Aldy, Joseph E.; Barrett, Scott; Stavins, Robert N.

Working Paper

Thirteen Plus One: A Comparison of Global Climate Policy Architectures

Nota di Lavoro, No. 64.2003

Provided in Cooperation with:
Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Aldy, Joseph E.; Barrett, Scott; Stavins, Robert N. (2003) : Thirteen Plus One: A Comparison of Global Climate Policy Architectures, Nota di Lavoro, No. 64.2003, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:
https://hdl.handle.net/10419/118092

Thirteen Plus One: A Comparison of Global Climate Policy Architectures

Joseph E. Aldy, Scott Barrett and
Robert N. Stavins

NOTA DI LAVORO 64.2003

JULY 2003

CLIM – Climate Change Modelling and Policy

Joseph E. Aldy, *Department of Economics, Harvard University*
Scott Barrett, *Paul H. Nitze School of Advanced International Studies, Johns Hopkins University*
Robert N. Stavins, *John F. Kennedy School of Government, Harvard University and Resources for the Future*

Thirteen Plus One: A Comparison of Global Climate Policy Architectures

Summary

We critically review the Kyoto Protocol and thirteen alternative policy architectures for addressing the threat of global climate change. We employ six criteria to evaluate the policy proposals: environmental outcome, dynamic efficiency, cost effectiveness, equity, flexibility in the presence of new information, and incentives for participation and compliance. The Kyoto Protocol does not fare well on a number of criteria, but none of the alternative proposals fare well along all six dimensions. We identify several major themes among the alternative proposals: Kyoto is "too little, too fast"; developing countries should play a more substantial role and receive incentives to participate; implementation should focus on market-based approaches, especially those with price mechanisms; and participation and compliance incentives are inadequately addressed by most proposals. Our investigation reveals tensions among several of the evaluative criteria, such as between environmental outcome and efficiency, and between cost-effectiveness and incentives for participation and compliance.

Keywords: Policy architecture, Kyoto Protocol, Efficiency, Cost effectiveness, Equity, Participation, Compliance

JEL: Q2, Q3, Q4

This paper draws, in part, upon Barrett and Stavins (2002). Financial support was provided by the U.S. Environmental Protection Agency. The authors are solely responsible for any errors.

Address for correspondence:

Robert N. Stavins
Harvard University
John F. Kennedy School of Government
79 JFK Street
Cambridge MA 02138
USA
Phone: 617-495-1820
Fax: 617-496-3783
E-mail: robert_stavins@harvard.edu

THIRTEEN PLUS ONE: A COMPARISON OF GLOBAL CLIMATE POLICY ARCHITECTURES

Joseph E. Aldy, Scott Barrett, and Robert N. Stavins*

1. INTRODUCTION

There is a growing consensus among both natural scientists and economists that a credible approach is needed to address the threat of global climate change (Watson *et al*., 2001). The Kyoto Protocol to the U.N. Framework Convention on Climate Change may or may not come into force, but serious questions have been raised regarding the Protocol's anticipated performance. A variety of alternative policy architectures[1] have been proposed, including thirteen that have been developed by economists and other scholars. In this paper, we review these thirteen proposals plus the Kyoto Protocol in the light of key performance criteria.

In Part 2 of the paper, we explore the six criteria for assessing global climate policy regimes. In Part 3, we describe the fundamental characteristics of the Kyoto Protocol and alternative policy architectures; and in Part 4, we synthesize the key architectural elements of the proposed climate regimes. In Part 5, we conclude.

2. ALTERNATIVE CRITERIA FOR ASSESSING GLOBAL CLIMATE POLICY REGIMES

Six potential criteria can guide an assessment of proposed global climate policy regimes: (1) the environmental outcome; (2) dynamic efficiency; (3) dynamic cost-effectiveness; (4) distributional equity (both cross-sectional and intertemporal); (5) flexibility in the presence of new information; and (6) participation and compliance [2]. The last criterion has frequently been ignored, but is essential for achievement of the first four criteria. While climate negotiations have focused on cost-effectiveness, attainment of this objective requires more than flexible mechanisms; it requires full participation. Similarly, the negotiations leading up to Kyoto emphasized the need for

---

*Aldy is a Ph.D. student in the Department of Economics at Harvard University; Barrett is Professor of Environmental Economics and International Political Economy, and Director of the Energy, Environment, Science, and Technology Program at the Paul H. Nitze School of Advanced International Studies, Johns Hopkins University; and Stavins is the Albert Pratt Professor of Business and Government, Chair of the Environment and Natural Resources Faculty Group, and Director of the Environmental Economics Program at the John F. Kennedy School of Government, Harvard University, and a University Fellow of Resources for the Future. This paper draws, in part, upon Barrett and Stavins (2002). Financial support was provided by the U.S. Environmental Protection Agency. The authors are solely responsible for any errors.

[1]The general importance of focusing on policy "architecture" and institutions in the global climate domain was first noted by Schmalensee (1996, 1998). See also: Victor and Salt, 1995; Stavins, 1997; Sandalow and Bowles, 2001.

[2]By "participation" we mean whether a country is a party to a treaty intended to mitigate emissions. By "compliance" we mean the degree to which a country that is a party to such a treaty implements the treaty's obligations.

stringent targets, but these are of little or no environmental benefit if participation is low or if parties fail to comply.

2.1 The Environmental Outcome

For many participants in the global climate policy process, particularly non-economists, the most important criterion for assessing alternative policy regimes is the likely magnitude of environmental outcomes.[3] The stock nature of climate change complicates any ranking of policies, because policies may differ in their respective time paths of changes in net emissions. Policies can take a wide variety of emissions paths to achieve the same steady-state atmospheric concentrations (Wigley et al., 1996). While an economic assessment would indicate similar if not identical impacts from climate change at any given steady-state concentration, the rate of climatic change would vary across policies and result in different transitional impacts (on the cost side of the ledger).

Environmental effectiveness is difficult to measure in this domain. Uncertainties abound in predicting global climate change, particularly in terms of economically-relevant geographic scales; quantifying biophysical impacts; and monetizing impacts, especially for non-market goods and services. In order to estimate the impacts of particular policies, it is necessary to estimate what countries would have done in the absence of policy, but such counterfactual baselines cannot be observed.[4]

The need to assess the environmental effectiveness of climate policies raises another difficulty if the policies induce "emissions leakage." If an international (but not fully global) climate policy results in differences in marginal compliance costs among countries, then emissions may "leak" from participating high-cost countries to non-participating low- or zero-cost countries through one of two economic channels.

First, a policy may foster comparative advantage for low-cost countries (for example, countries without emissions commitments) in the production of greenhouse gas-intensive goods and services. Some firms may relocate manufacturing plants from countries with emissions commitments (and higher energy costs) to countries without emissions commitments. In this case, countries with commitments may comply with their obligations, but some of their emissions reductions would be offset by increases in emissions in countries without commitments.

Second, the higher energy costs associated with compliance would reduce world energy demand, depressing oil and coal prices. Countries without emissions commitments would consume more fossil fuels, offsetting some of the emissions reductions by countries with commitments.

---

[3]From an economic perspective, the environmental outcome criterion is redundant, given the dynamic efficiency criterion. Any policy that satisfies dynamic efficiency delivers the socially optimal environmental outcome. But policy debates in international climate negotiations reveal much more interest in environmental outcomes (or proxies, such as emissions) than in efficiency.

[4]The Helsinki Protocol, for example, required that parties reduce their sulfur dioxide emissions by 30 percent. Actual emissions fell by more than 30 percent. This might suggest that the agreement succeeded environmentally, but the agreement did not significantly affect behavior (Levy, 1993; Barrett, 2003). In the absence of the treaty, most of the emission reductions would likely have occurred anyway.

Hence, a "narrow but deep" agreement may not significantly reduce net emissions, but largely redistribute emissions.

2.2 Dynamic Efficiency

It seems reasonable to ask whether the gains outweigh the losses of a public policy, and thus determine whether society as a whole is made better off as a result of the policy. A global climate policy that achieves maximum aggregate *net benefits* is said to be *efficient*.[5] Of course, global climate change policy must address actions, impacts, benefits, and costs that occur over very long time horizons. Greenhouse gases accumulate in the atmosphere because of their slow natural decay rates. Moreover, thermal ocean mixing can delay climatic response. In addition, private sector responses to climate change policies can require significant changes in long-lived capital stock: 50 to 70 years for electricity generators, and 60 to 100 years for residential buildings, for example (Jaffe, Newell, and Stavins, 1999). Exogenous and endogenous technological change can have great bearing on global climate change and policies to address it, especially over the long-term. For all three reasons, *dynamic efficiency* is an important criterion to employ.[6]

To assess dynamic efficiency, economic analysis must account for people's preferences over consumption across time. Individuals' rates of time preference and expectations about future income growth (which affects future consumption opportunities) influence how individuals discount future consumption (Goulder and Stavins, 2002). Individual behavior reflects these preferences in market activities, such as buying and selling government bonds, home mortgages, and credit card balances. At the societal level, concerns for intergenerational equity loom large, in part because explicit markets for intergenerational trade-offs do not exist. As a general matter, future net benefits should be discounted, but the appropriate value of the discount rate for very long-time horizons is unclear.[7]

Uncertainty in estimating benefits and costs also characterizes the global climate change problem. These uncertainties, the intertemporal nature of the problem, and the *irreversible* characteristics of investment in climate protection (economic, if not physical irreversibility), create the conditions for decision-makers to value delaying investment decisions (known as *quasi-option*

---

[5]Note that Pareto efficiency requires not only that aggregate net benefits be maximized but that no one be made worse off by the policy change. The practical question for policy is whether it is essential that no one *actually* be made worse off or that no one *potentially* be made worse off. This weaker condition is the frequently employed Kaldor-Hicks criterion. See Stavins (2001a) for a primer on global climate economics. Although efficiency is an important criterion for sound policy analysis, most economists think of benefit-cost analysis as no more than a tool to assist in decision making. Virtually all would agree, however, that the information in a well-done benefit-cost analysis can be of great value in helping to make decisions about risk reduction policies (Arrow et al., 1996).

[6]The application of this criterion to climate change policies is challenging in those cases where the policy proposals do not specify long-term emissions paths. This also complicates the assessment of the environmental effectiveness of climate policies, such as the Kyoto Protocol, which sets an emission constraint only for a five-year period.

[7]Comprehensive summaries are by Lind (1982) and Portney and Weyant (1999). Recent research has suggested a theoretical basis for employing lower discount rates for longer run analyses (Weitzman, 2001), and empirical research has illustrated this in the presence of uncertainty (Newell and Pizer, 2000). One study has suggested that for climate change a negative discount rate is conceivable (Dasgupta, Mäler, and Barrett, 1999).

value) until more information is available (Arrow and Fisher, 1974; Hanemann, 1989; Dixit and Pindyck, 1994; Kolstad and Toman, 2000). This value should, in principle, be included in the calculation of benefits and costs. In the global climate context, the irreversibilities include both the accumulation of greenhouse gases in the atmosphere and the accumulation of capital investments that cannot easily be reversed.[8]

2.3 Cost-Effectiveness

Although assessing the costs of global climate change mitigation is by no means a trivial task, it is vastly easier than estimating the benefits of policy action. The uncertainty in quantifying regionally disaggregated biophysical impacts of climate change and the difficulty of monetizing some categories of biophysical impacts substantially hinders such benefit estimation. A less demanding criterion circumvents the benefits estimation problem by focusing on cost-effectiveness, in which the least costly means of achieving some given target or goal (which may or may not be efficient) is identified.[9]

Cost-effectiveness analysis cannot be used to compare policies with different benefit streams. Moreover, relying on cost-effectiveness as an assessment criterion can lead to the identification of a low-cost way of doing something that is fundamentally not sensible in economic terms. That is, it can lead to the identification of "fast trains to the wrong station." On the other hand, this kind of analysis can reveal that some policy measures are simply inferior to others.

2.4 Equity

An exceptionally important issue in global climate change policy is the distribution of the benefits and costs of policy action, both cross-sectionally and over time. Although economists have given considerable thought over the years to the possibility of using weights to incorporate distributional considerations into determinations of efficiency, there is no consensus, nor likely to be one, on what those weights ought to be. It is reasonable, instead, to estimate benefits and costs, and separately provide as much information as possible to decision makers about winners and losers.

Assessments of international, intra-national, and intergenerational distributions of the benefits and costs of alternative policy regimes are necessary for the identification of equitable climate strategies. A number of criteria merit consideration (Goulder, 2000). First, the criterion of *responsibility* would suggest that — other things equal — those nations that are most responsible for the accumulation of greenhouse gases in the atmosphere should take on the greatest burden for containing the problem. Second, the criterion of *ability to pay* implies that the wealthier nations that possess greater capacity should lead the response to the global climate change problem. Third, the criterion of the *distribution of benefits* suggests that those nations which stand to benefit most from

---

[8]These two effects push a stochastic benefit-cost analysis of global climate policy in opposite directions. Which is dominant? Although it has been argued that the second effect is more important (Kolstad, 1996), it is ultimately an empirical question (Ulph and Ulph, 1997; Narain and Fisher, 2000).

[9]Efficiency subsumes cost-effectiveness. A policy that satisfies the efficiency criterion provides the optimal path of net emissions, and requires the cost-effective implementation of this path.

action taken ought to take on greater shares of the cost burden. The first two considerations suggest that industrialized nations should bear the principal burdens for dealing with the prospect of climate change. The third criterion suggests that developing countries should shoulder a relatively higher burden, as compared with the other equity criteria (though note that, while developing countries may be relatively the most vulnerable to climate change, the absolute benefits of mitigation are likely to be greater for industrialized countries).

Though the focus of our attention is with mitigation, it is important to note that climate policy may also involve adaptation. Since future climate change is unavoidable, given the accumulation of greenhouse gases in the atmosphere that has already occurred and their relatively gradual decay rates, individuals, institutions, and ecosystems will need to adapt. Hence, an efficient response to climate change would include a substantial adaptation component. Just as the burden for emissions mitigation raises questions for equity, so does adaptation. For example, the notions of responsibility and ability to pay could translate into technical and financial assistance from industrialized countries to developing countries for adaptation, as well as for mitigation.

The long time-horizon of the global climate change problem and potential policy responses raises important issues of *intergenerational equity*. While some have called for the use of low discount rates for long time-horizons (such as in the climate context), the use of discounting in benefit-cost analysis has ambiguous effects. A zero or low discount rate might not favor future generations, because it would distort investment decisions among climate change policies and other policies (in which a standard, positive discount rate would guide the decision-making). As a result, society may pass up opportunities to employ other, non-climate policies that could benefit future generations. A world with "too much" climate change investment and "too little" non-climate policy investment may make future generations worse off, not better off. More broadly, Schelling (1998) has highlighted the trade-off that may exist between policies to address intergenerational equity and those that address (current) distributional equity: acting to protect future generations (who presumably will be better off materially than current ones) means that fewer resources will be available to help today's poor in developing countries.

2.5 Policy Flexibility in the Presence of New Information

Because uncertainty in benefits and costs characterizes global climate change, the risks of premature or unnecessary actions need to be compared with the risks of failing to take actions that subsequently prove to be warranted (Goulder, 2000). Hence, many economic analyses have advocated a sequential decision-making approach to climate change policy that would facilitate the modification and adaptation of policies as new information reduces uncertainties. Because such new information is potentially of great value, flexible policies (that adapt to new information) have significant advantages over more rigid policy mechanisms (Arrow *et al*., 1996).

2.6 Participation and Compliance

When economists consider domestic environmental problems, they ordinarily put aside participation and compliance issues by assuming (quite reasonably in some cases) the existence of a sovereign government vested with effective, coercive powers. In the international domain, however, full national sovereignty for individual nations means that free rider problems would likely

undermine adequate participation and compliance. Countries can engage in free riding behavior through either non-participation or non-compliance, and so at a fundamental level this criterion asks whether a given climate change policy architecture is likely to deter free riding.

A truly efficient (and, hence, cost-effective) climate change agreement would secure full participation by all countries, with each and every country mitigating its emissions to the point where its own marginal abatement costs equaled the sum of marginal benefits globally. But taking the behavior of other countries as given, each country can do better by mitigating only up to the point where its own marginal benefit equals its marginal cost. As long as global marginal benefits exceed every nation's own marginal benefits, countries will either want to avoid participating or avoid complying fully, if they do participate. Successful international cooperation must change these incentives.

Full participation and compliance are necessary but not sufficient conditions for a dynamically efficient and cost-effective climate change policy. For example, an international agreement may be watered down so much that every country participates and complies, and yet the treaty achieves next to nothing. Ideally, a treaty would sustain full participation and compliance while at the same time implementing the dynamically efficient level of climate mitigation. The constraint of sovereignty, however, may make this ideal unattainable (Barrett, 2003).

One alternative is a "narrow-but-deep" agreement — one that achieves substantial per-party mitigation, but attracts relatively little participation. Another alternative is a "broad-but-shallow" agreement — one that achieves relatively little per-country mitigation, but attracts nearly full participation among nations. Current understanding of the benefit and cost functions characterizing climate change suggests that the latter type of policy is more likely to satisfy the dynamic efficiency criterion. Since marginal emissions control costs increase steeply, a broad-but-shallow policy would result in lower overall costs (Barrett, 2002). Moreover, a broad-but-shallow policy could mitigate emissions leakage.

3. ALTERNATIVE GLOBAL CLIMATE TREATY ARCHITECTURES

We now turn to a review of the fundamental architecture of the Framework Convention on Climate Change and the Kyoto Protocol, and the fundamental characteristics of thirteen alternative international approaches to the climate change problem (Table 1).

3.1 The Kyoto Protocol of the Framework Convention on Climate Change

At the United Nations Conference on Environment and Development, held in 1992 in Rio de Janeiro, Brazil, agreement was reached on the Framework Convention on Climate Change (FCCC), which established as its ultimate objective the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." As an interim step, the FCCC imposed a non-binding goal of reducing greenhouse gas emissions by industrialized countries (the so-called Annex I countries[10]) to their

[10]These include the developed nations plus economies in transition.

1990 levels by the year 2000. The FCCC allowed countries flexibility to develop and implement their own domestic policies to achieve their goals, and provided additional flexibility by allowing Annex I countries to sponsor emissions abatement and sequestration projects in other countries through "joint implementation" (a form of project-based emissions trading). Signed initially by 161 nations, the FCCC entered into force in January, 1994 after being ratified by 50 countries (including the United States). Today, the FCCC has 187 parties, more than any other international environmental agreement (Barrett, 2003).

In December, 1997, some 160 countries negotiated the Kyoto Protocol to the Framework Convention. Subsequent negotiations filled in many of the details of the Protocol, and the treaty was substantially completed by November, 2001. While the Protocol maintains the principle of differentiated responsibilities by the industrialized and developing worlds, it imposes ambitious targets and timetables for emissions reductions by industrialized nations, and it expands significantly the opportunities for countries to achieve their commitments cost-effectively through emissions trading and other "flexible mechanisms." The agreement stipulates "binding" commitments, although, as we explain below, the nature of the requirement that commitments be binding remains unsettled.

The Kyoto Protocol provides specific greenhouse gas emissions commitments for 38 industrialized (Annex B) countries for the 2008-2012 "commitment period."[11] These emissions targets are expressed relative to countries' emissions in the year 1990.[12] The relative commitments range from 8 percent below 1990 levels (for the European Union) to 10 percent *above* 1990 levels (in the case of Australia).[13] Considering the growth of some economies subsequent to 1990, and the essential collapse of others, the range of implicit targets is much greater, with the United States facing a target of about 30 percent below business-as-usual (BAU) levels in 2012, and Russia and other economies in transition facing targets that would allow substantial *increases* in emissions *above* anticipated BAU levels in 2012. Likewise, Germany's apparently ambitious Kyoto target of an 8 percent reduction translates into a targeted increase in emissions, due to the post-1990 reunification of the two German nations, and the United Kingdom's target of an 8 percent reduction likewise translates into a targeted emissions increase, due to the privatization of British coal mining and the opening up of North Sea natural gas sources.[14] These targets apply to six classes of

[11]The Kyoto Protocol designates those countries with emissions commitments as Annex B countries. With only a few exceptions, the set of countries with Annex B commitments is identical to the set of Annex I countries in the FCCC.

[12]Transition economy countries were allowed to use a base year other than 1990 if their economic transition from central planning began prior to that date. Countries may also choose to employ 1995 as the base year for measuring changes in emissions of the synthetic greenhouse gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

[13]Note, however, that the European Union can reallocate its emissions allocations among the 15 EU members through the "bubble" provision of the Kyoto Protocol (Article 4). Under this reallocation, the emissions commitments of EU members would range between 28 percent below to 27 percent above 1990 levels.

[14]It is this "hot air" in the German and British targets that render European Union compliance under its Kyoto bubble possible at low cost. According to one recent estimate, fully 80 percent of the EU targets will be achieved by Germany and the United Kingdom (Andersen, 2002).

greenhouse gases: carbon dioxide (CO_2), methane, nitrous oxide, hydroflourocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).[15]

The Kyoto Protocol acknowledged and reinforced the FCCC's principle of "common but differentiated responsibilities." Unlike industrialized nations, developing countries have no specific obligations to abate greenhouse gas emissions under the Protocol, and the Protocol provides no mechanism for developing countries to adopt emissions commitments voluntarily.[16]

The Kyoto Protocol includes three flexibility mechanisms that can help countries achieve their commitments at lower costs: international emissions trading, joint implementation, and the Clean Development Mechanism (CDM). The international emissions trading mechanism allows Annex B countries to trade portions of their assigned amounts (targeted emissions) with one another, whereas the joint implementation mechanism allows these same countries to cooperate on projects and transfer emissions allowances on the basis of such projects. The CDM allows Annex B countries to finance projects in non-Annex B countries in exchange for credits towards meeting their own emission reduction commitments.

The Protocol implicitly allows for trading across different types of gases and some limited trading across time. Since emissions commitments represent the weighted sum of a country's net emissions of greenhouse gases,[17] the Protocol implicitly allows inter-gas trading. By focusing on *net* emissions, the Protocol allows for (potentially cost-effective) substitution of carbon sequestration for greenhouse-gas abatement. Emissions quotas refer to five-year averages, and countries are allowed to bank and borrow emissions allowances within this five-year window. Countries may also bank (but not borrow) emissions allowances for use in future, as-yet-undefined commitment periods.

Unlike the underlying FCCC, the Kyoto Protocol stipulates that emissions commitments are legally binding. At the same time, however, Article 18 of the Kyoto Protocol prohibits use of a compliance mechanism entailing "binding consequences" unless adopted by means of an amendment. A compliance mechanism was agreed to in Bonn in July 2001: any industrialized country that fails to comply with its first commitment period obligation must make up for this shortfall in the second commitment period *with a 30 percent penalty*. This mechanism will fail to alter behavior for several reasons. First, by Article 18, the penalty cannot apply to any country without that country consenting to be bound by it, assuming that the penalty were even included in a future amendment. Second, the penalty applies to a future control period, and a country would have to agree to the emission limit applying in such a period. A country could insist on a generous future limit, taking any sting out of the penalty. Finally, the mechanism relies entirely on self-

[15]The agreement does not specify any obligations beyond 2012. These would have to be negotiated in a new agreement (possibly, an amendment), which would be binding only on the countries that ratified it, provided that the new agreement entered into legal force.

[16]This has confounded the attempts of two countries — Argentina and Kazakhstan — to adopt emissions commitments and participate within the Kyoto framework.

[17]Greenhouse gas emissions are aggregated based on their 100-year global warming potentials, and are reported in terms of "carbon dioxide equivalent." Refer to Schmalensee (1993), Reilly et al. (1999), and Manne and Richels (2000) for a discussion of the economics of global warming potentials.

punishment. Other countries do not take any actions to enforce compliance with the compliance mechanism itself.

The Kyoto architecture can be summarized as including four elements: ambitious, short-term reduction targets for industrialized countries; no emissions obligations for developing countries; flexibility for countries to achieve their commitments through market-based mechanisms; and non-compliance sanctioned with a penalty (not yet binding) linked to commitments in subsequent periods.

As of January, 2003, the Kyoto Protocol has been ratified by 104 parties (nations) to the FCCC. To enter into force, Kyoto must be ratified by at least 55 countries, accounting for at least 55 percent of 1990 Annex I CO_2 emissions. Only the latter trigger for entry into force remains to be fulfilled. As of January, 2003, 28 Annex I countries had ratified the Kyoto Protocol, accounting for 43.9 percent of 1990 Annex I emissions.[18]

Entry into force will thus require participation by other Annex I countries, especially Russia. To secure the participation of Russia (and other Annex I countries, including Japan), negotiating parties made concessions in Bonn and Marrakech. Giving these countries more (sink) allowances effectively relaxed the emissions constraints negotiated previously in Kyoto. These changes reduced the environmental effectiveness of the protocol and illustrate the potential trade-offs between participation incentives and the environmental outcome of an international agreement. This may hint at a key consequence of the Kyoto agreement: it may not achieve high participation and compliance while reducing emissions substantially. For example, while Canada has ratified the agreement, it has signaled its intention to count exports of "clean energy" to the United States towards its emission reduction obligations. This accounting violates the treaty, suggesting that compliance may prove to be a significant problem for the Kyoto Protocol, even if the agreement enters into force.

Environmentalists have supported the Kyoto Protocol partly because it has been "the only game in town" and partly because of the expectation that, with time, the emission limitations achieved by this agreement can be strengthened. The agreement, however, will not achieve substantial mitigation, in the short term or in the long term, partly because it fails to promote participation and compliance. This further undermines dynamic efficiency, although analyses of the Kyoto agreement with U.S. participation show that this policy's global emissions path would be severely sub-optimal (Nordhaus, 2001). Kyoto does incorporate mechanisms aimed at promoting cost-effectiveness, but the success of these ultimately depends on the ability of the agreement to achieve the agreed emission limits.

The agreement champions "distributional equity" by placing the burden of mitigation upon industrialized countries, but in so doing it sacrifices efficiency and cost-effectiveness. The Clean Development Mechanism, likely to bear substantial transaction costs, cannot correct for this failure.

By establishing the precedent of negotiating one five-year commitment period at a time, the Kyoto agreement promotes a flexible approach that can account for new information in subsequent

[18]These included the member states of the European Union, Canada, Japan, the Czech Republic, Estonia, Latvia, Norway, Romania, and Slovakia.

negotiations and emissions commitments. This approach also highlights a tension between a flexible, adaptive regime that incorporates new information, and a policy that provides more certainty by setting longer-term emissions commitments. The additional certainty of long-term commitments may provide sufficient incentive for investments in long-lived capital that may not occur under a system of periodically negotiated five-year periods. Some proposed long-term emissions paths may fail to provide such an incentive, however, if they are not dynamically consistent (Aldy, Orszag, and Stiglitz, 2001). The Kyoto agreement also fails to promote participation and compliance, evident by the U.S. withdrawal from the agreement, the effective prohibition on the adoption of emissions commitments by developing countries, and the weak self-enforcement regime under Article 18.

3.2 Alternatives to the Kyoto Protocol

Thus the Kyoto Protocol's architecture has been criticized on a variety of grounds, including: it imposes high costs and unfair burdens on some industrialized countries; it effectively forbids developing countries from taking on emissions commitments;[19] it provides ineffective incentives for participation; and it generates modest short-term climate benefits while failing to provide a long-term solution. In response to these and other perceived flaws[20] in the agreement and in response to uncertainty regarding the agreement's future given the declared non-participation by the United States, a variety of alternatives have been proposed. These proposals have been advanced in venues ranging from one-page editorials to book-length manuscripts. In the remainder of this section, we briefly describe the key architectural elements of each proposal, taking the proposals in alphabetical order according to their authors.

3.2.1 A Hybrid International Trading Program (Aldy, Orszag, and Stiglitz, 2001)

This first proposal is for a hybrid international trading instrument that combines an international trading mechanism, not unlike that found in the Kyoto Protocol, with a safety-valve or price ceiling, to be implemented by an international agency making available additional permits at a fixed price.[21] Proceeds from the sale of additional permits would finance climate change research and aid developing countries' efforts to abate greenhouse gas emissions. Developing

---

[19]It has been suggested that it is important for all countries — developing, as well as industrialized — to take on emission targets, because: (1) developing countries will account for more than half of global emissions by 2020, if not before; (2) developing countries provide the greatest opportunities now for relatively low-cost emissions reductions; and (3) if developing countries are not included, Annex B abatement will shift comparative advantage in the production of carbon-intensive goods and services outside of that coalition of countries, and render developing economies *more* carbon-intensive than they otherwise would be (see our discussion of emissions leakage in section 2.1, above).

[20]Most other critiques of the Protocol may be thought of as referring more to the details than to the general structure (architecture) of the agreement. For example, Hahn and Stavins (1999) note that the international emissions trading program outlined in Article 17 is unlikely to be truly cost-effective if it is implemented through a heterogeneous set of domestic policy instruments.

[21]The hybrid approach combining a tradable permit system with a "tax" (elastic supply of additional permits) has been examined by McKibbin and Wilcoxen (1997), Kopp, Morgenstern, and Pizer (1997), and Kopp, Morgenstern, Pizer, and Toman (1999), building on earlier work by Weitzman (1974) and Roberts and Spence (1976). A recent assessment is provided by Jacoby and Ellerman (2002).

countries would be included in the short term via voluntary measures and in the longer term via mandatory commitments.

The near-term environmental effectiveness of this proposal would depend upon the breadth of actual participation by developing countries.[22] The use of a safety valve may limit emissions reductions in contrast with a pure quantity system, but could deliver more environmental benefits than a pure quantity system if the proceeds from the safety valve provide sufficient incentive for developing countries to adopt emissions commitments. The hybrid price-quantity approach under this policy could approach efficiency in light of uncertainty in both costs and benefits. Support for full, unrestricted emissions trading could also promote cost-effective attainment of emissions commitments, especially once developing country participation becomes mandatory.

The authors of this proposal recommend a sequential process for determining emissions commitments and safety-valve prices in lieu of fixing such commitments over the long-term, allowing for policy adaptation to new information over time. Reflecting the ability to pay notion of equity, they suggest that developing countries should participate to the extent possible in the near term, with those adopting emissions commitments participating and enjoying economic gains from international emissions trading. Funds accruing from the sale of extra emissions permits through the safety valve could support emissions abatement efforts in developing countries as well.

To promote compliance, Aldy, Orszag, and Stiglitz recommend experimenting with social and economic (trade) sanctions. Some critics believe that trade restrictions would be difficult to calculate and prone to political manipulation. They could also allow for a sequence of reprisals and counter-reprisals that would damage trade relations.

3.2.2 A Research and Development Protocol (Barrett, 2001, 2003)

This proposal is for a fundamentally different approach, emphasizing common incentives for climate-friendly technology research and development, rather than targets and time tables. His approach includes a research and development (R&D) protocol that would support collaborative research, and protocols that would require common standards for technologies identified through collaborative research efforts. Barrett maintains that the departure from emissions commitments and market-based instruments is the necessary cost of designing a participation- and compliance-compatible regime. His proposal also includes a protocol aimed at making some short term progress, but without reliance on international enforcement.

This proposal could potentially support a high degree of environmental effectiveness, depending on the payoffs to the cooperative R&D efforts,[23] but the system would neither be efficient nor cost-effective, not least because the technology standards would not apply to every sector of the

[22]Our assessments of the alternative policy architectures are summarized in Table 2.

[23]For other commentaries on the potential for employing technological cooperation as a central architectural element, see: Buchner, Carraro, Cersosimo, and Marchiori (2002); Edmonds, Roop, and Scott (2001); Flannery (2001); and Jacoby (1998).

global economy, and may entail some technological lock-in.[24] Equity is considered explicitly, and flexibility would be aided by the public investment in basic research, although it may be hampered by lock-in. The real strength in this proposal lies in the incentives it would create for participation and compliance. Basic R&D would lower the cost of developing new technologies. Economies of scale, network externalities, and automatic trade restrictions would also make diffusion of the new technologies more attractive to each country, the greater the number of countries adopting the technology protocols. Minimum participation would need to be set high enough to ensure that participation was tipped.

3.2.3 A Portfolio Approach (Benedick, 2001)

This proposal is similar to Barrett's approach, and emphasizes (long-term) international standards and incentives for technology innovation and diffusion, but also includes a renegotiation of the Kyoto targets and a process in which participation in negotiations expands over time. The approach is to adopt a portfolio of policies, including a small carbon tax to fund new technology research, to move the international community toward a desirable technology strategy.

The proposal can reasonably be viewed as a blend of several other proposals. Like Barrett, Benedick proposes the adoption of standards, but unlike Barrett's, this proposal is not strategic in focus. The proposal is aimed at achieving environmental effectiveness, but it would be less successful in supporting efficiency or cost-effectiveness, partly because it focuses on the advantage of limiting negotiations to a relatively small subset of countries. Enforcement is not considered.

3.2.4 International Emissions Trading Without a Cap (Bradford, 2002)

This proposal is the equivalent of an international emissions trading program without a fixed cap on emissions. All nations, including developing countries, are allocated permits equivalent to their anticipated business-as-usual time path of emissions. Periodically, an international authority offers to purchase (and retire) emissions allowances. Distributional issues are handled through the financing of the international authority, with differential funding responsibilities being established on the basis of per capita income levels and other criteria.

The environmental effectiveness of Bradford's proposal would depend on the magnitude of countries' contributions to the central authority responsible for purchasing emissions allowances. While countries have incentives to sell emissions reductions (so long as the bidding price exceeds marginal costs), the proposal may not adequately induce participation in the financing scheme. This approach reveals the costs of participation in a much more transparent manner than other policies, such as straight quantity-based systems that allow for devolution to the private sector. It has the advantage of letting countries know how much they would be spending — in total — on climate change mitigation. However, it also has the disadvantage, because of its transparency, of possibly becoming a lightning rod for political opponents.

Subject to this financing participation constraint, the central authority could purchase emissions allowances from countries over time consistent with a dynamically efficient emissions

[24]This may also be a problem with other proposals

path. The process of soliciting bids for emissions allowances would result in cost-effective emissions abatement. This policy reflects several equity principles. Bradford recommends that a country's financial contribution to the central authority depend on its per capita income (ability to pay) and the benefits it will incur from climate change mitigation (distribution of benefits). As new information becomes available, the central authority could adjust its plans to purchase emissions allowances accordingly, allowing for substantial policy flexibility, so long as countries adequately finance this authority. There is no suggestion how the agreement would enforce either contributions to the international authority or the emissions limits associated with the purchase scheme.

3.2.5 Harmonized Domestic Carbon Taxes (Cooper, 1998, 2001)

This proposal is conceptually distant from the Kyoto framework: instead of multilateral negotiations over national emissions quotas, countries would negotiate a set of common actions aimed at achieving global emissions targets. In particular, a harmonized carbon tax would be used by all participating nations — industrialized and developing alike — to tax their domestic carbon usage at a common rate, thereby achieving cost effectiveness.

This proposal by Cooper (1998, 2001) for a uniform, harmonized carbon tax raises a number of problems. First, developing countries may argue that it is unfair that they should adopt the same tax as industrialized countries, given that the latter are largely responsible for the climate change problem in the first place. Second, developing countries may have little incentive to adopt such a tax (or, indeed, substantial mitigation effected by a different policy instrument), though transfers could be used to promote participation by developing countries. Finally, adoption of a harmonized tax may create incentives for gaming behavior. Countries may change their tax codes, for example, to neutralize the effect of a carbon tax.[25]

Overall, Cooper's proposal for a uniform carbon tax shares many of the strengths of an ideal quantity-based approach (with perfect trading). Indeed, under certain conditions, the fundamental difference between the two approaches depends only on the existence of uncertainty in mitigation costs (Weitzman 1974). The weakness in Cooper's proposal is also similar to the weakness in quantity-based proposals, and in the Kyoto Protocol itself: the difficulty in enforcing participation and compliance. Cooper (2000) addresses the compliance issue, but drawing on Chayes and Chayes (1995), he argues that explicit mechanisms for compliance are not needed (refer to part 4, below, for a discussion of this point).

3.2.6 A Portfolio of Case Studies (Hahn, 1998)

Another significant departure from the "targets and time tables model" is provided by Hahn (1998), who proposes experimentation with multiple "case studies" of potential policy instruments to abate greenhouse gas emissions in the short term, including: coordinated measures; an emissions tax; tradable emission permits among some set of industrialized nations; tradable emission permits

[25]Iterative approaches may be vulnerable to similar gaming behavior. The Kyoto Protocol's CDM, for example, creates incentives for "paper trades," and the Kyoto emission limits for certain key countries were diluted in the Conference of the Parties (Six) negotiations in Bonn and Marrakech. Bradford's bidding approach may also be vulnerable to strategic manipulation.

among industrialized nations with joint implementation for developing countries; and a hybrid system.

It is difficult to assess this approach, because it depends upon the particular set of case studies that are examined, and upon their performance (and hence ultimate adoption). It can be said, however, that the approach could well be cost effective, given the apparent focus on market-based instruments. Also, this is a highly flexible approach, given the reliance on learning by doing. Essentially no attention is given to issues of participation and compliance.

3.2.7 Domestic Hybrid Trading Schemes (McKibbin and Wilcoxen, 1997, 2000, 2002)

This is largely a price-based approach, with two domestic markets for tradable permits — one for annual emissions and another for perpetuities ("endowments"). As in other proposals, governments would provide a safety-valve of permit sales at a fixed price (which can rise over time). Endowments would be made to both industrialized and developing countries, the latter well in excess of current or anticipated emissions to allow for economic growth. In this proposal, there is no international trading system.

The McKibbin and Wilcoxen proposal would likely deliver modest environmental effectiveness in the near term with its fixed emissions permit price of $10 per ton. As a relatively flexible policy approach, the authors advocate international negotiations to set the emissions permit price once per decade. To induce developing country participation, McKibbin and Wilcoxen recommend that developing countries receive emissions endowments in excess of current emissions. In contrast with proposals that allow developing countries to gain from selling unused emissions allowances to developed countries, this proposal implies only modest costs in the near term (from investments anticipating positive domestic permit prices in the future). Although it distinguishes between developed and developing countries in terms of their near-term emissions abatement, the policy may address equity concerns to a lesser degree than other proposals that use some form of implicit side-payments for developing countries. The lack of any explicit or implicit side-payments may result in non-participation by these countries.

Like several other proposals, this architecture does not address the broader participation and compliance incentives problem. If these problems were overcome, however, the approach could achieve cost-effective emissions abatement in the long term (once developing countries' emissions permit prices equaled the price in developed countries), and perhaps close to cost-effectiveness in the short term. This could support an emissions path broadly consistent with dynamic efficiency, depending on the emissions prices set at the decadal climate policy negotiations.

3.2.8 An Efficient Set of Harmonized Carbon Taxes (Nordhaus, 1998)

This proposal combines the notion of harmonized carbon taxes with attention to the efficiency of the targets. This is done by setting the harmonized carbon tax at the efficient level through a dynamic benefit-cost analysis, where the benefits are determined through an international voting mechanism which is intended to reflect countries' true willingness-to-pay. As in other proposals, developing countries participate only when their per capita incomes reach particular

threshold levels. Compliance is promoted through import duties, which are levied on goods from non-participant countries, based on carbon content, with goods from poor countries exempted.[26]

The proposed harmonized carbon taxes in the Nordhaus proposal would likely deliver modest environmental effectiveness in the near term. He recommends a low carbon tax applied only to countries above an income threshold. Consistent with an ability-to-pay notion of distributional equity, this proposal requires emissions abatement efforts only among wealthy countries. Nordhaus suggests that some form of financial side-payment will be necessary to induce developing country participation. While the policy explicitly incorporates a mechanism based on a dynamic benefit-cost analysis, the distinction between participating and non-participating countries undermines the dynamic efficiency and cost-effectiveness of the proposal.[27] By allowing countries to reveal periodically their willingness to pay for climate protection, this policy structure can adjust and adapt to new information.

3.2.9 A Global Climate Marshall Plan (Schelling, 1997, 1998, 2000)

This proposed climate policy architecture is inspired by the process of dividing up resources made available by a "Marshall Plan." The approach would be for the industrialized countries to accept mutually agreed actions. International mechanisms in pursuit of targets and time tables (such as international permit trading) are dismissed, although domestic market-based instruments are recommended.

Schelling's proposal starts from the premise that substantial enforcement, requiring effective penalties for non-compliance, is needed but cannot be supported by existing international institutions (which do not have the authority to levy credible threats of significant penalties for non-compliance). His approach is thus to look at measures that might be adopted without such penalties. Starting from this premise, Schelling's proposal would presumably not reduce emissions substantially, and so would not receive high marks for environmental effectiveness. He recognizes the desirability of efficiency and cost-effectiveness, but his proposal does not incorporate mechanisms aimed at satisfying these criteria. However, financial transfers to developing countries would help reduce emissions cost-effectively, while at the same time satisfying some notion of equity. Schelling recognizes the need for flexibility, but his approach has neither advantages nor disadvantages in this regard as compared with most of the alternatives. Participation and compliance are not directly enforced, nor does this approach require enforcement. Indeed, it is predicated on enforcement being inevitably weak.

---

[26]In a subsequent paper, Nordhaus (2002) provides a detailed comparison of price-based and quantity-based architectures, in which he strongly favors the former. The architecture which is recommended includes harmonized carbon taxes with relatively modest short-term tax levels that increase significantly over time, combined with a mechanism for developing countries to take on increasing degrees of responsibility over time.

[27]With full compliance, the policy is cost-effective among all participating countries (through the harmonized carbon tax), but implicit prices on carbon emissions would vary among participating and non-participating countries.

3.2.10 A Broad but Shallow Beginning (Schmalensee, 1996, 1998)

Schmalensee (1996, 1998) focuses on two dimensions of an international climate change agreement: the breadth of the coalition of countries that are meaningfully participating; and the depth of their commitment (stringency of targets). He argues that the most productive first step is to include as many countries as possible, but not require very severe reductions. He terms this a broad and shallow approach, in contrast with the Kyoto Protocol, which he characterizes as being narrow and deep. Schmalensee's argument is that getting a large number of nations to make commitments now is the best strategy for building the depth and breadth necessary in the long term to address the problem in meaningful ways.

In terms of environmental effectiveness, this approach would have relatively small effects in the short term, but significant effects in the long term. If the targets are sufficient, it could thus be dynamically efficient. Likewise, this approach could be cost effective, due to its reliance on market-based instruments to achieve targets. Little attention is given to cross-sectional equity, but the time path may be consistent with intertemporal equity. The approach provides considerable flexibility by starting off with modest targets. No attention is given to participation and compliance.

3.2.11 A Three-Part Policy Architecture (Stavins, 2001b)

This policy architecture is consistent with the Framework Convention on Climate Change, but departs from the Kyoto Protocol: (1) all countries participate, with an explicit mechanism providing for voluntary accession by developing countries, and a trigger, linked with per capita income, which would require developing countries to take on "growth targets," commitments that are a function of per capita income and other negotiated factors;[28] (2) in aggregate, short-term targets that are moderate yet rigid, and long-term targets — put in place now — that are much more ambitious (in order to induce needed technological change), but flexible to respond to learning; and (3) market-based instruments, including international permit trading, possibly with a safety-valve.

In terms of environmental effectiveness, abatement would be very modest in the short term, but much more ambitious in the long term. Depending upon the specific time path of adopted targets, this could yield dynamic efficiency. In any event, there is considerable promise of cost effectiveness, due to reliance on tradable permits, carbon taxes, and related hybrid systems. Cross-sectional distributional equity can be addressed through the initial allocation of permits to developing countries and the use of growth targets. Flexibility is maintained by using firm (but modest) targets in the short term, but flexible (but more ambitious) targets in the long term, to allow for response to learning. Like many of the architectural proposals, there is little direct attention given to participation and compliance, although the incentives for developing countries to participate could be considerable.

[28]See, for example: Frankel (1999). In 1999, the Argentine government offered to take on an emissions commitment indexed to its economic growth. Lutter (2000) provides an analysis.

3.2.12 Using Quotas to Attract Developing Countries (Stewart and Wiener, 2001)

This approach focuses on increasing developing country participation by four instruments: (1) a streamlined CDM; (2) voluntary participation in emissions trading without emissions quotas;[29] (3) mechanisms for voluntary accession to the emissions quota system; and (4) automatic graduation to the quota system given particular per capita incomes having been reached. Stewart and Wiener (2001) specifically focus on the need to secure the participation of major developing countries such as China and India by giving these countries "headroom allowances" — allocations in excess of their likely BAU emissions.

The proposal is intended to increase participation in a Kyoto-like agreement by reducing emissions reduction burdens in the near term. The authors suggest that developing countries should have the option to adopt voluntary emissions commitments with headroom emissions allowances as the necessary, implicit side-payment. With international emissions trading, this could further reduce the environmental effectiveness from the current status of the Kyoto agreement. While this provides an economic incentive for developing countries to participate, it does not address the participation and compliance incentive problems for developed countries or for developing countries once they are no longer net exporters of emissions allowances in future commitment periods.

The participation and compliance concerns hinder dynamic efficiency and cost-effectiveness, although the policy does aim to improve on both dimensions by expanding opportunities to take advantage of low-cost emissions abatement in developing countries. The proposal addresses equity concerns by requiring developed countries to finance emissions abatement in developing countries, whether through the expanded CDM or trade in emissions allowances under developing country commitments. It maintains essentially the same structure and timing as the Kyoto agreement, and so is comparable in its flexibility with respect to new information.

3.2.13 Increasing Compliance through Buyer Liability (Victor, 2001)

Finally, Victor (2001) proposes an approach that in the short term is similar to the Kyoto Protocol, except that individual countries can buy unlimited numbers of allowances at a specified price (safety valve). In the short term, developing countries participate through the CDM, but in the long term, a graduation mechanism is proposed for developing countries as they reach particular incomes and then must adopt either quotas (as developed countries) or growth targets. Compliance, he argues, would be promoted through a buyer liability scheme.

The environmental effectiveness of this approach is necessarily compromised by its reliance on a safety-valve approach in the short term, but the overall result could be a time path of emissions reductions much closer to the dynamically efficient path than that likely to be forthcoming with the Kyoto Protocol, for example. Reliance on market-based instruments facilitates cost effectiveness, and distributional equity is addressed through the use of growth targets. Although compliance is considered through the buyer liability scheme, the proposal does not address participation.

---

[29]This would be the international version of an "emission reduction credit" program, as opposed to a "cap-and-trade" program (see Stavins, 2002 for definitions and examples), and can be thought of — in the Kyoto Protocol context — as a national-level CDM policy.

4. MAJOR THEMES AMONG THE POLICY ARCHITECTURES

Although there is considerable diversity among these thirteen alternatives to the Kyoto Protocol, a number of themes emerge (some of which are shared by *all* of the proposals): use of relatively moderate short-term goals; provision for increased developing country participation over time; use of market-based mechanisms; cost constraints through hybrid instruments; and provision of incentives for participation and compliance (Table 1).

First, many of the proposals reflect a general concern that the Kyoto commitments are "too little, too fast," that is, insufficient to do much about the climate change problem, but excessively ambitious (and hence costly) in the short term. Therefore, nearly all of the proposals feature commitments which are moderate in the short-term and become much more stringent in the long-term.

Second, many proposals maintain that developing countries must play a more significant role over time. Several proposals (Aldy, Orszag, and Stiglitz, 2001; Schmalensee, 1996, 1998; Stavins, 2001b; Stewart and Wiener, 2001) would require developing countries to take on emission commitments in the near term. These proposals plus others (McKibbin and Wilcoxen, 1997, 2000, 2002; Nordhaus, 1998; Victor, 2001) recommend some form of graduation: an income threshold above which nations must take on emission commitments. Other proposals include developing country participation in forms that do not involve emission commitments (Bradford, 2002; Hahn, 1998). Finally, one proposal would have developing countries participate in the financing of research and development activities, but with contributions reflecting their differentiated responsibilities and capabilities (Barrett 2001, 2002b).

Third, a number of proposals provide positive incentives for developing country participation. Some would require that developing countries adopt emission ceilings but with "head room" so that these countries could become net exporters of emission allowances, providing the resources needed to finance their abatement (Aldy, Orszag, and Stiglitz, 2001; Stavins, 2001b; Stewart and Weiner, 2001). The proposal by Barrett (2001, 2003) would have developing countries be bound by the technology standards incorporated in separate protocols, but the diffusion of these technologies in developing countries would be financed by industrialized countries, also an element of Benedick's (2001) proposal.

Fourth, nearly all of the proposals would allow, encourage, or require implementation through market-based instruments. While Cooper (1998, 2001) advocates harmonized carbon taxes, most proposals favor hybrid quota-tax schemes (Aldy, Orszag, and Stiglitz, 2001; Hahn, 1998, McKibbin and Wilcoxen, 1997, 2000, 2002; Victor, 2001) or tradable permit systems (Hahn, 1998; Stavins, 2001b; Stewart and Wiener, 2001). Bradford's (2002) proposal could potentially achieve a similar, cost-effective outcome by implementing a permit purchase scheme. Efficient implementation of all such instruments would allow countries to achieve their emissions commitments at lower cost, which would presumably increase the likelihood that they would comply with their commitments. It is precisely because of concerns about compliance/participation, however, that Barrett (2001, 2003) departs from the conventional economists' prescription of

market-based instruments, and advocates collaborative R&D combined with technology standards.[30] Schelling's (1997, 1998) proposal also drops the premise that targets and timetables can be enforced internationally, although his proposal is not far from unilateralism.

Fifth, in response to concerns about the costs of complying with emissions commitments, many proposals recommend a hybrid tax-quota or pure price regimes to set a cap on marginal costs (Aldy, Orszag, and Stiglitz, 2001; Cooper, 1998, 2001; McKibbin and Wilcoxen, 1997, 2000, 2002; Stavins, 2001b; Victor, 2001). Other proposals take different approaches to limiting the costs of climate policy (Barrett, 2001, 2003; Bradford, 2002; Hahn, 1998).

Sixth, although there is widespread recognition that the Kyoto Protocol does not provide effective incentives for participation and compliance, most proposals give relatively little attention to this aspect of an international climate agreement, the chief exceptions being Barrett (2001, 2003), Victor (2001), and Wiener (1999, 2001). More broadly, advocates of policies to ensure low costs of attaining emissions commitments believe that such low costs will provide incentives for participation and compliance. Other authors (Aldy, Orszag, and Stiglitz, 2001; Nordhaus, 1998) argue that a treaty such as the Kyoto Protocol can, in principle, be enforced by means of trade restrictions. Barrett (2003) shows how trade restrictions helped enforce other agreements, but he doubts the efficacy of trade restrictions in enforcing a climate agreement relying on either targets and timetables or taxes. Cooper (2000) rejects trade restrictions for a different reason. Citing Chayes and Chayes (1995), he argues more broadly that sanctions are not needed and that transparency in governmental actions (monitoring) should provide sufficient incentive for compliance.[31]

Any pragmatic proposal addressing developing country participation must confront a difficult trade-off if the United States is to participate as well. If a proposal includes aggressive developing country commitments, the agreement may be expected to fail to elicit developing country participation, since nearly all developing countries believe that the industrialized world should take on binding emissions commitments first.[32] On the other hand, if a proposal recommends modest or

---

[30]This proposal has its own problems (lack of cost-effectiveness, for example), but the important point here is that the proposal arose from a concern about international enforcement. For most other proposals, enforcement is either assumed not to be a problem or, as in the Kyoto Protocol itself, an enforcement mechanism is added almost as an afterthought to an approach that is advocated for other virtues.

[31]The reasoning embraced by Chayes and Chayes (1995) is flawed in a number of respects. First, evidence that countries comply is not evidence that compliance is not a problem. Countries may only be complying with agreements that do not seek to change behavior or that only aim to coordinate. Second, the Chayes's do not consider the participation problem. Under the rules of international law, countries are expected to comply with treaties to which they become a party, but they are not required to participate. A country that worried about its ability to comply would thus choose not to participate. For critiques of the Chayes' reasoning, see Downs, Rocke, and Barsoon (1996) and Barrett (1999, 2003).

[32]A coalition of developing countries rebuffed New Zealand's call during the 1997 Kyoto Conference of the Parties for developing country commitments. The coalition has succeeded in keeping the topic off the agendas of subsequent Conferences of the Parties. While the case has been made that developing countries with emissions commitments could become net exporters of emissions allowances and thus enjoy gains from trade (Yellen, 1998), this argument has generated little support in the developing world. Likewise, though Cooper (1998, 2001) suggests that developing country governments would be favorably disposed toward imposing (harmonized) carbon taxes for public finance (if

no near-term emissions commitments by developing countries, the agreement may be expected to fail to gain political acceptance in the United States, as evidenced by the unanimous (95-0) passage of the Byrd-Hagel Resolution in the U.S. Senate (1997), which called for similar treatment of industrialized and developing countries in any international agreement on global climate change.[33] The notion of allowing short-term developing country participation *exclusively* through the CDM (Victor, 2001) would likely garner little support from the United States, since such participation would fall well short of the criteria specified by the Byrd-Hagel Resolution.

5. CONCLUSIONS

As the international community considers efforts to address the risks posed by global climate change, a number of issues have been raised about the design and potential impacts of climate change policy. These issues have served as the basis for our review of the Kyoto Protocol and thirteen alternative climate change policies. We have employed six criteria by which to evaluate the Protocol and these other proposals: environmental outcome, dynamic efficiency, dynamic cost-effectiveness, distributional equity, flexibility in the presence of new information, and participation and compliance. The Kyoto Protocol does not fare well along several of these dimensions, including environmental outcome, dynamic efficiency, cost-effectiveness, and participation and compliance. And none of the thirteen alternative proposals we evaluated fared well along all six dimensions.

This reflects, in part, the fundamental tensions among the criteria. For example, the typical policy trade-off between efficiency and equity also characterizes the climate change problem, especially with respect to the role of developing countries. Fully efficient and cost-effective emissions abatement would require developing countries to actively limit their greenhouse gas emissions, while ability-to-pay and responsibility notions of equity would likely exempt most developing countries from emissions abatement. Some proposals attempt to address this conflict by allocating "headroom" emissions allowances to developing countries and allowing them to participate in international emissions trading, but this weakens environmental outcomes. A number of proposals advocate cost-effective implementation, but this would only occur conditional on participation and compliance by all countries — a condition most proposals do not effectively address. In contrast, proposals that focus on creating incentives for participation and compliance do so at the expense of cost-effective implementation. And pursuing policies with a primary goal of maximizing the environmental outcome may be inconsistent with dynamic efficiency, and could undermine participation and compliance incentives.

---

not environmental) reasons, no developing country has adopted such a tax. We note as well that a number of major developing countries have substantial energy subsidies (International Energy Agency, 1999).

[33]Senate Resolution 98 (June 12, 1997) states that the United States should not be a signatory to any agreement under the Framework Convention on Climate Change which would "mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties, unless the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period." The resolution refers to five developing countries by name: China, Mexico, India, Brazil, and South Korea. Subsequently, the Clinton Administration employed the phrase, "meaningful participation by key developing countries" (Eizenstat, 1998) in a "strategic interpretation" of the Byrd-Hagel Resolution.

In our review of the thirteen policy proposals, we identified several common themes: (1) Kyoto is "too little, too fast" – high costs for a small set of participants with very modest environmental gains; (2) developing countries should play a more substantial role over time; (3) incentives should be provided to promote developing country participation; (4) implementation should focus on market-based approaches; (5) price mechanisms should be a key element of market-based approaches, either through hybrid tax-quota schemes or emissions taxes; and (6) participation and compliance incentives merit more consideration and thought than evident in most proposals.

These major themes and the tensions among the relevant criteria for evaluating climate change policy illustrate the challenge in developing and implementing an international policy regime that can effectively mitigate climate change risks in an efficient, fair, and inclusive manner. Common to most policy proposals, including the Kyoto Protocol, is an emphasis on cost-effective implementation policies and inadequate concern for participation and compliance incentives.

In light of the current international context in which countries representing a majority of the world's greenhouse gas emissions will not take on emissions commitments under the Kyoto Protocol, future analytic work should focus on policies that can attempt to reconcile efficiency and cost-effectiveness with participation and compliance. This is certainly no easy task, given the domestic and international political constraints on climate change policy. Policy-makers would certainly benefit from quantitative assessments of these trade-offs. Various modeling teams have evaluated the costs and benefits of the Kyoto Protocol. Comparable assessments of alternative policy strategies, especially those that are substantially different in form. Finally, to the extent that the Kyoto process goes forward, researchers and policy-makers alike should take advantage of the opportunity to gain information about climate change policy *in practice* in order to exploit a positive attribute of the Kyoto agreement — the flexibility to adapt to new information.

TABLE 1
ALTERNATIVE INTERNATIONAL POLICY ARCHITECTURES
FOR GLOBAL CLIMATE CHANGE

Author	Relatively Modest Short-Term Goals	Provision for Increased Developing Country Participation Over Time	Use of Market-Based Instruments	Cost Constraints through Hybrid Instruments	Provisions of Incentives for Participation and Compliance
Aldy, Orszag, & Stiglitz (2001)	U	U	U	U	
Barrett (2001, 2003)	U	U			U
Benedick (2001)	U	U	U		
Bradford (2002)		U	U		
Cooper (1998, 2001)			U	U	
Hahn (1998)	U	U	U		
McKibbin & Wilcoxen (1997, 2000)	U	U	U	U	
Nordhaus (1998, 2002)	U	U	U		
Schelling (1997, 1998)	U				
Schmalensee (1996, 1998)	U	U	U		
Stavins (2001b)	U	U	U	U	
Stewart & Wiener (2001)	U	U	U		
Victor (2001)		U	U	U	U

TABLE 2
ALTERNATIVE INTERNATIONAL POLICY ARCHITECTURES FOR GLOBAL CLIMATE CHANGE

Alternative	Environmental Outcome	Dynamic Efficiency	Cost Effectiveness	Distributional Equity	Flexibility	Incentives for Participation and Compliance
Kyoto Protocol	Probably low, given short-term nature of commitments, and poor incentives for participation and compliance.	Requires reductions that are too large in short run, and silent on reductions required for long run.	Flexible mechanisms help cost effectiveness, but non-participation by key countries reduces cost effectiveness; CDM burdened by transactions costs.	Only industrial countries (ICs) face targets, but developing countries (DCs) help shape rules. DCs receive some adaptation assistance.	Emission ceilings are locked in, but only for five-year periods.	Incentives for participation and compliance are very weak.
Aldy, Orszag, & Stiglitz (2001)	Depends on safety valve price and extent of developing country participation.	Allows for policies that could be consistent with dynamic efficiency.	International emissions trading with a safety valve would likely result in common price for all participants.	Delays mandatory emissions commitments by DCs. Safety valve funds to DCs for abatement efforts.	Commitments and safety valve price adjusted over time in response to new information.	Use of sanctions, especially on trade, to promote compliance. Incentives for developing country participation.
Barrett (2001, 2003)	Depends on the agreed standards.	Technology lock-in may impair efficiency, but increased R&D may also lower costs.	Would not equalize marginal costs across all sectors.	R&D funded according to UN scale. ICs pay for technology adoption by DCs; adaptation funded by ICs.	R&D protocol provides information about technologies to lower costs, but standards may create lock-in.	R&D investment, economies of scale, network externalities, and trade restrictions create incentives for participation. No need to enforce compliance.
Benedick (2001)	Depends on levels for R&D, technology standards, etc.	Technology lock-in may be a problem, but public sector R&D may lower costs.	Would not be a global agreement, and would not equalize marginal costs across all sectors.	ICs to transfer new technologies to DCs. US to show leadership in reducing emissions unilaterally.	R&D would provide more information about new technologies.	Participation deliberately restricted, at least initially and in some areas. No explicit mention of compliance.
Bradford (2002)	Would depend on the magnitude of financial contributions to the central authority.	Could potentially support a dynamically efficient outcome.	Common offer bid for emissions allowances to all countries would insure cost-effectiveness.	Financing obligations would reflect ability to pay and expected benefits from mitigating climate change.	Central authority could adjust emissions allowances purchases with new information over time.	Does not explicitly address enforcement of financing obligations.
Cooper (1998, 2001)	Would depend on the level of the carbon tax.	Could potentially support a dynamically efficient outcome.	Common carbon tax would be cost-effective.	Tax would be uniform, but part of revenue could be redistributed to DCs.	Tax level can be changed, to adjust to new information.	Does not incorporate explicit mechanisms. Relies on a "commitment" to treaty objectives plus transparency.

Alternative	Environmental Outcome	Dynamic Efficiency	Cost Effectiveness	Distributional Equity	Flexibility	Incentives for Participation and Compliance
Hahn (1998)	Depends upon levels at which instruments are set.	Depends upon levels and time paths of instruments.	Could be cost-effective, due to reliance on market-based and related instruments.	Depends upon allocations.	Very flexible; instruments that perform best are continued.	No attention is given to participation and compliance.
McKibbin & Wilcoxen (1997, 2000, 2002)	Relatively low carbon emissions price implies modest near-term emissions reductions.	Could potentially support a dynamically efficient outcome.	Common carbon price across all countries supports cost-effective implementation.	DCs would receive emissions endowments in excess of current emissions.	Decadal negotiations to select carbon price allows for accounting of new information.	Does not substantially address participation or compliance issues.
Nordhaus (1998, 2002)	Relatively low carbon tax implies modest near-term emissions reductions.	Could potentially support a dynamically efficient outcome.	Harmonized carbon tax insures cost-effective implementation among participating countries.	Participation conditional on per capita income. DCs would also likely receive financial transfers.	Periodic international votes allows for adjusting carbon tax to new information.	Promotes compliance through trade measures. Developing country participation supported through financial transfers.
Schelling (1997, 1998)	Would probably have little effect on emissions.	Does not front-load mitigation. Promotes R&D to reduce future mitigation costs.	Would aim to reduce emissions globally.	Financial transfers to DCs.	Emphasizes the need to act, rather than to meet a particular target.	Enforcement of compliance not needed by design.
Schmalensee (1996, 1998)	Little effect in short run, but significant effects in long term.	If targets are sufficient, could be dynamically efficient.	Could be cost-effective, due to reliance on market-based and related instruments.	Little attention given to distributional equity in the cross-section, but could provide intertemporal equity.	Quite flexible, due to focus on beginning with modest targets.	No attention given to participation and compliance issues.
Stavins (2001b)	Abatement would be very modest in the short term, but much more ambitious in the long term.	If targets are sufficient, could be dynamically efficient.	Could be cost-effective, due to reliance on tradable permits, carbon taxes, and hybrid systems.	Addresses cross-sectional distributional equity through allocation of permits and use of growth targets.	Long-term targets are flexible, to allow for effects of learning.	Little attention to participation and compliance, except for incentives for DCs.
Stewart & Wiener (2001)	Would depend on the magnitude of the "headroom" allowances given to DCs.	Dynamic efficiency weakened by participation & compliance problems.	Reliance on an expanded CDM, and participation and compliance problems undermine cost-effectiveness.	Headroom allowances to DCs plus emissions trading provide potential economic gains to poor countries.	Emission commitments would need to be periodically negotiated.	Similar to Kyoto Protocol, with exception of incentives from "headroom" allowances.
Victor (2001)	Similar in targets to KP, but with safety-valve sales of additional permits.	Better than KP in its emission path, but not defined.	Includes flexible mechanisms of Kyoto Protocol; hence, can be cost-effective.	By bringing DCs into set of nations facing binding constraints only as they become more wealthy, equity is addressed.	Subsequent periods would need to be renegotiated.	Compliance is considered through buyer liability scheme, but participation is not addressed.

REFERENCES

Aldy, J.E., Orszag, P.R., Stiglitz, J.E., 2001. Climate Change: An Agenda for Global Collective Action. Prepared for the conference on The Timing of Climate Change Policies, Pew Center on Global Climate Change, Washington, D.C., October 2001.

Andersen, M.S., 2002. "Regulation or Coordination: European Climate Policy Between Scylla and Charybdis." Paper presented at 10th Symposium of the Egon Sohmen Foundation, "Climate Protection and Emissions Trading — U.S. and European Views." Dresden, Germany, October 25-26.

Arrow, K.J., Fisher, A.C., 1974. Environmental Preservation, Uncertainty, and Irreversibility. Quarterly Journal of Economics 88, 312-319.

Arrow, K.J., J. Parikh, G. Pillet, et al., 1996. Decision-Making Frameworks for Addressing Climate Change. In: Bruce, J.P., Lee, H., Haites, E.F. (Eds.) , Climate Change 1995: Economic and Social Dimensions of Climate Change. Cambridge University Press, Cambridge, pp. 53-77.

Barrett, S., 1999. A Theory of Full International Cooperation. Journal of Theoretical Politics 11(4), 519-541.

Barrett, S., 2001. Towards a Better Climate Treaty. Policy Matters, 01-29. Washington, DC: AEI-Brookings Joint Center for Regulatory Studies. November. Reprinted in World Economics, 3(2): 35-45.

Barrett, S., 2002. Consensus Treaties. Journal of Institutional and Theoretical Economics, 158(4): 529-547.

Barrett, S., 2003. Environment and Statecraft. Oxford University Press, Oxford.

Barrett, S., Stavins, R., 2002. Increasing Participation and Compliance in International Climate Change Agreements. Working paper, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts, August 13.

Benedick, R.E., 2001. Striking a New Deal on Climate Change. Issues in Science and Technology Fall, 71-76.

Bradford, D.F., 2002. Improving on Kyoto: Greenhouse Gas Control as the Purchase of a Global Public Good. Princeton University working paper. April 30, 2002 draft.

Buchner, B., Carraro, C., Cersosimo, I., Marchiori, C., 2002. Back to Kyoto? U.S. Participation and the Linkage between R&D and Climate Cooperation. FEEM Climate Modelling and Policy Unit, Venice, Italy.

Chayes, A., Chayes, A., 1995. The New Sovereignty. Harvard University Press, Cambridge, MA.

Cooper, R., 1998. Toward a Real Treaty on Global Warming. Foreign Affairs 77(2), 66-79.

Cooper, R., 2000. International Approaches to Global Climate Change. World Bank Research Observer 15 (2), 145-172.

Cooper, R., 2001. The Kyoto Protocol: A Flawed Concept. Environmental Law Reporter 31, 11,484-11,492.

Dasgupta, P., Mäler, K.-G., Barrett, S., 1999. Intergenerational Equity, Social Discount Rates, and Global Warming. In: Portney, P.R., Weyant, J.P. (Eds.), Discounting and Intergenerational Equity. Johns Hopkins University Press, Baltimore, pp. 51-77.

Dixit, A., Pindyck, R., 1994. Investment Under Uncertainty. Princeton University Press, New York.

Downs, G.W., Rocke, D.M., Barsoon, P.N., 1996. Is the Good News About Compliance Good News About Cooperation? International Organization 50, 379-406.

Edmonds, J., Roop, J.M., Scott, M., 2001. Technological Change and Its Effects on Mitigation Costs. In: Claussen, E., Cochran, V.A., Davis, D.P. (Eds.), Climate Change Science, Strategies, and Solutions. Brill Publishing, Boston, pp. 209-226.

Eizenstat, S., 1998. Testimony before the Senate Foreign Relations Committee. February 11, 1998. United States Senate, Washington, D.C.

Flannery, B.P., 2001. Alternative Climate Proposals: An Efforts-Based Approach. Exxon Mobil Corporation. Presentation prepared for the International Conference on Climate Policy — Do We Need a New Approach?, Venice, September 6-8.

Frankel, J., 1999. Greenhouse Gas Emissions. Policy Brief No. 52. Brookings Institution, Washington, D.C.

Goulder, L.H., 2000. "Central Themes and Research Results in Global Climate Change Policy." Paper prepared for the Intergovernmental Panel on Climate Change, Working Group III, Third Assessment Report. Mimeo, Stanford, California, May.

Goulder, L.H., Stavins, R.N., 2002. An Eye on the Future: How Economists' Controversial Practice of Discounting Really Affects the Evaluation of Environmental Policies. Nature 419, 673-674.

Hahn, R.W., 1998. The Economics and Politics of Climate Change. American Enterprise Institute Press, Washington, D.C.

Hahn, R.W., Stavins R.N., 1999. What Has the Kyoto Protocol Wrought? The Real Architecture of International Tradable Permit Markets. American Enterprise Institute Press, Washington, D.C.

Hanemann, W.M., 1989. Information and the Concept of Option Value. Journal of Environmental Economics and Management 16(1), 23-37.

International Energy Agency, 1999. World Energy Outlook 1999 Insights: Looking at Energy Prices: Getting the Prices Right. Paris: IEA.

Jacoby, H.D., 1998. The Uses and Misuses of Technology Development as a Component of Climate Policy. MIT Report No. 43, MIT Joint Program on the Science and Policy of Climate Change, Cambridge, Massachusetts.

Jacoby, H.D., Ellerman, A.D., 2002. The 'Safety Valve' and Climate Policy. MIT Report No. 83, MIT Joint Program on the Science and Policy of Climate Change, Cambridge, Massachusetts.

Jaffe, A.B., Newell, R.N., Stavins, R.N. 1999. "The Induced Innovation Hypothesis and Energy-Saving Technological Change." *Quarterly Journal of Economics*, volume 114, Issue 3, pp. 941-975.

Kolstad, C.D., 1996. Learning and Stock Effects in Environmental Regulation: The Case of Greenhouse Gas Emissions. Journal of Environmental Economics and Management 31, 1-18.

Kolstad, C.D., Toman, M., 2000. The Economics of Climate Policy. Resources for the Future Discussion Paper 00-45, Washington, D.C.

Kopp, R., Morgenstern, R., Pizer, W., 1997. Something for Everyone: A Climate Policy That Both Environmentalists and Industry Can Live With. Policy Brief. Washington, D.C.: Resources for the Future.

Kopp, R., Morgenstern, R., Pizer, W., Toman, M., 1999. A Proposal for Credible Early Action in U.S. Climate Policy. Weathervane Feature. Washington, DC: Resources for the Future.

Levy, M.A., 1993. European Acid Rain: The Power of Tote-Board Diplomacy. In: Keohane, R.O., Haas, P.M., Levy, M.A. (Eds.), Institutions for the Earth: Sources of Effective Environmental Protection. MIT Press, Cambridge, MA, pp. 75-132.

Lind, R.C. (Ed.), 1982. Discounting for Time and Risk in Energy Policy. Washington, DC: Resources for the Future.

Lutter, R., 2000. Developing Countries' Greenhouse Emissions: Uncertainty and Implications for Participation in the Kyoto Protocol. Energy Journal 21(4), 93-120.

Manne, A.S., Richels, R.G., 2000. A Multi-Gas Approach to Climate Policy – With and Without GWPs. Fondazione Eni Enrico Mattei Note di Lavoro, 44/2000. June.

McKibbin, W.J., Wilcoxen, P.J., 1997. A Better Way to Slow Global Climate Change. Policy Brief No. 17. Brookings Institution, Washington, D.C.

McKibbin, W.J., Wilcoxen, P.J., 2000. Moving Beyond Kyoto. Policy Brief No. 66. Brookings Institution, Washington, D.C.

McKibbin, W.J., Wilcoxen, P.J., 2002. The Role of Economics in Climate Change Policy. Journal of Economic Perspectives 16(2), 107-129.

Narain, U., A. Fisher, 2000. "Irreversibility, Uncertainty, and Catastrophic Global Warming." Giannini Foundation Working Paper 843. Berkeley: University of California, Department of Agricultural and Resource Economics.

Newell, R., Pizer, W., 2000. Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations? Resources for the Future Discussion Paper 00-45.

Nordhaus, W.D., 1998. Is the Kyoto Protocol a Dead Duck? Are There Any Live Ducks Around? Comparison of Alternative Global Tradable Emissions Regimes. Working Paper, Department of Economics, Yale University, New Haven, CT. July 31.

Nordhaus, W.D., 2001. Global Warming Economics. Science 294, 1283-1284.

Nordhaus, W.D., 2002. After Kyoto: Alternative Mechanisms to Control Global Warming. Paper prepared for presentation at the annual meetings of the Allied Social Science Associations, Atlanta, Georgia. January 4.

Pizer, W. 1999. The Optimal Choice of Climate Change Policy in the Presence of Uncertainty. Resource and Energy Economics 21, 255-287.

Portney, P.R., Weyant, J.P. (Eds.), 1999. Discounting and Intergenerational Equity. Resources for the Future, Washington, D.C.

Reilly, J., Prinn, R., Harnisch, J., Fitzmaurice, J., Jacoby, H., Kicklighter, D., Melillo, J., Stone, P., Sokolov, A., Wang, C., 1999. Multi-Gas Assessment of the Kyoto Protocol. Nature 401, 549-555.

Roberts, M.J., Spence, M., 1976. Effluent Charges and Licenses Under Uncertainty. Journal of Public Economics 5, 193-208.

Sandalow, D.B., Bowles, I.A. 2001. Fundamentals of Treaty-Making on Climate Change. Science 292, 1839-1840.

Schelling, T.C., 1997. The Cost of Combating Global Warming: Facing the Tradeoffs. Foreign Affairs 76(6), 8-14.

Schelling, T.C., 1998. Costs and Benefits of Greenhouse Gas Reduction. American Enterprise Institute Press, Washington, D.C.

Schelling, T.C., 2002. What Makes Greenhouse Sense? Time to Rethink the Kyoto Protocol. Foreign Affairs 81(3), 2-9.

Schmalensee, R., 1993. Comparing Greenhouse Gases for Policy Purposes. Energy Journal 14(1), 245-255.

Schmalensee, R., 1996. Greenhouse Policy Architecture and Institutions. MIT Joint Program on the Science and Policy of Climate Change, Cambridge, MA.

Schmalensee, R., 1998. Greenhouse Policy Architecture and Institutions. In: Nordhaus, W.D. (Ed.), Economics and Policy Issues in Climate Change. Resources for the Future, Washington, D.C., pp. 137-158.

Stavins, R.N., 1997. Policy Instruments for Climate Change: How Can National Governments Address a Global Problem? University of Chicago Legal Forum 1997, 293-329.

Stavins, R.N., 2001a. Economic Analysis of Global Climate Change Policy: A Primer. In: Claussen, E., Cochran, V.A., Davis, D.P. (Eds.), Climate Change: Science, Strategies, and Solutions. Brill Publishing, Boston.

Stavins, R.N., 2001b. Give Bush Time on Climate Issues. Boston Globe, April 4.

Stavins, R.N., 2002. Experience with Market-Based Environmental Policy Instruments. In: Mäler, K.-G., Vincent, J. (Eds.), Handbook of Environmental Economics. Elsevier Science, Amsterdam, forthcoming.

Stewart, R.B., Wiener, J.B., 2001. Reconstructing Climate Policy: The Paths Ahead. Policy Matters, 01-23. AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C., August.

Ulph, A., Ulph, D., 1997. Global Warming, Irreversibility, and Learning. Economic Journal 107, 636-650.

Victor, D.G., 2001. International Agreements and the Struggle to Tame Carbon. July 4.

Victor, D.G., Raustiala, K., Skolnikoff, E.B. (Eds.), 1998. The Implementation and Effectiveness of International Environmental Commitments: Theory and Practice. MIT Press, Cambridge, MA.

Victor, D.G., Salt, J.E., 1995. Keeping the Climate Treaty Relevant. Nature 373 (6512), 280-282.

Watson, R.T. (Ed.), 2001. Climate Change 2001: Synthesis Report. Contribution of Working Group I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Weitzman, M.L., 1974. Prices vs. Quantities. Review of Economic Studies 41(4), 477-491.

Weitzman, M.L., 2001. Gamma Discounting. American Economic Review 91(1), 260-271.

Wiener, J.B., 1999. Global Environmental Regulation: Instrument Choice in Legal Context. Yale Law Journal 108, 677-800.

Wiener, J.B., 2001. Designing Global Climate Regulation. In: Schneider, S., Rosencranz, A., Niles, J. (Eds.), The Stanford Reader in Global Climate Change Policy.

Wigley, T.M.L., Richels, R., Edmonds, J.A., 1996. Economic and Environmental Choices in the Stabilization of Atmospheric CO_2 Concentrations. Nature 379, 240-243.

Yellen, J., 1998. Testimony before the House of Representatives Commerce Committee, Subcommittee on Energy and Power. October 6. United States House of Representatives, Washington, D.C.

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI
Fondazione Eni Enrico Mattei Working Paper Series
Our working papers are available on the Internet at the following addresses:
http://www.feem.it/Feem/Pub/Publications/WPapers/default.html
http://papers.ssrn.com

SUST	1.2002	*K. TANO, M.D. FAMINOW, M. KAMUANGA and B. SWALLOW*: Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa
ETA	2.2002	*Efrem CASTELNUOVO and Paolo SURICO*: What Does Monetary Policy Reveal about Central Bank's Preferences?
WAT	3.2002	*Duncan KNOWLER and Edward BARBIER*: The Economics of a "Mixed Blessing" Effect: A Case Study of the Black Sea
CLIM	4.2002	*Andreas LÖSCHEL*: Technological Change in Economic Models of Environmental Policy: A Survey
VOL	5.2002	*Carlo CARRARO and Carmen MARCHIORI*: Stable Coalitions
CLIM	6.2002	*Marzio GALEOTTI, Alessandro LANZA and Matteo MANERA*: Rockets and Feathers Revisited: An International Comparison on European Gasoline Markets
ETA	7.2002	*Effrosyni DIAMANTOUDI and Eftichios S. SARTZETAKIS*: Stable International Environmental Agreements: An Analytical Approach
KNOW	8.2002	*Alain DESDOIGTS*: Neoclassical Convergence Versus Technological Catch-up: A Contribution for Reaching a Consensus
NRM	9.2002	*Giuseppe DI VITA:* Renewable Resources and Waste Recycling
KNOW	10.2002	*Giorgio BRUNELLO*: Is Training More Frequent when Wage Compression is Higher? Evidence from 11 European Countries
ETA	11.2002	*Mordecai KURZ, Hehui JIN and Maurizio MOTOLESE*: Endogenous Fluctuations and the Role of Monetary Policy
KNOW	12.2002	*Reyer GERLAGH and Marjan W. HOFKES:* Escaping Lock-in: The Scope for a Transition towards Sustainable Growth?
NRM	13.2002	*Michele MORETTO and Paolo ROSATO*: The Use of Common Property Resources: A Dynamic Model
CLIM	14.2002	*Philippe QUIRION*: Macroeconomic Effects of an Energy Saving Policy in the Public Sector
CLIM	15.2002	*Roberto ROSON*: Dynamic and Distributional Effects of Environmental Revenue Recycling Schemes: Simulations with a General Equilibrium Model of the Italian Economy
CLIM	16.2002	*Francesco RICCI* (l): Environmental Policy Growth when Inputs are Differentiated in Pollution Intensity
ETA	17.2002	*Alberto PETRUCCI*: Devaluation (Levels versus Rates) and Balance of Payments in a Cash-in-Advance Economy
Coalition Theory Network	18.2002	*László Á. KÓCZY* (liv)*:* The Core in the Presence of Externalities
Coalition Theory Network	19.2002	*Steven J. BRAMS, Michael A. JONES and D. Marc KILGOUR* (liv): Single-Peakedness and Disconnected Coalitions
Coalition Theory Network	20.2002	*Guillaume HAERINGER* (liv): On the Stability of Cooperation Structures
NRM	21.2002	*Fausto CAVALLARO and Luigi CIRAOLO:* Economic and Environmental Sustainability: A Dynamic Approach in Insular Systems
CLIM	22.2002	*Barbara BUCHNER, Carlo CARRARO, Igor CERSOSIMO and Carmen MARCHIORI*: Back to Kyoto? US Participation and the Linkage between R&D and Climate Cooperation
CLIM	23.2002	*Andreas LÖSCHEL and ZhongXIANG ZHANG:* The Economic and Environmental Implications of the US Repudiation of the Kyoto Protocol and the Subsequent Deals in Bonn and Marrakech
ETA	24.2002	*Marzio GALEOTTI, Louis J. MACCINI and Fabio SCHIANTARELLI*: Inventories, Employment and Hours
CLIM	25.2002	*Hannes EGLI:* Are Cross-Country Studies of the Environmental Kuznets Curve Misleading? New Evidence from Time Series Data for Germany
ETA	26.2002	*Adam B. JAFFE, Richard G. NEWELL and Robert N. STAVINS*: Environmental Policy and Technological Change
SUST	27.2002	*Joseph C. COOPER and Giovanni SIGNORELLO*: Farmer Premiums for the Voluntary Adoption of Conservation Plans
SUST	28.2002	*The ANSEA Network*: Towards An Analytical Strategic Environmental Assessment
KNOW	29.2002	*Paolo SURICO*: Geographic Concentration and Increasing Returns: a Survey of Evidence
ETA	30.2002	*Robert N. STAVINS:* Lessons from the American Experiment with Market-Based Environmental Policies

NRM	31.2002	*Carlo GIUPPONI and Paolo ROSATO:* Multi-Criteria Analysis and Decision-Support for Water Management at the Catchment Scale: An Application to Diffuse Pollution Control in the Venice Lagoon
NRM	32.2002	*Robert N. STAVINS*: National Environmental Policy During the Clinton Years
KNOW	33.2002	*A. SOUBEYRAN and H. STAHN* : Do Investments in Specialized Knowledge Lead to Composite Good Industries?
KNOW	34.2002	*G. BRUNELLO, M.L. PARISI and Daniela SONEDDA:* Labor Taxes, Wage Setting and the Relative Wage Effect
CLIM	35.2002	*C. BOEMARE and P. QUIRION* (lv): Implementing Greenhouse Gas Trading in Europe: Lessons from Economic Theory and International Experiences
CLIM	36.2002	*T.TIETENBERG* (lv): The Tradable Permits Approach to Protecting the Commons: What Have We Learned?
CLIM	37.2002	*K. REHDANZ and R.J.S. TOL* (lv): On National and International Trade in Greenhouse Gas Emission Permits
CLIM	38.2002	*C. FISCHER* (lv): Multinational Taxation and International Emissions Trading
SUST	39.2002	*G. SIGNORELLO and G. PAPPALARDO:* Farm Animal Biodiversity Conservation Activities in Europe under the Framework of Agenda 2000
NRM	40.2002	*S .M. CAVANAGH, W. M. HANEMANN and R. N. STAVINS:* Muffled Price Signals: Household Water Demand under Increasing-Block Prices
NRM	41.2002	*A. J. PLANTINGA, R. N. LUBOWSKI and R. N. STAVINS:* The Effects of Potential Land Development on Agricultural Land Prices
CLIM	42.2002	*C. OHL* (lvi): Inducing Environmental Co-operation by the Design of Emission Permits
CLIM	43.2002	*J. EYCKMANS, D. VAN REGEMORTER and V. VAN STEENBERGHE* (lvi): Is Kyoto Fatally Flawed? An Analysis with MacGEM
CLIM	44.2002	*A. ANTOCI and S. BORGHESI* (lvi): Working Too Much in a Polluted World: A North-South Evolutionary Model
ETA	45.2002	*P. G. FREDRIKSSON, Johan A. LIST and Daniel MILLIMET* (lvi): Chasing the Smokestack: Strategic Policymaking with Multiple Instruments
ETA	46.2002	*Z. YU* (lvi): A Theory of Strategic Vertical DFI and the Missing Pollution-Haven Effect
SUST	47.2002	*Y. H. FARZIN*: Can an Exhaustible Resource Economy Be Sustainable?
SUST	48.2002	*Y. H. FARZIN*: Sustainability and Hamiltonian Value
KNOW	49.2002	*C. PIGA and M. VIVARELLI*: Cooperation in R&D and Sample Selection
Coalition Theory Network	50.2002	*M. SERTEL and A. SLINKO* (liv): Ranking Committees, Words or Multisets
Coalition Theory Network	51.2002	*Sergio CURRARINI* (liv): Stable Organizations with Externalities
ETA	52.2002	*Robert N. STAVINS*: Experience with Market-Based Policy Instruments
ETA	53.2002	*C.C. JAEGER, M. LEIMBACH, C. CARRARO, K. HASSELMANN, J.C. HOURCADE, A. KEELER and R. KLEIN* (liii): Integrated Assessment Modeling: Modules for Cooperation
CLIM	54.2002	*Scott BARRETT* (liii)*:* Towards a Better Climate Treaty
ETA	55.2002	*Richard G. NEWELL and Robert N. STAVINS*: Cost Heterogeneity and the Potential Savings from Market-Based Policies
SUST	56.2002	*Paolo ROSATO and Edi DEFRANCESCO*: Individual Travel Cost Method and Flow Fixed Costs
SUST	57.2002	*Vladimir KOTOV and Elena NIKITINA* (lvii): Reorganisation of Environmental Policy in Russia: The Decade of Success and Failures in Implementation of Perspective Quests
SUST	58.2002	*Vladimir KOTOV* (lvii): Policy in Transition: New Framework for Russia's Climate Policy
SUST	59.2002	*Fanny MISSFELDT and Arturo VILLAVICENCO* (lvii): How Can Economies in Transition Pursue Emissions Trading or Joint Implementation?
VOL	60.2002	*Giovanni DI BARTOLOMEO, Jacob ENGWERDA, Joseph PLASMANS and Bas VAN AARLE:* Staying Together or Breaking Apart: Policy-Makers' Endogenous Coalitions Formation in the European Economic and Monetary Union
ETA	61.2002	*Robert N. STAVINS, Alexander F.WAGNER and Gernot WAGNER*: Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity
PRIV	62.2002	*Carlo CAPUANO*: Demand Growth, Entry and Collusion Sustainability
PRIV	63.2002	*Federico MUNARI and Raffaele ORIANI*: Privatization and R&D Performance: An Empirical Analysis Based on Tobin's Q
PRIV	64.2002	*Federico MUNARI and Maurizio SOBRERO*: The Effects of Privatization on R&D Investments and Patent Productivity
SUST	65.2002	*Orley ASHENFELTER and Michael GREENSTONE*: Using Mandated Speed Limits to Measure the Value of a Statistical Life
ETA	66.2002	*Paolo SURICO:* US Monetary Policy Rules: the Case for Asymmetric Preferences
PRIV	67.2002	*Rinaldo BRAU and Massimo FLORIO*: Privatisations as Price Reforms: Evaluating Consumers' Welfare Changes in the U.K.
CLIM	68.2002	*Barbara K. BUCHNER and Roberto ROSON*: Conflicting Perspectives in Trade and Environmental Negotiations
CLIM	69.2002	*Philippe QUIRION*: Complying with the Kyoto Protocol under Uncertainty: Taxes or Tradable Permits?
SUST	70.2002	*Anna ALBERINI, Patrizia RIGANTI and Alberto LONGO*: Can People Value the Aesthetic and Use Services of Urban Sites? Evidence from a Survey of Belfast Residents
SUST	71.2002	*Marco PERCOCO:* Discounting Environmental Effects in Project Appraisal

NRM	72.2002	*Philippe BONTEMS and Pascal FAVARD*: Input Use and Capacity Constraint under Uncertainty: The Case of Irrigation
PRIV	73.2002	*Mohammed OMRAN:* The Performance of State-Owned Enterprises and Newly Privatized Firms: Empirical Evidence from Egypt
PRIV	74.2002	*Mike BURKART, Fausto PANUNZI and Andrei SHLEIFER:* Family Firms
PRIV	75.2002	*Emmanuelle AURIOL, Pierre M. PICARD:* Privatizations in Developing Countries and the Government Budget Constraint
PRIV	76.2002	*Nichole M. CASTATER***:** Privatization as a Means to Societal Transformation: An Empirical Study of Privatization in Central and Eastern Europe and the Former Soviet Union
PRIV	77.2002	*Christoph LÜLSFESMANN*: Benevolent Government, Managerial Incentives, and the Virtues of Privatization
PRIV	78.2002	*Kate BISHOP, Igor FILATOTCHEV and Tomasz MICKIEWICZ*: Endogenous Ownership Structure: Factors Affecting the Post-Privatisation Equity in Largest Hungarian Firms
PRIV	79.2002	*Theodora WELCH and Rick MOLZ*: How Does Trade Sale Privatization Work? Evidence from the Fixed-Line Telecommunications Sector in Developing Economies
PRIV	80.2002	*Alberto R. PETRUCCI*: Government Debt, Agent Heterogeneity and Wealth Displacement in a Small Open Economy
CLIM	81.2002	*Timothy SWANSON and Robin MASON* (lvi): The Impact of International Environmental Agreements: The Case of the Montreal Protocol
PRIV	82.2002	*George R.G. CLARKE and Lixin Colin XU:* Privatization, Competition and Corruption: How Characteristics of Bribe Takers and Payers Affect Bribe Payments to Utilities
PRIV	83.2002	*Massimo FLORIO and Katiuscia MANZONI*: The Abnormal Returns of UK Privatisations: From Underpricing to Outperformance
NRM	84.2002	*Nelson LOURENÇO, Carlos RUSSO MACHADO, Maria do ROSÁRIO JORGE and Luís RODRIGUES*: An Integrated Approach to Understand Territory Dynamics. The Coastal Alentejo (Portugal)
CLIM	85.2002	*Peter ZAPFEL and Matti VAINIO* (lv): Pathways to European Greenhouse Gas Emissions Trading History and Misconceptions
CLIM	86.2002	*Pierre COURTOIS*: Influence Processes in Climate Change Negotiations: Modelling the Rounds
ETA	87.2002	*Vito FRAGNELLI and Maria Erminia MARINA* (lviii): Environmental Pollution Risk and Insurance
ETA	88.2002	*Laurent FRANCKX* (lviii): Environmental Enforcement with Endogenous Ambient Monitoring
ETA	89.2002	*Timo GOESCHL and Timothy M. SWANSON* (lviii): Lost Horizons. The noncooperative management of an evolutionary biological system.
ETA	90.2002	*Hans KEIDING* (lviii): Environmental Effects of Consumption: An Approach Using DEA and Cost Sharing
ETA	91.2002	*Wietze LISE* (lviii): A Game Model of People's Participation in Forest Management in Northern India
CLIM	92.2002	*Jens HORBACH*: Structural Change and Environmental Kuznets Curves
ETA	93.2002	*Martin P. GROSSKOPF:* Towards a More Appropriate Method for Determining the Optimal Scale of Production Units
VOL	94.2002	*Scott BARRETT and Robert STAVINS*: Increasing Participation and Compliance in International Climate Change Agreements
CLIM	95.2002	*Banu BAYRAMOGLU LISE and Wietze LISE:* Climate Change, Environmental NGOs and Public Awareness in the Netherlands: Perceptions and Reality
CLIM	96.2002	*Matthieu GLACHANT*: The Political Economy of Emission Tax Design in Environmental Policy
KNOW	97.2002	*Kenn ARIGA and Giorgio BRUNELLO*: Are the More Educated Receiving More Training? Evidence from Thailand
ETA	98.2002	*Gianfranco FORTE and Matteo MANERA*: Forecasting Volatility in European Stock Markets with Non-linear GARCH Models
ETA	99.2002	*Geoffrey HEAL*: Bundling Biodiversity
ETA	100.2002	*Geoffrey HEAL, Brian WALKER, Simon LEVIN, Kenneth ARROW, Partha DASGUPTA, Gretchen DAILY, Paul EHRLICH, Karl-Goran MALER, Nils KAUTSKY, Jane LUBCHENCO, Steve SCHNEIDER and David STARRETT*: Genetic Diversity and Interdependent Crop Choices in Agriculture
ETA	101.2002	*Geoffrey HEAL:* Biodiversity and Globalization
VOL	102.2002	*Andreas LANGE*: Heterogeneous International Agreements – If per capita emission levels matter
ETA	103.2002	*Pierre-André JOUVET and Walid OUESLATI*: Tax Reform and Public Spending Trade-offs in an Endogenous Growth Model with Environmental Externality
ETA	104.2002	*Anna BOTTASSO and Alessandro SEMBENELLI*: Does Ownership Affect Firms' Efficiency? Panel Data Evidence on Italy
PRIV	105.2002	*Bernardo BORTOLOTTI, Frank DE JONG, Giovanna NICODANO and Ibolya SCHINDELE*: Privatization and Stock Market Liquidity
ETA	106.2002	*Haruo IMAI and Mayumi HORIE* (lviii): Pre-Negotiation for an International Emission Reduction Game
PRIV	107.2002	*Sudeshna GHOSH BANERJEE and Michael C. MUNGER*: Move to Markets? An Empirical Analysis of Privatisation in Developing Countries
PRIV	108.2002	*Guillaume GIRMENS and Michel GUILLARD*: Privatization and Investment: Crowding-Out Effect vs Financial Diversification
PRIV	109.2002	*Alberto CHONG and Florencio LÓPEZ-DE-SILANES*: Privatization and Labor Force Restructuring Around the World
PRIV	110.2002	*Nandini GUPTA*: Partial Privatization and Firm Performance
PRIV	111.2002	*François DEGEORGE, Dirk JENTER, Alberto MOEL and Peter TUFANO*: Selling Company Shares to Reluctant Employees: France Telecom's Experience

PRIV	112.2002	*Isaac OTCHERE*: Intra-Industry Effects of Privatization Announcements: Evidence from Developed and Developing Countries
PRIV	113.2002	*Yannis KATSOULAKOS and Elissavet LIKOYANNI*: Fiscal and Other Macroeconomic Effects of Privatization
PRIV	114.2002	*Guillaume GIRMENS:* Privatization, International Asset Trade and Financial Markets
PRIV	115.2002	*D. Teja FLOTHO:* A Note on Consumption Correlations and European Financial Integration
PRIV	116.2002	*Ibolya SCHINDELE and Enrico C. PEROTTI*: Pricing Initial Public Offerings in Premature Capital Markets: The Case of Hungary
PRIV	1.2003	*Gabriella CHIESA and Giovanna NICODANO*: Privatization and Financial Market Development: Theoretical Issues
PRIV	2.2003	*Ibolya SCHINDELE*: Theory of Privatization in Eastern Europe: Literature Review
PRIV	3.2003	*Wietze LISE, Claudia KEMFERT and Richard S.J. TOL*: Strategic Action in the Liberalised German Electricity Market
CLIM	4.2003	*Laura MARSILIANI and Thomas I. RENSTRÖM*: Environmental Policy and Capital Movements: The Role of Government Commitment
KNOW	5.2003	*Reyer GERLAGH*: Induced Technological Change under Technological Competition
ETA	6.2003	*Efrem CASTELNUOVO*: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model
SIEV	7.2003	*Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI:* The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers
NRM	8.2003	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources: A Blessing or a Curse?
CLIM	9.2003	*A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT*: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information
KNOW	10.2003	*Giorgio BRUNELLO and Daniele CHECCHI*: School Quality and Family Background in Italy
CLIM	11.2003	*Efrem CASTELNUOVO and Marzio GALEOTTI*: Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis
KNOW	12.2003	*Carole MAIGNAN, Gianmarco OTTAVIANO and Dino PINELLI (eds.)*: Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A critical survey of the state-of-the-art
KNOW	13.2003	*Carole MAIGNAN, Gianmarco OTTAVIANO, Dino PINELLI and Francesco RULLANI* (lix): Bio-Ecological Diversity vs. Socio-Economic Diversity. A Comparison of Existing Measures
KNOW	14.2003	*Maddy JANSSENS and Chris STEYAERT* (lix): Theories of Diversity within Organisation Studies: Debates and Future Trajectories
KNOW	15.2003	*Tuzin BAYCAN LEVENT, Enno MASUREL and Peter NIJKAMP* (lix): Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life
KNOW	16.2003	*Alexandra BITUSIKOVA* (lix): Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia
KNOW	17.2003	*Billy E. VAUGHN and Katarina MLEKOV* (lix): A Stage Model of Developing an Inclusive Community
KNOW	18.2003	*Selma van LONDEN and Arie de RUIJTER* (lix): Managing Diversity in a Glocalizing World
Coalition Theory Network	19.2003	*Sergio CURRARINI:* On the Stability of Hierarchies in Games with Externalities
PRIV	20.2003	*Giacomo CALZOLARI and Alessandro PAVAN* (lx): Monopoly with Resale
PRIV	21.2003	*Claudio MEZZETTI* (lx): Auction Design with Interdependent Valuations: The Generalized Revelation Principle, Efficiency, Full Surplus Extraction and Information Acquisition
PRIV	22.2003	*Marco LiCalzi and Alessandro PAVAN* (lx): Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions
PRIV	23.2003	*David ETTINGER* (lx): Bidding among Friends and Enemies
PRIV	24.2003	*Hannu VARTIAINEN* (lx): Auction Design without Commitment
PRIV	25.2003	*Matti KELOHARJU, Kjell G. NYBORG and Kristian RYDQVIST* (lx): Strategic Behavior and Underpricing in Uniform Price Auctions: Evidence from Finnish Treasury Auctions
PRIV	26.2003	*Christine A. PARLOUR and Uday RAJAN* (lx): Rationing in IPOs
PRIV	27.2003	*Kjell G. NYBORG and Ilya A. STREBULAEV* (lx): Multiple Unit Auctions and Short Squeezes
PRIV	28.2003	*Anders LUNANDER and Jan-Eric NILSSON* (lx): Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts
PRIV	29.2003	*TangaMcDANIEL and Karsten NEUHOFF* (lx): Use of Long-term Auctions for Network Investment
PRIV	30.2003	*Emiel MAASLAND and Sander ONDERSTAL* (lx): Auctions with Financial Externalities
ETA	31.2003	*Michael FINUS and Bianca RUNDSHAGEN:* A Non-cooperative Foundation of Core-Stability in Positive Externality NTU-Coalition Games
KNOW	32.2003	*Michele MORETTO*: Competition and Irreversible Investments under Uncertainty
PRIV	33.2003	*Philippe QUIRION:* Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?
KNOW	34.2003	*Giuseppe MEDA, Claudio PIGA and Donald SIEGEL*: On the Relationship between R&D and Productivity: A Treatment Effect Analysis
ETA	35.2003	*Alessandra DEL BOCA, Marzio GALEOTTI and Paola ROTA:* Non-convexities in the Adjustment of Different Capital Inputs: A Firm-level Investigation

GG	36.2003	*Matthieu GLACHANT*: Voluntary Agreements under Endogenous Legislative Threats
PRIV	37.2003	*Narjess BOUBAKRI, Jean-Claude COSSET and Omrane GUEDHAMI*: Postprivatization Corporate Governance: the Role of Ownership Structure and Investor Protection
CLIM	38.2003	*Rolf GOLOMBEK and Michael HOEL*: Climate Policy under Technology Spillovers
KNOW	39.2003	*Slim BEN YOUSSEF*: Transboundary Pollution, R&D Spillovers and International Trade
CTN	40.2003	*Carlo CARRARO and Carmen MARCHIORI*: Endogenous Strategic Issue Linkage in International Negotiations
KNOW	41.2003	*Sonia OREFFICE*: Abortion and Female Power in the Household: Evidence from Labor Supply
KNOW	42.2003	*Timo GOESCHL and Timothy SWANSON*: On Biology and Technology: The Economics of Managing Biotechnologies
ETA	43.2003	*Giorgio BUSETTI and Matteo MANERA*: STAR-GARCH Models for Stock Market Interactions in the Pacific Basin Region, Japan and US
CLIM	44.2003	*Katrin MILLOCK and Céline NAUGES*: The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness
PRIV	45.2003	*Bernardo BORTOLOTTI and Paolo PINOTTI*: The Political Economy of Privatization
SIEV	46.2003	*Elbert DIJKGRAAF and Herman R.J. VOLLEBERGH*: Burn or Bury? A Social Cost Comparison of Final Waste Disposal Methods
ETA	47.2003	*Jens HORBACH*: Employment and Innovations in the Environmental Sector: Determinants and Econometrical Results for Germany
CLIM	48.2003	*Lori SNYDER, Nolan MILLER and Robert STAVINS:* The Effects of Environmental Regulation on Technology Diffusion: The Case of Chlorine Manufacturing
CLIM	49.2003	*Lori SNYDER, Robert STAVINS and Alexander F. WAGNER*: Private Options to Use Public Goods. Exploiting Revealed Preferences to Estimate Environmental Benefits
CTN	50.2003	*László Á. KÓCZY and Luc LAUWERS* (lxi): The Minimal Dominant Set is a Non-Empty Core-Extension
CTN	51.2003	*Matthew O. JACKSON* (lxi)*:* Allocation Rules for Network Games
CTN	52.2003	*Ana MAULEON and Vincent VANNETELBOSCH* (lxi): Farsightedness and Cautiousness in Coalition Formation
CTN	53.2003	*Fernando VEGA-REDONDO* (lxi): Building Up Social Capital in a Changing World: a network approach
CTN	54.2003	*Matthew HAAG and Roger LAGUNOFF* (lxi): On the Size and Structure of Group Cooperation
CTN	55.2003	*Taiji FURUSAWA and Hideo KONISHI* (lxi): Free Trade Networks
CTN	56.2003	*Halis Murat YILDIZ* (lxi): National Versus International Mergers and Trade Liberalization
CTN	57.2003	*Santiago RUBIO and Alistair ULPH* (lxi): An Infinite-Horizon Model of Dynamic Membership of International Environmental Agreements
KNOW	58.2003	*Carole MAIGNAN, Dino PINELLI and Gianmarco I.P. OTTAVIANO*: ICT, Clusters and Regional Cohesion: A Summary of Theoretical and Empirical Research
KNOW	59.2003	*Giorgio BELLETTINI and Gianmarco I.P. OTTAVIANO:* Special Interests and Technological Change
ETA	60.2003	*Ronnie SCHÖB:* The Double Dividend Hypothesis of Environmental Taxes: A Survey
CLIM	61.2003	*Michael FINUS, Ekko van IERLAND and Robert DELLINK*: Stability of Climate Coalitions in a Cartel Formation Game
GG	62.2003	*Michael FINUS and Bianca RUNDSHAGEN*: How the Rules of Coalition Formation Affect Stability of International Environmental Agreements
SIEV	63.2003	*Alberto PETRUCCI:* Taxing Land Rent in an Open Economy
CLIM	64.2003	*Joseph E. ALDY, Scott BARRETT and Robert N. STAVINS*: Thirteen Plus One: A Comparison of Global Climate Policy Architectures

(l) This paper was presented at the Workshop "Growth, Environmental Policies and Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001
(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001
(lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001
(liii) This paper was circulated at the International Conference on "Climate Policy – Do We Need a New Approach?", jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001
(liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002
(lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001
(lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy "The International Dimension of Environmental Policy", organised with the collaboration of the Fondazione Eni Enrico Mattei , Acquafredda di Maratea, October 6-11, 2001
(lvii) This paper was presented at the First Workshop of "CFEWE – Carbon Flows between Eastern and Western Europe", organised by the Fondazione Eni Enrico Mattei and Zentrum fur Europaische Integrationsforschung (ZEI), Milan, July 5-6, 2001
(lviii) This paper was presented at the Workshop on "Game Practice and the Environment", jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002
(lix) This paper was presented at the ENGIME Workshop on "Mapping Diversity", Leuven, May 16-17, 2002
(lx) This paper was presented at the EuroConference on "Auctions and Market Design: Theory, Evidence and Applications", organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002
(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003

2002 SERIES

CLIM *Climate Change Modelling and Policy* (Editor: Marzio Galeotti)

VOL *Voluntary and International Agreements* (Editor: Carlo Carraro)

SUST *Sustainability Indicators and Environmental Valuation* (Editor: Carlo Carraro)

NRM *Natural Resources Management* (Editor: Carlo Giupponi)

KNOW *Knowledge, Technology, Human Capital* (Editor: Dino Pinelli)

MGMT *Corporate Sustainable Management* (Editor: Andrea Marsanich)

PRIV *Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)

ETA *Economic Theory and Applications* (Editor: Carlo Carraro)

2003 SERIES

CLIM *Climate Change Modelling and Policy* (Editor: Marzio Galeotti)

GG *Global Governance* (Editor: Carlo Carraro)

SIEV *Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)

NRM *Natural Resources Management* (Editor: Carlo Giupponi)

KNOW *Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)

IEM *International Energy Markets* (Editor: Anil Markandya)

CSRM *Corporate Social Responsibility and Management* (Editor: Sabina Ratti)

PRIV *Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)

ETA *Economic Theory and Applications* (Editor: Carlo Carraro)

CTN *Coalition Theory Network*