



## Thirteen plus one: a comparison of global climate policy architectures

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### Abstract

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 (DCs) 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.

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### 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, 2001). The Kyoto Protocol to the UN Framework Convention on Climate Change (FCCC) 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<sup>1</sup> have been proposed, including thirteen that have been developed by economists

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<sup>1</sup> 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).

and other scholars. In this paper, we review these thirteen proposals plus the Kyoto Protocol in the light of key performance criteria. Our review emphasizes economic and design aspects of climate regimes. We give less attention to the politics of regime formation. The latter is important, particularly in comparing Kyoto with the alternatives. While Kyoto has been shaped and molded by a political process, the alternatives have been designed only “on paper”. Nonetheless, the proposals have been developed in response to perceived design flaws in the Kyoto approach, and hence it is reasonable and, we believe, useful to compare Kyoto with the alternatives on the basis of their fundamental architectures.

In [Section 2](#) of the paper, we explore the six criteria for assessing global climate policy regimes. In [Section 3](#), we describe the fundamental characteristics of the Kyoto Protocol and alternative policy architectures; and in [Section 4](#), we synthesize the key architectural elements of the proposed climate regimes. In [Section 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.<sup>2</sup> 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 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.<sup>3</sup> 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).

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<sup>2</sup> 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.

<sup>3</sup> 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 reductions) than in efficiency. To some observers, “more emission reductions are better,” whatever a comparison of benefits and costs may suggest, but fundamental trade-offs cannot be avoided, even from a strictly environmental perspective. Under some plans, for example, emission reductions would be achieved by greater use of nuclear power, an outcome that would not be welcomed by most champions of the environmental outcome criterion.

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.<sup>4</sup>

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. There may be a shift in production of greenhouse-gas-intensive output. 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. Therefore, a “narrow-but-deep” agreement may not significantly reduce net emissions, but largely redistribute emissions.<sup>5</sup>

## 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*.<sup>6</sup> 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: 50–70 years for electricity generators, and 60–100 years for residential buildings, for example (Jaffe et al., 1999). Exogenous and

<sup>4</sup> The Helsinki Protocol, for example, required that parties reduce their sulfur dioxide emissions by 30%. Actual emissions fell by more than 30%. 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.

<sup>5</sup> Estimates of the magnitude of leakage vary widely. In the case of a unilateral reduction in emissions by the European Union, estimated leakage rates range from 2 to 80% (see Fisher et al., 1996). That is, for every 100 tonnes of carbon abated by the EU, global emissions could fall from 20 to 98 tonnes.

<sup>6</sup> 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).

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.<sup>7</sup>

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.<sup>8</sup>

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 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.<sup>9</sup>

### 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.<sup>10</sup>

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.

<sup>7</sup> 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 5-year period.

<sup>8</sup> 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 et al., 1999).

<sup>9</sup> 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).

<sup>10</sup> 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.

## 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 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 (DCs) should shoulder a relatively higher burden, as compared with the other equity criteria.<sup>11</sup>

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.

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<sup>11</sup> Note, however, 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. This is because industrialized countries have much higher levels of national income, and, thus more to lose economically for a given percentage loss in gross domestic product.

### 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).<sup>12</sup>

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.

<sup>12</sup> A review of the theory and practice of international cooperation suggests there is not a trade-off between full participation and full compliance (Barrett, 1999, 2003). While participation in international environmental agreements varies widely, compliance appears to be full, irrespective of participation level (Chayes and Chayes, 1995). One reason is that customary international law requires that countries comply with agreements to which they are parties. Another reason is that countries can easily—and legally—avoid the need to comply simply by failing to participate.

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 et al. (2001)	✓	✓	✓	✓	
Barrett (2001, 2003)	✓	✓			✓
Benedick (2001)	✓	✓	✓		
Bradford (2002)		✓	✓		
Cooper (1998, 2001)			✓	✓	
Hahn (1998)	✓	✓	✓		
McKibbin and Wilcoxon (1997, 2000)	✓	✓	✓	✓	
Nordhaus (1998, 2002)	✓	✓	✓		
Schelling (1997, 1998)	✓				
Schmalensee (1996, 1998)	✓	✓	✓		
Stavins (2001b)	✓	✓	✓	✓	
Stewart and Wiener (2001)	✓	✓	✓		
Victor (2001)		✓	✓	✓	✓

### 3. Alternative global climate treaty architectures

We now turn to a review of the fundamental architecture of the Framework Convention on Climate Change (FCCC) 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, 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<sup>13</sup>) to their 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

<sup>13</sup> These include the developed nations plus economies in transition.

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”.<sup>14</sup> These emissions targets are expressed relative to countries’ emissions in the year 1990.<sup>15</sup> The relative commitments range from 8% below 1990 levels (for the European Union) to 10% *above* 1990 levels (in the case of Australia).<sup>16</sup> 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% 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% 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% 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.<sup>17</sup> These targets apply to six classes of greenhouse gases: carbon dioxide (CO<sub>2</sub>), methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>).<sup>18</sup>

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.<sup>19</sup>

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

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<sup>14</sup> 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.

<sup>15</sup> 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).

<sup>16</sup> 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 and below to 27% above 1990 levels.

<sup>17</sup> 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% of the EU targets will be achieved by Germany and the United Kingdom (Andersen, 2002).

<sup>18</sup> 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.

<sup>19</sup> This has confounded the attempts of two countries—Argentina and Kazakhstan—to adopt emissions commitments and participate within the Kyoto framework.



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,<sup>20</sup> 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 5-year averages, and countries are allowed to bank and borrow emissions allowances within this 5-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% 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-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 July 2003, the Kyoto Protocol had been ratified by 111 parties (nations) to the FCCC. To enter into force, Kyoto must be ratified by at least 55 countries, accounting for at least 55% of 1990 Annex I CO<sub>2</sub> emissions. Only the latter trigger for entry into force remained to be fulfilled. As of July 2003, 29 Annex I countries had ratified the Kyoto Protocol, accounting for 44.2% of 1990 Annex I emissions.<sup>21</sup>

Entry into force only awaits ratification by 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

<sup>20</sup> 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.

<sup>21</sup> These included the member states of the European Union, Canada, Japan, the Czech Republic, Estonia, Latvia, Norway, Romania, and Slovakia.

emission reduction obligations.<sup>22</sup> This accounting, if implemented, would violate 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, is unlikely to achieve substantial mitigation, in the short term or in the long term, partly because it is ill-equipped to promote participation and compliance. This further undermines dynamic efficiency, although analyses of the Kyoto agreement with US 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 5-year commitment period at a time, the Kyoto agreement promotes a flexible approach that can account for new information in subsequent 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 5-year periods. Some proposed long-term emissions paths may fail to provide such an incentive, however, if they are not dynamically consistent (Aldy et al., 2001). The Kyoto agreement also fails to promote participation and compliance, evident by the US withdrawal from the agreement, the lack of a requirement that developing countries adopt emissions commitments, 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 does not require that developing countries take on emissions commitments;<sup>23</sup> it provides ineffective incentives for participation and compliance; and it generates modest short-term climate benefits while failing to provide a long-term solution. In

<sup>22</sup> See, for example, Steven Chase, “Liberal MPs Threaten to Withdraw Kyoto Votes”, *Globe and Mail*, 13 September 13 2002, p. A4. The Government of Canada’s press release on the ratification says that “Canada will . . . continue to work with the international community for improvements to the Kyoto Protocol regime, whether in the recognition of cleaner energy exports or in identifying how more countries can be engaged in setting and achieving targets.” See [http://www.climatechange.gc.ca/english/whats\\_new/20021217.htm](http://www.climatechange.gc.ca/english/whats_new/20021217.htm).

<sup>23</sup> 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).

response to these and other perceived flaws<sup>24</sup> 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.<sup>25</sup> Perhaps unsurprisingly, all of these proposed alternatives have been developed by researchers working in the United States. Indeed, we are not aware of any comprehensive proposals developed elsewhere—at least not since the Kyoto Protocol was negotiated. The proposals reviewed here 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 et al., 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.<sup>26</sup> Proceeds from the sale of additional permits would finance climate change research and aid developing countries' efforts to abate greenhouse-gas emissions. Developing countries would be included in the short term via voluntary measures and in the longer term via mandatory commitments (Table 2).

The near-term environmental effectiveness of this proposal would depend upon the breadth of actual participation by developing countries.<sup>27</sup> 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

<sup>24</sup> 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.

<sup>25</sup> Obviously, one clear distinction between the Kyoto Protocol and these alternatives lies in the fact that the Kyoto agreement represents the outcome of years of international negotiations and, with the ratification of Russia, will serve as the basis for international climate change policy through 2012. The alternative proposals have not undergone the same real-world evaluation as the Kyoto Protocol, which could be inferred as *ex ante* political acceptance of the Kyoto approach by ratifying countries.

<sup>26</sup> The hybrid approach combining a tradable permit system with a “tax” (elastic supply of additional permits) has been examined by McKibbin and Wilcoxon (1997), Kopp et al. (1997) and Kopp et al. (1999), building on earlier work by Weitzman (1974) and Roberts and Spence (1976). A recent assessment is provided by Jacoby and Ellerman (2002).

<sup>27</sup> Our assessments of the alternative policy architectures are summarized in Table 2.

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 5-year periods.	Incentives for participation and compliance are very weak.
Aldy et al. (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.
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 and Wilcoxon (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 and Wiener (2001)	Would depend on the magnitude of the "headroom" allowances given to DCs.	Dynamic efficiency weakened by participation and 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.

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 (R&D), rather than targets and time tables. Barrett's approach includes a research and development 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,<sup>28</sup> but the system would neither be efficient nor cost-effective, not least because the technology standards would not apply to every sector of the global economy, and may entail some technological lock-in.<sup>29</sup> 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

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<sup>28</sup> For other commentaries on the potential for employing technological cooperation as a central architectural element, see Buchner et al. (2002), Edmonds et al. (2001), Flannery (2001) and Jacoby (1998).

<sup>29</sup> This may also be a problem with other proposals.

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 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.<sup>30</sup>

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

<sup>30</sup> 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.

(2000) addresses the compliance issue, but drawing on Chayes and Chayes (1995), he argues that explicit mechanisms for compliance are not needed (refer to Section 4 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 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 Wilcoxon, 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 Wilcoxon proposal would likely deliver modest environmental effectiveness in the near term with its fixed emissions permit price of US\$ 10 per tonne. 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 Wilcoxon 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.<sup>31</sup>

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.<sup>32</sup> 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, 2002)*

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.

### 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

<sup>31</sup> 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.

<sup>32</sup> 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.

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;<sup>33</sup> (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.

### 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;<sup>34</sup> (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

<sup>33</sup> 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.

<sup>34</sup> 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.

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. Under this arrangement, if the seller of a permit did not reduce its emissions as promised, the buyer could not claim the emission credit. Since buyers of emission credits are most likely to be private entities in the liberal democracies, Victor argues that the buyer liability rule could be reliably enforced by domestic institutions in these countries.

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.

## 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 et al., 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 Wilcoxon, 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, 2002).

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 et al., 2001; Stavins, 2001b; Stewart and Wiener, 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 et al., 2001; Hahn, 1998, McKibbin and Wilcoxon, 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.<sup>35</sup> 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 et al., 2001; Cooper, 1998, 2001; McKibbin and Wilcoxon, 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 et al., 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

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<sup>35</sup> 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.

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.<sup>36</sup>

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—and many industrialized countries as well—believe that the industrialized world should take on binding emissions commitments first.<sup>37</sup> On the other hand, if a proposal recommends 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 US Senate (1997), which called for similar treatment of industrialized and developing countries in any international agreement on global climate change.<sup>38</sup> 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,

<sup>36</sup> 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 et al. (1996) and Barrett (1999, 2003).

<sup>37</sup> 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 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).

<sup>38</sup> Senate Resolution 98 (12 June 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.

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.

In our review of the 13 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 are needed 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.

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