domestic instruments than does an international tax system.

This is the price paid for the key advantage of such a scheme, namely that global emissions will be known in advance for a global agreement, and net of carbon leakage will be known for a non-global agreement. Thus, the weight of evidence would appear to favor—in the long term—a permit scheme over a charge system at the international level.[102] In the short term, however, political problems—in particular, the lack of an adequate institutional structure—would appear to make it highly unlikely that a global permit trading program will be adopted by the community of nations.[103]

VI. CONCLUSIONS

Nations will need to consider a wide variety of factors before they can identify their optimal (and feasible) portfolios of greenhouse policy instruments. Countries differ dramatically in their institutional structures, their resource endowments, and their levels of industrialization. Their policymakers will invariably consider alternative instruments in intensely political environments.

The choice of policy instruments at the international level could affect the likelihood of reaching an agreement because the adoption of any such instruments will affect the distribution of wealth among countries. Hence, debates and negotiations about distributional issues are likely to be central to determining the final portfolio of policies.

On the domestic level, even the most cost-effective greenhouse policy instrument will be desirable only if the national target it seeks to achieve is part of an accepted set of international mandates. Because unilateral action will invariably be highly inefficient, any domestic program requires an effective international agreement, if not a set of international greenhouse policy instruments. This brings us back to the international context, where we are faced with the awesome task of identifying (or, more likely, creating) an institutional framework for achieving

[102] For a review of legal issues pertaining to the implementation of an international greenhouse gas trading system, see Richard B. Stewart, Jonathan B. Wiener, and Phillipe Sands, *Legal Issues Presented by a Pilot International GHG Trading System Final Report Prepared under UNCTAD Emissions Trading Project* (NYU School of Law 1996).

[103] This is not to deny that significant elements within the Clinton Administration in the United States are firmly committed to developing an international emissions trading or joint implementation system that is "credible, efficient, transparent, and verifiable." Hambley, *U.S. Submission on Elements of a New Legal Instrument* (prepared for the Climate Convention Secretariat and the Ad Hoc Group on the Berlin Mandate 1996).

agreement among nations and for credibly administering any program.[104]

A. A "Broad, Then Deep" Time-Path for Goals, Institutions, and Policy Instruments

As I emphasized at the outset, it is generally acknowledged that tremendous uncertainty characterizes both the future damages of greenhouse warming and the costs of avoiding or adapting to such warming. Because much of this uncertainty may be resolved gradually over time, it is important to consider alternative *time-paths* of public policies, which might feature "insurance policies" in earlier years and more aggressive abatement policies later on. Furthermore, because the creation of a satisfactory institutional framework is a precondition for the successful implementation of any international policy instrument (and, as argued above, for the enactment of a serious domestic program), it is also important to consider *time-paths* for developing *institutions* that can implement such policies.

There are compelling arguments for beginning with broad-based (if not global) agreements that require only low-cost measures to achieve moderate goals with relatively unsophisticated instruments. As appropriate institutions develop and as we learn more about the benefits and costs of addressing climate change, there might be an evolution toward more ambitious goals, requiring higher-cost measures, achieved (cost-effectively) with more sophisticated policy instruments. This is the "broad, then deep" policy architecture that Professor Schmalensee[105] and—by implication—Professor Schelling have proposed.[106]

This "broad, then deep" strategy is similar to the approach frequently taken to address other kinds of international problems. For example, if one were to seek the eventual peaceful coexistence of Israelis and Palestinians, a reasonable first step might simply be to bring the parties together; in this case, bringing all of the relevant interest groups into a single room would be a "broad, but shallow" first step. As institutions develop, more

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[104] Further, the international domain inescapably links considerations of cost-effective instruments with the difficult question of the desirable degree of greenhouse action, a question that is ignored at the risk of "designing fast trains to the wrong station."

[105] Richard Schmalensee, *Greenhouse Policy Architecture and Institutions* (Paper Presented for NBER Conference "Economics and Policy Issues in Global Warming: An Assessment of the Intergovernmental Panel Report," 1996).

[106] Thomas C. Schelling, *Some Economics of Global Warming*, 82 Am Econ Rev 1, 11-14 (1992).

ambitious targets might be adopted, but still ones that would be relatively low-cost to achieve, such as more efficient and equitable allocation of scarce water supplies or support for movement of tourists. Only later, after the relevant parties were more comfortable working with one another and after credible implementing institutions had come into being, would truly ambitious goals (such as the location of settlements and ultimate authority of governments) be adopted that—by necessity—would require (politically) high-cost strategies and potentially complex implementing instruments.

So too, in the case of global climate change, reasonable first steps should involve the broad participation of many nations (presumably including, at the very least, the countries in the Organization for Economic Cooperation and Development ("OECD"), as well as China, Russia, and India) in low-cost agreements, which could later be made more ambitious (and costly), as appropriate. The default alternative would be to begin with narrow participation by a limited set of countries (most likely, some subset of the OECD) in a relatively ambitious agreement that involves considerable costs and hence requires fairly sophisticated policy instruments. Examples of this approach include some proposals for ambitious harmonized taxes and JI programs among European nations.[107]

Potentially severe free-rider and emissions-leakage problems, together with other implementation concerns discussed above, are among the reasons why a default "deep, then broad" strategy would be unlikely to succeed. Emissions leakage induced by a bilateral or narrowly multilateral greenhouse agreement means that the very existence of an effective multilateral agreement can make it more difficult to formulate a global agreement. This is because such an initial greenhouse agreement would cause nonparticipant countries to increase their economic specialization in

[107] For a review of such proposals, see B.S. Fisher, et al, *An Economic Assessment of Policy Instruments for Combating Climate Change*, in James P. Bruce, Hoesung Lee, and Erik F. Haites, eds, *Climate Change 1995: Economic and Social Dimensions of Climate Change* 397 (Cambridge 1996). At the July 1996 climate change meeting in Geneva, Switzerland, the United States initially proposed a completely open regime on joint implementation and emissions trading, but the Chinese and Indian delegations objected. The result was that the proposal was revised to include only Annex I countries, a list from the Framework Convention on Climate Change that consists essentially of the OECD countries plus the former Soviet Union. Dale Curtis, *How Utilities View Latest Climate Policy Moves*, Greenwire (Oct 17, 1996).

carbon-intensive production, and thus to be even more resistant than previously to joining any future agreements.[108]

Furthermore, the severe enforcement problems that characterize the global climate policy realm suggest another advantage of the "broad, then deep" approach. Successful collaborative agreements—in the absence of some kind of low-cost, effective enforcement regimes—require substantial degrees of mutual confidence, which is typically fostered through increased interaction over time.[109]

B. Positive Political Economy: Political Barriers to Better Policy Instruments

Turning from normative to positive considerations, we may reflect on the fact that despite thirty years of normative arguments from economists, the U.S. political system has typically taken a command-and-control regulatory approach, rather than an economic incentive-based approach, to environmental problems.[110] Why has this been the case? First, in terms of the demand for environmental regulation by interest groups, private industry clearly prefers command-and-control standards to auctioned permits and taxes. Standards produce rents, while auctioned permits and taxes require firms to pay not only abatement costs to reduce pollution to a specified level, but also costs of polluting up to that level. Environmental interest groups also tend to prefer command-and-control instruments, for philosophical, strategic, and technical reasons. In terms of the supply of environmental regulatory options, command-and-control standards are also typically preferred by legislators: their training and experience makes them more comfortable with a direct standards approach; standards tend to hide the costs of pollution control while emphasizing the benefits; and standards may offer greater opportunities for symbolic politics.[111] These factors have

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[108] See Schmalensee, *Greenhouse Policy Architecture* (cited in note 105).

[109] Robert O. Keohane, *Reciprocity in International Relations*, 40 Intl Org 1 (1986); Robert D. Putnam, *Bowling Alone: America's Declining Social Capital*, 6 J Democracy 65, 73-74 (1995); Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action* 43-45, 185-92 (Cambridge 1990).

[110] Robert W. Hahn and Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea?*, 18 Ecol L Q 1, 5-7 (1991)

[111] Nathaniel O. Keohane, Richard L. Revesz, and Robert R. Stavins, *The Positive Political Economy of Instrument Choice in Environmental Policy*, in Paul Portney and Robert Schwab, eds, *Environmental Economics and Public Policy: Essays in Honor of Wallace Oates* (Edward Elgar 1997).

led to twenty-five years of resistance to market-based policy instruments in the United States and to the predominance of command-and-control regulation for a host of environmental problems. There is no reason to think that these factors will be any less important in affecting the domestic choice of policy instruments for global climate change.

CONCLUSION

The current situation suggests that despite the great theoretical advantages of market-based approaches to addressing global climate change, in terms of static cost-effectiveness, dynamic efficiency, and distributional equity, the domestic political barriers to this set of policy instruments should not be underestimated, nor should the severe institutional challenges that characterize the international domain. The ultimate test of any greenhouse policy instrument—whether domestic or international—will be whether it is scientifically effective, economically rational, and politically feasible.

Where does this leave us in terms of an agenda for future research, at least within the social sciences? First of all, economics, as a discipline, can continue to play a central role by helping formulate and address questions about appropriate greenhouse targets and cost-effective and equitable instruments to achieve those targets. But if some of the greatest barriers to progress in dealing with the threat of global climate change are political hurdles domestically and institutional challenges internationally, we should be modest—to say the least—about the likelihood of analytical dominance by economics. The profession is simply less suited to address political and institutional dimensions of the climate change problem, both because of the nature of the analytical tools of economics and because of professional incentives within the discipline that tend to work against institutional research, particularly when it is of a qualitative nature. Instead, this is an area where economists can learn from their colleagues in political science and law. Over the past several decades, legal scholarship and political science have been significantly influenced by economics. Now, global climate change policy—with its centrally important political and institutional features—presents an opportunity for that favor to be repaid.

Table 1
Taxonomy of Costs of Environmental Regulation

Government Administration of Environmental Statutes and Regulations
- Monitoring
- Enforcement

Private Sector Compliance Expenditures
- Capital
- Operating

Other Direct Costs
- Legal and Other Transactional Costs
- Shifted Management Focus
- Disrupted Production

Negative Costs
- Natural Resource Inputs
- Worker Health
- Innovation Stimulation

General Equilibrium Effects
- Product Substitution
- Discouraged Investment
- Retarded Innovation

Transition Costs
- Unemployment
- Obsolete Capital

Social Impacts
- Loss of Middle-Class Jobs
- Economic Security Impacts

Table 2

Taxonomy of Policy Instruments for Global Climate Change

DOMESTIC INSTRUMENTS
- A. Command-and-Control and Voluntary Instruments
  - Energy efficiency standards
  - Product prohibitions
  - Voluntary agreements
- B. Market-Based Instruments
  - 1. Charges, Fees, and Taxes
    - Carbon taxes
    - BTU taxes on fossil fuels; other energy taxes
  - 2. Tradeable Rights
    - Tradeable carbon rights
    - Tradeable "emission reduction" credits

INTERNATIONAL INSTRUMENTS
- A. Command-and Control Instruments
  - Uniform energy efficiency standards
  - Fixed national emission limits
- B. Market-Based Instruments
  - 1. Charges, Fees, and Taxes
    - Harmonized domestic taxes
    - Uniform international tax
  - 2. Tradeable Rights
    - International tradeable permits
    - Joint implementation