International Equity and Climate Change Policy

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Defining (or divining) an internationally equitable distribution of the burdens of reducing climate change risks has been a core concern for as long as greenhouse gas (GHG) emissions policies have been debated. Countries clearly differ greatly in their vulnerability to climate change, their historical and projected contributions to global GHG emissions, and their ability to bear the costs of mitigating GHG emissions. And neither history nor philosophy provides a definitive guide to what would constitute a fair distribution of burden.

In this paper, we first review briefly the history and background of the international climate equity debate. Next, we put the equity debate in the broader context of the challenge of achieving international environmental (or other) agreements in general. Then, we review the many alternative equity principles that have been advanced for defining common but differentiated responsibilities; our key conclusion is that no single principle can be expected to govern resolution of this issue. However, approaches that involve adjusting responsibilities over time on the basis of more than one criterion may offer more promise for successful negotiation over the longer term. We conclude with some observations concerning constructive first steps for advancing international agreement on sharing the burden of risk associated with climate change.

Background

Article 3 of the 1992 U.N. Framework Convention on Climate Change (UNFCCC) contains the following language: “The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effect thereof.”

The phrase “common but differentiated responsibilities” has become a touchstone for the international climate equity debate. During the first Conference of Parties to the UNFCCC (COP-1; held in 1995 in Berlin, Germany), negotiators debated whether developing countries, in addition to developed countries, would commit to binding reductions for GHG emissions. The developing countries ultimately rejected binding commitments, asserting that the historical

responsibility for climate change was not theirs, that they had less financial ability to pay for reductions, and that they had more urgent priorities for their limited resources.

In the Kyoto Protocol negotiated at the third Conference of Parties (COP-3) in December 1997, the Annex I developed countries (referred to as Annex B countries in the protocol document) agreed to legally binding commitments to reduce their collective GHG emissions by an average of 5% compared with 1990 levels during the first commitment period (2008–12). Consistent with the Berlin Mandate at COP-1, developing countries did not agree to any targets at Kyoto. Developing countries share with developed countries some common obligations for emissions monitoring and reporting, and under the UNFCCC, all countries are generally exhorted to take steps to enhance sustainable development that would limit the growth of GHG emissions. However, developing countries at Kyoto did not accept language that would have required them to pursue "best efforts" to reduce GHG emissions through such measures as energy market reforms and also rejected language that would have set future limits on their emissions as a negotiating target.

It is worth noting that different percentage emissions limits were agreed to by Annex I countries in the Kyoto Protocol. The differentiated targets among Annex I countries were not based on a standardized formula but rather on complex negotiations on multiple issues. In addition, Article 4 of the protocol allows groups of countries to negotiate a redistribution of their collective GHG emissions limits. This flexibility has been used by the European Union to set widely varying emissions targets for GHGs among member countries. These complex procedures may foreshadow even more complex future negotiations among developed and developing countries over obligations for GHG emissions control.

Debate over a long-term equitable sharing of the burden has continued since the negotiation of the Kyoto Protocol, while the details of the protocol's implementation are still being negotiated. Several developing country representatives continue to press the claim that the Annex I countries should do even more to reduce GHG emissions given their historical responsibility for GHG emissions. Developed countries accept the concept of differentiated responsibilities but want greater assurance on when and how developing countries would start assuming greater responsibilities, because developing countries are likely to be the primary industrial emitters in the future. This concern was underscored in the Byrd–Hagel resolution, passed 95–0 by the U.S. Senate prior to COP-3. That resolution opposed ratification of a Kyoto treaty until developing countries committed to binding emission limits in the same time frame as the United States. Developing countries counter that developed countries generally have done little to implement their previous voluntary reduction commitments, even while some developing

countries have slowed their emissions growth through reforms in the economic and energy sectors. This ongoing debate about the adequacy of commitments illustrates how differently countries interpret what constitutes fairness or equity in mitigating the risks of global climate change.

In the midst of this debate, one set of observations is widely accepted: Developed countries are responsible for the largest share of cumulative past GHG emissions by far. Moreover, current emissions intensities vary dramatically between rich and poor countries (see Table 1). In addition, developing countries need to increase their emissions over some period in the future as a necessary consequence of critically needed economic growth and improved living standards. Ultimately, however, the sources of climate change risk (GHG emissions and land use changes) are globally distributed. Therefore, responsibility for resolving the problem also must ultimately be widely shared. This point is vividly illustrated by the calculations of future changes in atmospheric GHG emissions presented by Jacoby and others (see Suggested Reading), who analyze the consequences of having continued and strengthened GHG emissions controls within the Annex I industrialized countries while allowing rapid business-as-usual emissions growth in the developing world. Their projections indicate that even if the current developed world drives its net GHG emissions to zero by the end of this century, the effects on the atmosphere would be small given the strong expected future growth of emissions in developing countries.

Table 1. Comparison of Emissions Intensities among Countries.

	Per capita GDP[a] *(1995$)*	*Per capita CO_2 emissions (metric tons, 1995)*	*CO_2/GDP (kg/$)*
United States	26,980	20.5	0.76
European Union[b]	19,050[c]	7.9[c]	0.41
Russia	4,820	12.2	2.53
China	2,970	2.7	0.91
Africa	1,760[c]	1.1[c]	0.63
India	1,420	1.0	0.70

Source: World Resources Institute (see Suggested Reading).
[a] Based on estimated purchasing power parities rather than exchange rates.
[b] Luxembourg is not included.
[c] Population figures are from 1998.

It is obvious from Table 1 that emission patterns and the ability to absorb the costs of GHG emissions mitigation (as indicated by per capita income) vary widely across countries. One other point worthy of mention is the differential vulnerability of developing and developed countries to climate change. The IPCC Second Assessment Report presented results of studies

showing that the damaging effects of a doubling of concentrations of GHG emissions in the atmosphere could cost on the order of 1.0–1.5% of gross domestic product (GDP) for developed countries and 2.0–9.0% of GDP for developing countries, with some developing countries (for example, low-lying island states) much more vulnerable still. Although controversy surrounds the scale of these estimates, the increased vulnerability of developing countries is subject to little debate. Their high vulnerability reflects both a greater dependence on natural systems (such as agriculture), which could be affected by climate change, and a more limited capacity to adapt to climate change given limited resources.

International Negotiation of GHG Mitigation

The problem of achieving effective and lasting international agreements can be stated simply: A self-enforcing deal is easiest to strike when the stakes are relatively small, or when no other option exists (a clear and present risk). No global police organization exists to enforce an international climate agreement. As such, an agreement must be voluntary and self-enforcing—all sovereign parties must have no incentive to deviate unilaterally from the terms of the agreement. As part of this negotiation process, countries can negotiate various enforcement provisions, such as trade sanctions for noncompliance. This does not change the basic point that the agreement as a whole, including enforcement provisions, must satisfy the self-interest of the participants. (Sanctions also must be credible to be meaningful; if sanctions will cost more than the benefit of obtaining greater compliance, they are not credible.)

Nations have a common interest in responding to the risk of climate change, yet many are reluctant to reduce GHG emissions voluntarily or unilaterally. They hesitate because climate change is a global public good—all nations can enjoy protection against the risks of climate change, regardless of whether they participate in a treaty intended to mitigate those risks. Each nation's incentive to reduce emissions is thus limited because it cannot be prevented from enjoying the fruits of other nations' efforts. This incentive to free ride reflects the divergence between national actions and global interests.

A self-enforcing agreement is hardest to achieve in the gray area between low and infinite stakes. By free riding, some nations can be better off refusing an agreement. The greater the global net benefits of cooperation, the stronger the incentive to free ride; therefore, a self-enforcing agreement is harder to maintain. A self-enforcing agreement is most easily maintained when the global net benefits are not much bigger than those in the absence of an agreement. This is a basic paradox of international agreement.

To achieve significant reductions in GHG emissions, it is not necessary that every country in the world participate. The Organization for Economic Co-operation and Development (OECD) countries, eastern Europe, Russia, and Ukraine, along with a few large developing countries (China, India, and Brazil) account for most of the current volume of GHG emissions and a significant fraction of future emissions as well. However, even a self-enforcing agreement that involved only a subset of the world's emitters would probably lead to total emissions in excess of desirable global targets if several small nations refused to agree, and achieving a self-enforcing agreement even among a few major emitting countries or regions is not easy, as the negotiations among the Annex I countries reveal.

Many decisionmakers in industrialized countries worry about the consequences to their economies of reducing emissions while developing countries face no limits. This situation could adversely affect comparative advantages in the industrialized world, whereas the "leakage" of emissions from controlled to uncontrolled countries would limit the environmental effectiveness of a partial agreement. Estimates of carbon leakage vary from a few percent to more than one-third of the Annex I reductions, depending on model assumptions regarding substitutability of different countries' outputs and other factors. On the other hand, many developing countries see more immediately pressing national needs, such as clean water and a stable food supply. Given their limited resources, developing countries will be less inclined to join an agreement that they see as imposing unacceptable costs on them, even if the costs are manageable and acceptable for developed countries.

All of these considerations must be incorporated when addressing equity issues related to GHG emissions agreements. Equity may be one motivation for countries to pursue GHG emissions policies. However, equity principles will not override other elements of national self-interest. Moreover, differences in perceptions about what constitutes equitable distributions of effort complicate any agreement. The international policy objective is obvious but elusive: finding incentives to motivate nations with strong and diverse self-interests to move voluntarily toward a collective goal of reduced carbon emissions.

Equity Principles for Burden Sharing

The concept of equity can be to interpreted in many ways, and it often has been the root of misunderstandings and conflict between developed and developing countries in past negotiations. However, any criteria that might be used to distribute current and future burdens of GHG mitigation must be based, explicitly or otherwise, on some concept of equity. Table 2

summarizes some of the many equity principles that have been applied to the issue of sharing the burden of climate risk, with illustrations of how each could be translated into rules for the

Box 2. The Montreal Protocol Model

The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer is one of the best examples of successful implementation of equity principles in relation to an international environmental issue. The participation of developing countries was one of the reasons for the success of the Montreal Protocol, and their participation was primarily due to the protocol's inclusion of developing country concerns about equity, economic constraints, and flexibility. The IPCC Second Assessment Report cites the following elements as important in encouraging developing country participation (see Banuri and others in Suggested Reading):

- differentiated standards for developed and developing country parties,
- additional financial assistance to developing country parties,
- technology transfer facilitated by protocol financial resources if necessary, and
- acknowledgement that developing country compliance was contingent on effective implementation of financial assistance and technology transfer obligations.

The Montreal Protocol was frequently discussed as a model prior to the Kyoto Protocol. However, the Montreal Protocol addressed a problem that was in several ways less complex to resolve than the climate change problem (see Chapter 2, How the Kyoto Protocol Developed). That point notwithstanding, the questions of financial assistance and technology transfer continue to be important topics in climate change negotiations.

distribution of GHG emissions abatement costs. Obviously, some of the categories in the table overlap. Moreover, most of the principles would yield more than one possible distribution of mitigation burden and cost, depending on how key parameters are set.

Table 2. Alternative Equity Criteria for Climate Change Policy.

Equity principle	*Interpretation*	*Implied burden-sharing rule*
Egalitarian	People have equal rights to use atmospheric resources.	Reduce emissions in proportion to population or equal per capita emission.
Ability to pay	Equalize abatement costs across nations relative to economic circumstances.	Net cost proportions are inversely correlated with per capita GDP.
Sovereignty	Current rate of emissions constitutes a status quo right now.	Reduce emissions proportionally across all countries to maintain relative emission levels between them ("grandfathering").
Maxi-min	Maximize the net benefit to the poorest nations.	Distribute the majority of abatement costs to wealthier nations.
Horizontal	Similar economic circumstances have similar emission rights and burden sharing responsibilities.	Equalize net welfare change across countries so that net cost of abatement as a proportion of GDP is the same for each country.
Vertical	The greater the ability to pay, the greater the economic burden.	Set each country's emissions reduction so that net cost of abatement grows relative to GDP.
Compensation (Pareto rule)	"Winners" should compensate "losers" so that both are better off.	Share abatement costs so that no nation suffers a net loss of welfare.
Market justice	Make greater use of markets.	Create tradable permits to achieve lowest net world cost for emissions abatement.
Consensus	Seek a political solution that promotes stability.	Distribute abatement costs (power weighted) so the majority of nations are satisfied.
Sovereign bargaining	Principles of fairness emerge endogenously as a result of multistage negotiations.	Distribute abatement costs according to equity principles that result from international bargaining and negotiation over time.
Polluter pays	Allocate abatement burden corresponding to emissions (may include historical emissions).	Share abatement costs across countries in proportion to emission levels.
Kantian allocation rule	Each country chooses an abatement level at least as large as the uniform abatement level it would like all countries to undertake.	Differentiate by country's preferred world abatement, possibly in tiers or groups.

Source: Adapted from Burtraw and Toman, Ringius and others, and Rose 1992 (see Suggested Reading).

The *egalitarian* principle is popular with many developing countries, because it would shift most abatement responsibility to developed countries where per capita emissions are much higher than in developing countries. The *sovereignty* principle in its strict form implies symmetrical cost burdens. The *ability to pay* approach would allocate the majority of costs to wealthy nations; developing nations would pay more as they became wealthier over time and increasingly were able to pay for mitigation. The *maxi-min* principle would maximize the welfare of the least-well-off countries by distributing the majority of abatement costs to wealthier nations.

The next three approaches are based on allocation of net benefit, not only cost. *Horizontal* and *vertical* equity principles seek to distribute costs relative to GDP. The meaning of these terms in this context is similar to their meaning in debates about tax policy: Horizontal equity seeks to treat equals equally, whereas vertical equity seeks to increase the burden as the

ability to pay grows. The *compensation* approach would entail payments through income transfers or investment to avoid loss by any nation.

The next three principles are process-based and assume that the correct process of cost allocation will result in an equitable outcome. The principle of *market justice* is based on the theory that a free market mechanism for cost allocation is the fairest because its efficiency results in greater overall welfare. *Consensus* equity simply asserts that the process of political negotiation itself results in an equitable outcome. A variation on the consensus principle is the *sovereign bargaining* principle, in which principles of fairness emerge endogenously as a result of international multistage negotiations.

The *polluter pays* principle is self-explanatory and relatively simple. Although developed countries are responsible for the majority of past and present pollution, developing countries will be the primary emitters within a few decades. Thus, this principle implies a reallocation of burdens over time (as do other rules that depend on cost or income shares). Under the *Kantian allocation rule*, each country would choose an abatement level at least as large as the uniform abatement level it would like all countries to undertake, ensuring that countries' true preferences for abatement are revealed so that each country takes on a relative cost burden equal to what it expects of other countries.

The criteria in Table 2 are presented in a relatively static context. Interest is now growing in the possibility of long-term differentiation and graduation formulas for burden sharing. These formulas would define the terms under which developing countries would accept commitments and how the commitments of developed countries would be strengthened over time.

To illustrate this approach, Nordhaus proposed a climate allowances protocol that "would embed the price and quantity [of] targets within a framework that considers both environmental and economic objectives and sets the policies to maximize net benefits" (see Suggested Reading). The climate allowances protocol would issue tradable allowances or permits with carbon price ceilings and floors that are derived from a dynamic cost–benefit analysis of slowing climate change. Participant countries would be allocated emissions permits for each budget period according to what are in essence rolling targets rather than targets based on an arbitrary historical benchmark. Developing countries would begin to participate as their economies grew, making small emissions reductions as their per capita incomes reached entry levels and making greater emissions reductions when their incomes reached full participation levels. The allocation of permits would be based on a formula that reflects each country's uncontrolled emissions and its ability to pay. The climate allowances protocol would provide an incentive to participate

through the imposition of duties on the carbon content of imports from nonparticipants into participating countries. The aim of this proposal is thus to promote forward-looking rather than backward-looking formulas for the allocation of emissions reduction costs and burdens. How well a forward-looking approach (with essentially endogenous targets) could work remains unclear.

The idea of making per capita emissions the basis for equitable burden sharing is a much-discussed option that is favored by many developing countries. Such formulas are often referred to as convergence measures. However, different formulas have different bases for convergence and thus different consequences.

A dynamic example of this approach from the Global Commons Institute is "contraction and convergence" (see Suggested Reading). Under this option, developed countries would reduce emissions over time in proportion to their population, and developing countries would increase emissions according to their population. Eventually, developed and developing countries would converge to the same per capita emissions ratio. For the environmental goals of the UNFCCC to be met, the ratio and length of expected of time until convergence would have to be calculated to ensure the necessary amount of GHG emissions reductions. Another example of this approach is a Brazilian proposal made during the Kyoto Protocol negotiations to allocate permits according to relative historical contribution to global warming. Various criteria for contributing to cumulative climatic impacts could be used to determine which countries have reached a threshold for sharing the burden of emission reduction.

Edmonds and Wise attempt to sidestep direct debate over equity rules by proposing a technology-based graduation framework (see Suggested Reading). In their proposal, any new fossil fuel electric power capacity in Annex I nations installed after the year 2020 must scrub and dispose of the carbon from its exhaust stream, any new synthetic fuels capacity must capture and dispose of carbon released in the conversion process, and non–Annex I nations that participate must undertake the same obligations that Annex I nations undertake when their per capita income equals the average for Annex I nations in 2020. The authors note that in their technology graduation scenario, China is the first to join the protocol in approximately 2040, and countries in South Asia and East Asia join by 2055. They acknowledge that a technology-based protocol would be economically inefficient but state that its graduation mechanism would allow developing nations to achieve an economic status comparable to that of developed nations before being required to undertake binding obligations.

Several authors also have suggested that by broadening the number of elements included in the terms of agreement among negotiating parties, multiple-criteria formulas may make political agreement among negotiating entities with very disparate interests more likely. For example, Ridgley proposed that several equity criteria could be used together (see Suggested Reading). The factors he considers include population (as an indicator of entitlement), baseline emissions (as an indication of responsibility), and ability to pay. Grubb adds to this list factors such as basic trends in energy efficiency, competitiveness, and institutional capacities in arguing for a sectorally differentiated approach (see Suggested Reading).

Analyzing Impacts of Different Burden-Sharing Rules

Proposals for per capita contract-and-converge options face several challenges in reaching agreement. China and India would be able to increase their national emissions significantly before reaching the population-to-emissions ratio limit because of their large and rapidly growing populations and rapid economic growth. For this increase to not endanger environmental goals, stringent long-term environmental limits would have to be placed on the industrialized countries, or the emissions ceiling for the developed world would have to grow less than proportionally with future population increases. In the absence of tighter constraints on the growth of developing countries' ceilings, the convergence limits would in turn imply a level of either domestic compliance cost (without international emissions trading) or wealth transfer (with trading) that is currently unacceptable to developed countries. By the same token, however, allocating emission limits based on historical emissions conveys a huge advantage to the developed world, given their historically overwhelming share of emissions. Simply extending this approach to developing countries limits their incentives to pursue modest "win-win" emissions controls in the short term, for fear that doing so would put them on a lower emissions baseline and jeopardize their position in future negotiations.

It is also unlikely that a majority of nations would accept a multiple-criteria approach simply because it includes a lot of equity principles. Countries will still look to see how a specific formula affects their self-interest. Contentious negotiation on the criteria and weights would still be required, even in determining how to divide burdens among developing countries. For example, within Latin America, Brazil and Honduras have large differences with regard to wealth, past and current emissions, and vulnerability to climate change impacts.

Several modelers have attempted to assess the potential outcomes of different burden-sharing criteria. Unfortunately, it is difficult to compare results because each model uses different time frames, parameters, variables, and methods. One analysis by Rose and others

attempted to quantify the minimum cost of the different equity principles for each of nine world regions: United States, Canada and western Europe, other OECD countries, eastern Europe and the former Soviet Union, China, the Middle East, Africa, Latin America, and Southeast Asia (see Suggested Reading). The analysis is framed in terms of a global allocation of a fixed number of tradable emission permits. Under this scenario, global allocation of abatement activity is cost-effective in all cases, and the initial permit allocation affects only the distribution of costs. The study used a nonlinear programming model based on an abatement cost function that corresponded to each equity principle to calculate the net cost of implementing each principle. The analysis of the cost allocation from each principle was performed for three future years (2005, 2020, and 2035), and this cost was discounted to a 1990 present value. Table 3 illustrates the findings of the study.

Table 3. Cost of Different Allocation Rules in 2020 (present value, in billions of $1990).

Country or area	*Sovereignty*	*Egalitarian*	*Horizontal*	*Vertical*	*Consensus*
United States	44.1	354.5	52.2	95.7	121.1
Canada and Western Europe	17.8	29.9	156.2	38.1	19.2
Other OECD countries	8.0	65.3	21.6	50.9	–25.7
Eastern Europe and former Soviet Union	272.0	37.2	337.6	24.2	7.5
China	23.3	–109.1	8.3	0.1	43.2
Middle East	6.3	1.1	8.4	9.2	–11.0
Africa	8.1	–226.3	5.2	0.1	99.6
Latin America	7.4	56.6	8.1	0.5	–21.4
Southeast Asia	13.0	345.5	10.9	0.1	–119.3

Notes: The operational rules for the equity principles in this analysis are as follows: Sovereignty distributes permits in proportion to emissions; egalitarian distributes permits in proportion to population; horizontal distributes permits to equalize net welfare change (net gain or loss as proportion of GDP equal for each nation); vertical progressively distributes permit (net gain/loss) proportions inversely with per capita GDP; consensus distributes permits in a manner that satisfies the (power weighted) majority of nations.
Source: Rose and others (see Suggested Reading).

The analysis of the distributional implications of the different principles in Table 3 illustrates the large range of net cost outcomes for a given country or region. Under the egalitarian principle, for example, large amounts of wealth are transferred from the United States and the former Soviet Union to China, Africa, and Southeast Asia. The vertical principle results in large burdens for OECD countries and minute burdens for developing countries, but no wealth transfer. The sovereignty and horizontal equity principles result in roughly similar outcomes.

The use of per capita emissions as the criteria for emissions reduction was also the focus of a study by Manne and Richels (see Suggested Reading). They calculate the welfare effects on five regions (United States, OECD countries, the former Soviet Union, China, and “rest of

world" [ROW]) of a transition from allocation of emissions permits based on 1990 baseline emissions levels to allocation based on per capita emissions. In a relatively rapid transition completed by 2030, all cooperating regions benefit from reduced climate change damages compared with a business-as-usual scenario. However, under this scenario, the majority of the burden falls on the United States, OECD countries, and the former Soviet Union, whereas China and ROW benefit from reduced damages and the sale of emissions permits. The distribution of overall burdens is very different in a scenario of slower transition from permit allocation according to 1990 baselines to permit allocation according to per capita emissions with the transition completed by 2200 (170 years later than in the rapid transition scenario). In this scenario, damage and nonmarket costs are the same as in the rapid transition scenario, but the OECD countries receive positive net benefits and the rest of the world no longer benefits due to smaller wealth transfers. China still benefits, but not as much as under the rapid transition scenario.

Reiner and Jacoby argue that it would be most equitable to allocate differentiated burdens based on a starting point of zero for all nations instead of historical emissions levels (such as 1990 emissions; see Suggested Reading). Starting from this premise, their Emissions Prediction and Policy Assessment (EPPA) model calculates a percentage allocation of emissions permits according to either per capita emissions or the carbon intensity of GDP. The resulting allocations are shown in Table 4.

Table 4. Percentage Allocation of Emissions Permits According to the Emissions Prediction and Policy Assessment (EPPA) Model.

	Allocation according to C/POP (%)	*Allocation according to C/GDP (%)*
United States	4	25
Japan	2	10
European Union	5	16
Other OECD countries	2	6
Former Soviet Union	5	6
Central and eastern Europe	2	2
Energy-exporting countries	16	14
India	16	3
Brazil	3	2
China	20	8
Dynamic Asian economies	3	3
Rest of the world	22	5

Note: C = carbon; POP = population.
Source: Reiner and Jacoby (see Suggested Reading).

As shown in Table 4, zero-based allocation according to a per capita emissions rule would require draconian decreases in allowed emissions from OECD countries and allow large increases for populous less-developed countries such as China and India. Zero-based allocation according to carbon intensity of GDP, however, results in a distribution of allowed emissions that is closer to the status quo and therefore would provide no headroom for growth by developing countries. Using the carbon intensity ratio, the United States would receive 25% of all permits, the European Union would receive 16%, and energy-exporting countries (such as OPEC contains) would receive 14%.

In 2000, Rose and Stevens simulated net benefits for different countries or areas in various scenarios that involved participation in emissions limits and international emissions permit trading (see Suggested Reading). Net benefits incorporate both avoided climate change damages and the costs of abating GHG emissions, plus potential revenue flows from permit sales and purchases. Scenario 1 is a base case with fixed Kyoto emission targets for developed countries but no interperiod or interregional permit trading; in Scenario 2, all developing countries must constrain their emissions starting in 2020 based on 2020 emissions levels; and in Scenario 3, developing country accession to a GHG emissions protocol is based on per capita income (PCI). The authors divided developing countries into two groups: Group A, with greater than $1,000 PCI (Middle East, rapidly developing "Asian Tigers," and Latin America), and Group B, with less than $1,000 PCI (China, South Asia, India, and Africa). Group A developing country limits begin in 2010, and Group B developing country limits begin in 2020, with Kyoto target levels still in effect for Annex I countries. Their findings are summarized in Table 5.

In Scenario 1, the present discounted value of the global net benefits of achieving the Kyoto targets by Annex I countries is actually a loss of $12.6 billion. Net benefits are also negative for Annex I (that is, industrialized) countries but positive for developing countries, particularly China and South Asia. In Scenario 2, all regions except for Africa, India, and the Asian Tigers are better off than in the baseline Kyoto case. In Scenario 3, global net benefits are less relative to Scenario 2 because the increases in mitigation costs for Group A countries greatly outweigh the benefits not only to themselves but also to all other countries; Group A countries are worse off and all Group B and Annex I countries are better off than in the baseline Kyoto case. In each scenario, some countries are "losers," and losing countries could require compensation in return for their participation in the climate change mitigation regime.

Table 5. Summary of Net Benefits from Different Participation and Permit Trading Simulations.

	Scenario		
Country or area	*1*	*2*	*3*
Africa	24.2	16.6	11.2
Australia/New Zealand	–2.1	–1.3	–1.3
Canada	–6.9	–3.7	–4.4
China	81.0	88.8	123.9
Eastern Europe	–2.8	1.1	3.3
Former Soviet Union	–0.1	41.9	58.8
India	27.5	26.8	30.2
Japan	–36.1	–13.0	–15.9
Latin America	23.2	33.7	3.5
Middle East	9.6	20.2	–16.2
Asian Tigers	8.1	2.3	–17.8
South Asia	62.2	91.9	98.1
United States	–84.6	–50.3	–58.4
Western Europe	–115.8	–46.4	–56.2
Global net benefits	–12.6	208.6	158.8
Cumulative net benefit increase (relative to Kyoto base case)	221.2		171.4

Notes: Results are given in billions of present discounted $2010 summed over the entire time horizon 2010–35 (4% discount rate). Scenario 1 = Kyoto quotas for Annex I countries; Scenario 2 = Kyoto, interperiod and interregional permit trading, with 2020 quotas for developing countries; Scenario 3 = Kyoto, interperiod and interregional permit trading, with Group A quotas in 2010 and Group B quotas in 2020. See text for additional discussion.
Source: Rose and Stevens 2000 (see Suggested Reading).

Conclusions

Attempts to limit global climate change by mitigating GHG emissions would be futile without relatively broad international participation. Global participation also is supported by a powerful economic argument for cost-effectiveness. Poorer countries tend to have less efficient technology and more rapid growth rates for population and per capita income than richer countries do. Consequently, poorer countries are likely to have a comparative advantage in carrying out mitigation, and richer countries are likely to have a comparative advantage in developing and supplying the necessary technical opportunities, at least over the short to medium term. But to achieve a successful international agreement for GHG emissions abatement, this cost-effectiveness argument must be supplemented with policies for acceptably distributing mitigation costs across countries as well as over time.

The application of simple, fixed principles of equity will most often result in winners and losers. For example, the net costs to major emitters such as the United States and China differ significantly depending on which equity principles or criteria are applied. As principles of equity are discussed and analyzed in the international arena, it is sometimes difficult to distinguish between a country's concern with equitable burden sharing under a climate change regime and its informed calculation of how use of a given principle for cost allocation might affect its welfare.

Our review of equity analyses highlights the difficulty of constructing a single formula—even a simple composite formula—that is in the basic self-interest of enough developed and developing countries to provide a foundation for organizing international climate change policy. Efforts to find a magic solution to equity disputes are likely to be in vain, and the question of which international climate policies will be equitable over the long term will require a great deal of additional time and effort to resolve.

However, it appears that dynamic graduation formulas offer a critical degree of flexibility for balancing the short-term concerns of developing countries (bearing excessive costs of mitigating GHG emissions) against the long-term concerns of developed countries (expanding participation in GHG emissions mitigation and reducing leakage). Although this kind of approach still requires difficult negotiation, it is broadly consistent with the general notion of "common but differentiated" responsibilities in the UNFCCC; it moves the debate from *whether* developing countries should act to *how* and *when*.

The long-term equity debate over climate change mitigation often has been framed as a property rights problem—how rights to use the global atmospheric commons for releases of GHG emissions might be allocated. Because different answers to this question have profoundly different implications for global wealth distribution, the solution to this problem is obviously quite difficult.

Critics claim that there is no hope for solving this problem. They endorse other solutions, such as individually administered national carbon taxes. However, this approach is not a panacea for distributional concerns. An initial allocation of rights and responsibilities is implicit in any international control agreement, including taxes. Moreover, the argument for taxes rests on the willingness of the developing world to implement substantially higher energy taxes than exist today. Although developing countries theoretically would reap some advantages of increased energy taxes (for example, more reliable revenue than from income taxes), it is unclear whether the advantages would be so compelling in practice. Without broad participation, the tax approach

becomes an inefficient partial agreement, like the Kyoto Protocol. It also is difficult to monitor changes in domestic tax provisions that would nullify the effects of carbon taxes in the developing world and, to an extent, in the developed world. Several efficiency and political economy arguments favor a quantity-based over a tax-based approach; however, negotiating a global distribution of emission rights and responsibilities is a formidable task.

If the long-term climate equity problem is this difficult, then one important policy challenge is to keep this difficulty from impeding useful short-term progress toward cooperative mitigation of GHG emissions. Richer and poorer countries need to continue to develop relationships that will support long-term commitment to pursuing shared benefits in a mutually agreeable fashion. Given the uncertainties that surround future economic growth, climate change impacts, and willingness to pay to ameliorate those risks, this process needs to be adaptive rather than immediate. Initial steps to cooperate in climate policy and share benefits can be pursued without precluding options in the future.

The clean development mechanism (CDM) offers one avenue toward short-term policy cooperation with shared benefits (see Climate Issue Brief #22, Establishing and Operating the Clean Development Mechanism, Toman). It involves efforts to provide GHG emissions credits for developed countries through offsetting GHG emissions reductions in developing countries, thereby lowering the cost of mitigating GHG emissions in Annex I countries and providing local environmental, economic, and technological benefits in developing countries.

For this policy tool to be successful, developing countries need assurance that participation in the CDM meets their near-term needs and does not compromise their long-term interests. As for meeting near-term needs, analysis and experience should help to demonstrate the immediate economic and environmental benefits of CDM participation. Concrete steps in CDM design also can be useful—notably, allowing developing countries to create and bank their own CDM emission credits so they are not subject to profit-taking market power by CDM credit buyers. As for the protection of long-term interest, Annex I countries need to establish a firm policy precedent that future binding limits for developing countries will not be based on some historical base year, which would penalize earlier efforts to reduce GHG emissions in those countries. This discussion could be the beginning of a broader negotiation of mutually acceptable graduation protocols.

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