Combining Efficiency with Equity: A Pragmatic Approach

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As Sandmo (in this volume) shows, under some circumstances efficiency and equity concerns must go hand in hand to avoid further inequity. The challenge is to strike the appropriate balance between efficiency and equity—with equity largely determined by society's notions of justice and fairness.

At the same time, Albin (in this volume) points out the wide range of often conflicting views that people and scholars hold when it comes to justice and fairness. Views on justice and fairness for environmental issues—the focus of this chapter—are no exception. The international community has acknowledged that industrial and developing countries have "common but differentiated responsibilities" and different capabilities for contributing to the provision of climate stability, a global public good (UNFCCC 1992, art. 3). A first step toward applying this principle was the decision to define binding commitments for industrial countries to reduce greenhouse gas emissions by 2008–12.

But greenhouse gas emissions from developing countries are expected to grow rapidly over the coming decades. Thus future international negotiations on climate stability—and the reductions in greenhouse gas emissions needed to achieve it—will have to address developing country contributions to this global public good. What notions of justice and fairness should guide policy proposals and targets for emission limits in developing countries? This question has no easy answer, and negotiations on these issues face several challenges.

The basic principle of common but differentiated responsibilities and different capabilities has been translated into a series of specific differentiation rules.

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But analysis of these rules leads to a conclusion similar to that of Albin (in this volume)—that no single rule is likely to achieve broad political acceptance in the foreseeable future. This is the first challenge facing negotiators.

A second challenge is that the goal is not to achieve merely equity but also efficiency. The current international regime for stabilizing the climate, the Kyoto Protocol (UNFCCC 1997), proposes "flexibility mechanisms" so that countries can achieve emission targets in efficient, affordable ways. These mechanisms—international emissions trading, joint implementation, and the Clean Development Mechanism—involve interntional trading of permits to emit greenhouse gases (for more details, see Castro and Cordero in this volume). So, even if negotiators succeeded in agreeing on a principle of equity, what would happen to distributive justice once trading occurs? In other words, how fair will the ultimate policy outcome be?

These challenges cannot be resolved without scenario building and modeling efforts. In the past, negotiators often had to make decisions despite uncertainties about the realities of climate change. Today, however, extensive data are available to generate well-informed analyses.

Indeed, this chapter's purpose is to demonstrate the possibilities for better, more informed decisionmaking. Such decisionmaking opens new avenues for political pragmatism, making it possible to explore the effects of incremental policy changes resulting from possible decisions—concessions—made by one negotiating party or another. Most important, this chapter shows that it is possible to do what many have considered difficult: to combine efficiency and equity considerations and even to satisfy various rules on differentiation and various notions of justice.

The approach proposed here is pragmatic and politically feasible because it does not require agreement on specific criteria at the outset. The model can be based on different assumptions, and the assumptions can be changed through an iterative process until the negotiating parties are satisfied with the projected outcome. Moreover, there is a greater likelihood that the parties will agree on the projected outcome because it will likely satisfy several of the expectations that they bring to the bargaining table. With current analytical tools, there is no longer a need to wait three or four decades to see the consequences of today's policy choices. It is now possible to determine likely outcomes before embarking on certain policy paths.

Common but differentiated responsibility: an accepted principle leading to contested rules

This section first examines the differentiation of countries' commitment to contribute to global climate stability as indicated by the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. The section then reviews various proposals on how this principle could be translated into rules to guide policymaking. Finally, it discusses the dilemma that this multiplicity of rules creates for policymakers—and why this dilemma is less of a problem than it would appear at first sight.

Differentiation: a key component of the climate change regime

The UNFCCC uses the term *differentiation* in the broad sense of taking into account national characteristics in order to achieve the convention's ultimate goal. Here, however, the term is used in the more restrictive sense of differentiating countries' quantified objectives for limiting and reducing emissions, because the analysis focuses on how these objectives can be shared among the parties to the convention.

As noted, climate stability is the global public good in question, and its properties are nonrival and nonexcludable. But climate stability is based on another, impure global public good (a "common pool" resource): an atmosphere protected against excessive emissions of anthropogenic greenhouse gases. Carbon dioxide emissions are a major component of anthropogenic greenhouse gases. So, one of the tasks facing the international community in achieving climate stability is reducing these emissions.

Accordingly, countries have an incentive to maximize the emissions allowance granted to them and to minimize the costs of achieving required emission reductions. Thus while the final good of climate stability is public and available for all to enjoy, the effort of producing it needs to be apportioned. The production effort involves two tasks: quantifying emission allowances (that is, creating rules for sharing the scarce good—the "entitlement" to emit greenhouse gases) and sharing the costs of achieving emissions reduction targets. These tasks are closely intertwined, because the costs of a country's efforts depend, among other things, on its emissions allowance.

The UNFCCC differentiates emissions reduction targets by country groups. Annex 1 countries—industrial countries and transition economies—have agreed to stabilize greenhouse gas emissions by 2000 at 1990 levels. Non–Annex 1 countries—developing countries—have no such obligation. This setup reflects the parties' differing historical responsibilities for creating the greenhouse effect. The distinction between Annex 1 and non–Annex 1 countries can be called the primary differentiation.

The Kyoto Protocol, adopted in 1997, introduces a secondary differentiation. The protocol stipulates that between 2008 and 2012, Annex 1 countries must, as a group, cut greenhouse gas emissions by at least 5 percent below 1990 levels. Emissions reduction requirements are similar for the European Union (–8 percent), the United States (–7 percent), and Japan (–6 percent). Elsewhere, however, reduction rates are more differentiated, and some are actually growth rates. Examples include Iceland (+10 percent), Australia (+8 percent), Norway (+1 percent), and New Zealand, the Russian Federation, and Ukraine (no change). No clear rule led to this differentiation; it was more the result of political haggling (Babiker and Eckaus 2000; Viguier 1999). Still, the differentiation roughly reflects the parties' different economic, technological, and energy situations.

Proposed differentiation rules for achieving climate stability

Thus recent negotiations and existing agreements provide limited guidance on exactly how to implement the principle of common but differentiated responsibilities and different capabilities for contributing to climate stability. Little concrete policy advice is available on options for the possible inclusion of developing countries in future agreements on emission targets. So, in assessing options, one should start by examining various proposals put forward by policymakers and scientists since the late 1980s, in preparation for and in response to the 1992 United Nations Conference on Environment and Development (the Earth Summit).

These proposals address the two main tasks, identified above, in the production effort for climate stability—quantifying emission allowances and sharing the costs of achieving emissions reduction targets. Most of the differentiation rules proposed by country representatives in negotiations refer to emission allowances, because emission levels are easier to monitor than mitigation costs. Some of the most frequently proposed rules include (see also table 1):

- *Equalizing per capita emission limits.* This rule would inevitably lead to lower emission allowances for industrial countries and higher emission allowances for developing countries, compared with current levels.[1] Thus developing countries would be allowed to increase per capita emissions for a certain period.[2]
- *Allocating emission allowances based on current or cumulative emissions.* This rule is also known as that of "inherited quotas" or "grandfathering." It would undoubtedly benefit industrial countries because current emissions would be considered an "acquired right" (Godard 1997). Developing countries would be severely disadvantaged because there would be no way for them to increase emissions over the next few decades.
- *Differentiating emission allowances or mitigation costs based on contributions to climate change.* If responsibilities for climate change were determined solely on the basis of past emissions, under this rule developing countries would be expected to contribute less to corrective action than would industrial countries.[3]
- *Differentiating commitments based on the intensity of emissions relative to GDP.* This rule would require the greatest efforts from countries with energy systems emitting relatively high levels of greenhouse gases. Thus it is often seen as unfavorable not only to industrial but also developing countries—China, India, the United States—with greenhouse gas–intensive energy systems.

TABLE 1

Proposed differentiation rules, criteria, and most favored beneficiaries

Rule	Differentiation criteria	Most favored party
Equalizing per capita emission limits	Per capita emissions	Developing countries
Allocating emission allowances based on current or cumulative emissions (grandfathering)	Current or cumulative emissions	Industrial countries
Differentiating emission allowances or mitigation costs based on contributions to climate change	Current or cumulative emissions Share of responsibility for global warming	Developing countries
Differentiating commitments based on the intensity of emissions	Emissions/GDP	Countries whose energy relative to GDP systems emit low levels of greenhouse gases
Differentiating commitments based on per capita GDP	Per capita GDP	Developing countries
Equalizing marginal abatement costs	Marginal abatement costs	Depends on the reduction level
Differentiating abatement costs based on expected benefits from lower greenhouse gas emissions and climate stabilization	Benefits from mitigation of climate change	Industrial countries

- *Differentiating commitments based on per capita GDP.* This rule would allow policymakers to take into account both the ability of industrial countries to pay and the priority that developing countries place on such goals as economic growth and poverty reduction. But because the rule is not directly related to emission levels or mitigation costs, it might not provide the right incentives to reduce greenhouse gas emissions.
- *Equalizing marginal abatement costs.* This rule is sometimes claimed to establish relatively severe emissions reduction targets for countries with inefficient energy systems. The reason is that such countries have greater potential for low-cost emission cuts than do countries with efficient energy systems. But this approach should be qualified by taking into account the

structure and dynamics of each country's energy system, because countries with already efficient energy systems may encounter high marginal costs while reducing emissions.

- *Differentiating abatement costs based on expected benefits from lower greenhouse gas emissions and climate stabilization.* Because developing countries will likely suffer most of the negative effects of climate instability, the benefits of prevention might be more important for these countries. The implication is that developing countries should be willing to pay the highest abatement costs. In a way it would require that the "victims" pay. But this approach must take into account the fact that developing countries have limited financial resources for their development needs and would probably not view investments in global climate stabilization as deserving priority over other investments. Moreover, because this rule ignores past emissions, it may not be very feasible politically.

All of these rules will likely generate a divergence of interests (see Shue 1992). Even among developing countries, under certain rules some countries would be better off than others, depending on their characteristics. Thus any international negotiations using these rules would face multiple dividing lines cutting across various subgroups. Moreover, the rules are partly based on different principles of justice. Some reflect principles of equality (such as the rule calling for equal per capita emission limits). Others are based on the principle of proportionality but use varying reference criteria (such as emissions intensity or per capita GDP). These different principles of justice add another source of potential disagreement, further limiting the possibility of an easy settlement between competing expectations and claims.

The impossibility of identifying just one fair solution

Given the array of differentiation rules, coupled with the lack of consensus on any one of them, it is easy to understand why the literature depicts the application of principles of justice in international relations as a hotly debated, disputed, and often unattempted solution.[4] So, is there a way forward? To begin answering that question, it is useful to explain some of the hurdles on the way.

No single criterion will be feasible. Theory tells us that some principles of justice are "configurational" in that fair allocation is determined by characteristics of the negotiating parties (Dupuy 1992). Albin (in this volume) uses the term "internal" in this sense. In theory, nonconfigurational principles are more likely to lead to an agreement. In practice, parties involved in climate change negotiations want an agreement that takes into account their positions. The more the characteristics of the parties differ, the less an agreement based on a nonconfigurational principle can be expected, and the less such an agreement might derive from a single configurational principle. Thus any future burden-sharing agreement involving developing countries will probably be based on a complex differentiation scheme combining different basic rules.

In fact, in past negotiations countries often advocated not just one rule but a combination (see, for example, UNFCCC 1996). Proposals for an approach using multiple rules have also begun to emerge in the literature (see Blanchard and others 1998; Helm and Simonis 2001; and Müller 1998, 2001). But they generally fail to simultaneously define equitable and efficient policy options for providing climate stability.

Initial decisions will not necessarily deliver intended outcomes. Assume, for the sake of argument, that negotiators agree to blend several differentiation rules. As noted, the question immediately arises of how emissions trading will affect the agreed arrangement. The flexibility mechanisms incorporated in the Kyoto Protocol are designed to achieve emission reductions at the lowest possible costs. If these international mechanisms are used, the final distribution of actual emissions will necessarily differ from the initial allocation of allowances. Thus it should be determined how market outcomes are deviating from the agreed initial allocation pattern. One could argue that, at least in theory, the market process will be set up from behind a "veil of ignorance" (Rawls 1971). That is, at the outset parties would agree on trading rules and emission allocations without being able to forecast trading actions and thus final outcomes. But according to Dupuy (1992), the outcomes of trade are efficient and fair because the market is free from human will, conscience, and control.

In practice, however, parties know more or less what they can expect from greenhouse gas emissions trading under different initial allocation schemes.[5] The "veil of ignorance" is partly removed because parties have some information about their current and future abatement costs (through modeling exercises, for example) as well as such costs in other countries. But the market may become a new source of disputes—this time about the fairness of the distribution of gains from trade, making policy consensus even harder to obtain.

In other words, final outcomes can look quite different from initial agreements. Thus it may be a waste of time to debate distribution formulas and related policy choices without analyzing how they might be affected by other conditions along the way.

Ex post validation of pragmatic policy scenarios. Given the impossibility of agreeing on a single criterion and the inadvisability of reaching an initial agreement without regard to final outcomes, how can the current negotiation dilemma be resolved?

Clearly, a large group of countries cannot be expected to share the same concepts of distributive justice. As Fishkin (1986) points out, the ethics of international relations are confronted with the need to find an equilibrium between immeasurable considerations and thus with the impossibility of satisfying absolutist expectations—a point that Albin (in this volume) corroborates. This realization guides this chapter's approach to the challenge of reducing greenhouse gas emissions. The main premise is that several differentiation rules must be combined to achieve climate stability as efficiently as possible.

If, in addition, there is a desire to know the likely final outcomes of various policy choices, this complex analytical challenge can be tackled only through scenario building and modeling. In fact, this chapter argues that one way to advance climate change negotiations is to support them more systematically with insights from policy research and analysis. More concretely, it provides a scenario building and modeling exercise with two main features. First, the exercise is based on realistic assumptions—ethical, political, economic, and technical—about global climate stabilization. Second, the exercise provides an ex post (model run) validation of the outcome against a number of criteria that might already enjoy broad support among different negotiating parties.[6]

A PRAGMATIC SCENARIO FOR STABILIZING GREENHOUSE GAS EMISSIONS BY 2030

This section explores a pragmatic "post Kyoto" (beyond 2010) scenario in which developing countries (along with industrial countries) may be included in a commitment to emission limits. The goal is not to propose a normative solution to the climate change equity dilemma or to test the likelihood of success for any agreement. Rather, it is to demonstrate the usefulness of scenario building and modeling as tools for decisionmaking on complex, contested issues.

The pragmatic scenario is built around a few basic assumptions. The first is that the Kyoto Protocol emission reductions will be achieved by 2010. The scenario then takes into account the total emission restrictions aimed at limiting climate change and the economic, energy, and demographic constraints of developing countries. It is called a "soft landing" scenario because it will allow all countries to contribute to the global goal and global public good of climate stability in a way that is politically, technically, and economically feasible. The assumptions underlying the scenario are described in more detail below.

A first set of constraints: meeting a common target to stabilize emissions

The latest report from the Intergovernmental Panel on Climate Change (IPCC) reviews a wide variety of possible trajectories for changes in emissions of the most important greenhouse gas—carbon dioxide from the burning of fossil fuels—from 1990 onward, leading to the stabilization of atmospheric concentrations by 2100 or later. The scientifically defined trajectories generally aim to stabilize carbon dioxide concentrations at 550 parts per million by volume (ppmv). Although "it does not imply an agreed-upon desirability of stabilization" (IPCC 2001, p.

124), this target is often used in political discussions. Thus the scenario for allocating emission allowances is based on this stabilization hypothesis.

Most of the trajectories for stabilizing concentrations at 550 ppmv by 2100 follow an inverted U-shaped curve for fossil fuel carbon dioxide emissions. After an initial growth period, emissions peak between 2020 and 2060, briefly stabilize at that point, then decline to different levels at different rates. The maximum of this curve most frequently ranges between 9 and 12 gigatons of carbon (IPCC 2001, pp.130, 150).

Scenario assumption 1: fossil fuel carbon dioxide emissions will peak and briefly stabilize at 10 gigatons of carbon by 2030.

Based on this assumption, the scenario develops along the lines of the Kyoto Protocol's primary differentiation between industrial and developing countries for the first commitment period (2008–12). This approach is used to take into account extremely different energy and economic dynamics.

For Annex 1 countries the scenario proposes the same emissions reduction rates as those in the Kyoto Protocol for Canada, the United States, and the European Union. For other countries the targets are adjusted slightly. The reduction rate for Eastern European countries matches that of the European Union (–8 percent) because these countries are expected to join the union. The target rate for all the former Soviet republics (–5 percent) is more stringent than that under the Kyoto Protocol (no change) because the region may benefit from better economic conditions after 2010. In addition, the region may transfer its large surplus of emission allowances from the first commitment period to the second. Australia and New Zealand are supposed to stabilize emissions during 2010–30.

Scenario assumption 2: in Annex 1 countries the emissions reduction rate will average –6.5 percent between 2010 and 2030.

For non–Annex 1 countries, based on the condition in assumption 1 that world emissions will peak and stabilize by 2030, the scenario projects that emissions will stabilize between 2015 and 2045.

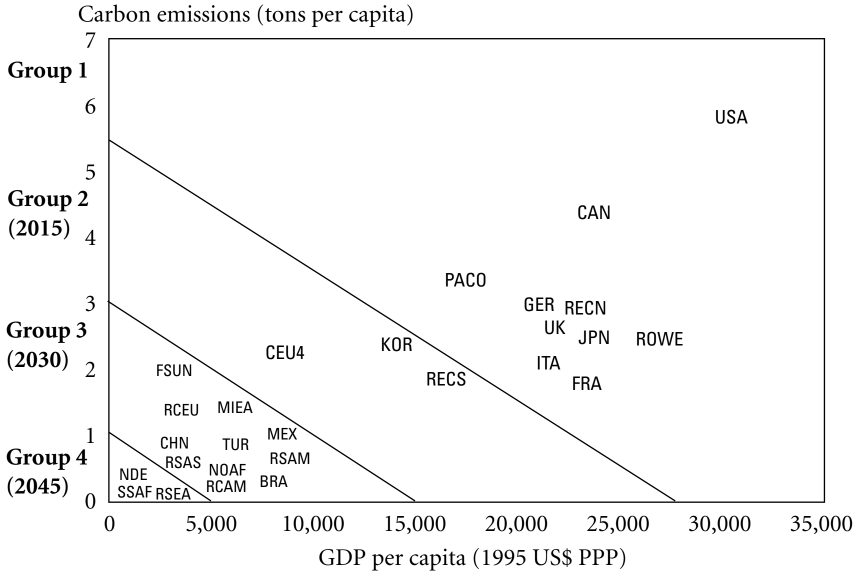
A second set of constraints: stabilizing emissions from developing countries

For non–Annex 1 countries the proposed assumptions involve no a priori allocation principles. Rather, they require defining:

- *A departure year* for determining the initial situation and dynamics of these countries. This year is defined as 2010. By then these countries' emissions under a "business as usual" scenario will be about twice the level in 1990.
- *Initial emissions growth rates,* differentiated to account for regional population growth between 2000 and 2010. Gradual reductions in these rates—along with the expected absolute reductions in Annex 1 countries (assumption 2)—lead to overall stabilization.

FIGURE 1

Countries and regions grouped by expected year of emissions stabilization



Note: Country and region codes are defined in the appendix. Per capita GDP is expressed in 1995 dollars, adjusted for purchasing power parity.
Source: POLES (Prospective Outlook on Long-Term Energy Systems) model database.

- *Future years by which emissions must stabilize.* To define these years, developing and industrial countries were grouped according to two criteria: per capita GDP and per capita carbon dioxide emissions in 2000. These criteria are used not to allocate emission allowances but to define stabilization horizons for each of the four resulting groups (figure 1).

Group 1 in figure 1 consists of Annex 1 countries. Although the rest of the southern European Union (RECS); the Czech Republic, Hungary, Poland, and the Slovak Republic (CEU4); the former Soviet Union (FSUN); and the rest of Central European countries (RCEU) fall into groups 2 and 3 in the figure, they are Annex 1 countries and regions. Thus they are included in group 1 in the analysis below for consistency with assumption 2. The resulting picture shows why the primary differentiation of the Kyoto Protocol (between Annex 1 and non–Annex 1 countries) may—in hindsight and with today's data—be considered legitimate.

Meanwhile, non–Annex 1 countries fall into groups 2 (relatively high income and emissions), 3 (intermediate income and emissions), and 4 (low income and emissions). Why such groupings? To define a horizon of stabilization, the higher are a country's income and emissions, the sooner should its emissions be stabilized. Conversely, a poor country with low per capita emissions should not be required to stabilize emissions until much later.

Scenario assumption 3: countries in group 2 will stabilize emissions by 2015, those in group 3 by 2030, and those in group 4 by 2045.
With the three preliminary assumptions in place, how can emissions allowance profiles be designed for non–Annex 1 countries, leading from the nonbinding situation in 2010 to the country-specific stabilization horizon? The initial emissions growth rate in 2010 is taken as the sum of an across-the-board annual growth rate of 3 percent in per capita emissions for all developing countries[7] and of the average annual population growth rate in each country between 2000 and 2010 (see Blanchard and others 2000 for mathematical details on this growth rate). Then this initial growth rate decreases until it reaches zero in the stabilization year (2015, 2030, or 2045) defined for each group of developing countries. For each group the reduction in the growth rate follows the same linear function, resulting in a "soft landing" of the growth rate to zero.

So, to summarize the structure of the soft-landing scenario:

- It aims to achieve a stable 10 gigatons of carbon emissions by 2030.
- It assumes that the Kyoto targets will be achieved by Annex 1 countries and reapplied (with minor adjustments) for the second period (2010–30).
- It proposes reducing linearly the emissions growth rates for developing countries at different horizons, taking into account their per capita GDP, per capita carbon dioxide emissions, and population growth rates.

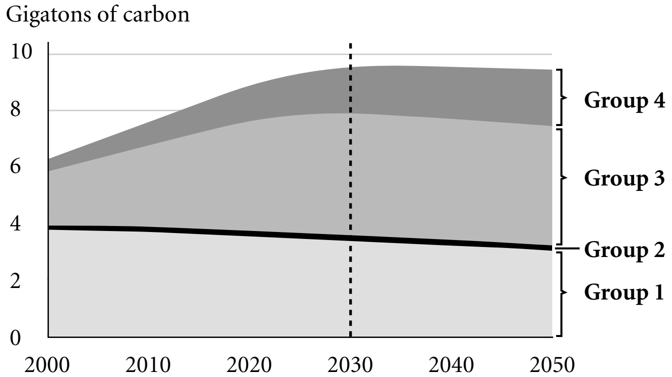
In addition, the model will be run without and with the assumption that international emissions trading occurs.

In defining the stabilization rate for developing countries, no particular differentiation rule has been chosen. So, the intriguing question is, what allocation patterns (of emission allowances or costs of emission reductions) result from the assumptions and constraints for realistic, pragmatic considerations? And are they fair? This is the subject of the next section.

Assessing the results of the soft-landing scenario

Figure 2 shows emissions under the scenario for 2000–50, differentiated by country group. The scenario achieves the overall target: combined emissions are stabilized at 9.5 gigatons of carbon in 2030. In addition, the global stabilization target is reached: emissions from Annex 1 countries decrease over the entire period, while emissions from group 2 countries stabilize in 2015, those from group 3 countries in 2030, and those from group 4 countries in 2045. Of the 9.5 gigatons of carbon in 2030, 3.7 gigatons are endowed to Annex 1 countries and 5.8 gigatons to developing countries.

FIGURE 2
Carbon dioxide emissions under the soft landing scenario, 2000–2050



Source: POLES (Prospective Outlook on Long-Term Energy Systems) model.

One requirement for the soft-landing scenario is that it be politically acceptable to most of the negotiating parties. This goal could be achieved only if the scenario were compatible with several of the differentiation rules described above. Accordingly, this section evaluates the results of the scenario by answering several questions. How equitable are the final outcomes? How does the scenario address efficiency concerns? And does the scenario achieve the overall objective of combining efficiency with equity?

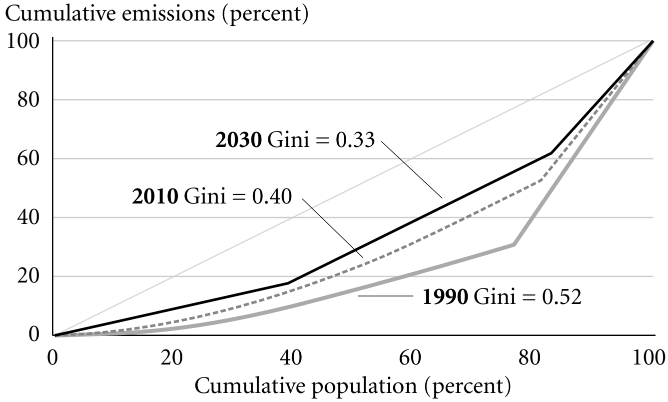
Equity considerations

Gauging the equity of a distribution depends on the principle of justice used to define equity (Blanchard and others 2000). One way is to consider the changes in the distribution of per capita emissions over the period.

Figure 3 shows Lorenz curves and Gini coefficients for world carbon dioxide emissions in 1990, 2010, and 2030.[8] The 1990 curve represents real carbon dioxide emissions, or de facto allowances for that year. The 2010 curve shows the de jure distribution of emission allowances as called for in the Kyoto Protocol. The 2030 curve is based on the allocation of allowances under the soft-landing scenario.

When a Lorenz curve is a straight line, the distribution is considered perfectly egalitarian. In the allocation of allowances such a distribution would reflect universally equal per capita emissions. Thus figure 3 shows that the situation in 1990 was the most unequal, the situation in 2010 will be less unequal, and the hypothetical situation in 2030 even less unequal. These observations are confirmed by the Gini coefficients, which drop from 0.52 in 1990 to 0.40 in 2010 and 0.33 in 2030.[9] Thus the soft-landing scenario would reduce inequalities

FIGURE 3
Lorenz curves and Gini coefficients for world emission allowances



Source: POLES (Prospective Outlook on Long-Term Energy Systems) model.

among countries by moving toward more equal per capita emission allowances. The scenario does not, however, achieve equality. If further equality is desired, some initial assumptions would have to be modified or further constraints introduced.

Efficiency considerations

Governments and other stakeholders are seriously concerned about reducing abatement costs as much as possible. What do the results of the soft-landing scenario indicate about this concern?

Abatement costs have been calculated using the POLES (Prospective Outlook on Long-Term Energy Systems) model, a partial equilibrium model of the world energy system.[10] This model is situated between the "top down" approach of general computable equilibrium models and the "bottom up" approach of analytical engineering studies. In the POLES model abatement costs are estimated by introducing a shadow carbon tax—a "carbon value"—in all the energy consumption transformation modules. This shadow tax induces adjustments in final energy demand through technological progress or behavioral change, as well as substitutions in energy conversion systems for which the technologies are explicitly identified. By first projecting a reference case in which the shadow tax is zero, it is possible to perform iterative simulations to calculate the emissions associated with a shadow tax that gradually increases from, say, $0 to $600 per ton of carbon. The marginal abatement costs for a particular level of emissions are then deduced (Criqui and Kouvaritakis 1997).[11]

No trading allowed. Abatement costs under the soft-landing scenario are listed in table 2. These costs assume that countries pursue fully autarkic policies—that is, that they cannot trade emission allowances. Annex 1 countries are highlighted to ease reading, and countries are ordered according to abatement costs as a percentage of GDP.

Under the scenario, by 2030 world emissions would be reduced by about 2,500 million tons of carbon relative to the reference situation. Annex 1 countries would account for almost 1,400 million tons of emission reductions, or about 55 percent, and incur 66 percent of total abatement costs. The annual sectoral cost of complying with the commitments for 2030 would range between 0.01 and 1.1 percent of GDP for Annex 1 countries and between 0 and 1 percent for non–Annex 1 countries.[12] The marginal cost of the projected reductions would vary considerably by region, and in extreme cases would exceed $600 per ton of carbon, with the highest values found in Europe and Central America.

The analysis of total abatement costs recalls that costs are built up from the combination of a price effect and a quantity effect. Thus some regions can face a similar cost stemming from either:

- A limited amount of reductions combined with high marginal costs (the Netherlands, rest of Western Europe).
- A greater volume of reductions achieved at low marginal costs (India).

Trading allowed. Now consider a situation where emissions trading is possible. Numerous studies have demonstrated the economic rationale of developing a market for emission permits (see Criqui, Mima, and Viguier 1999; *Energy Journal* 1999; and UNCTAD 2001). This section uses the soft-landing scenario to support this approach.

With trading, the emissions reduction target is still about 2,500 million tons of carbon below the reference level by 2030 (table 3). The world marginal cost of compliance—or the permit price—comes out to $95 per ton of carbon. More than 750 million tons of carbon would be traded, representing 30 percent of the emissions reduction required by the scenario, at a total value of about $71 billion. A dozen countries and regions would export permits, the main ones being China and the former Soviet Union. The main permit buyer would be the United States, with 288 million tons of carbon ($27 billion). Other Annex 1 countries would buy about 250 million tons, and permit-importing non–Annex 1 countries would buy just over 200 million tons.

Taking the situation with no trading as a benchmark, it is possible to analyze the potential gains from introducing international emissions trading. Table 3 confirms the efficiency gains from trade at the global level (a cost of 0.11 percent of GDP instead of 0.2 percent in the no-trade case) and at the national level for all countries. The net gains compared with the no-trading situation are significant

TABLE 2

Abatement costs under the soft-landing scenario, with no trading

Country or region	Emissions in 2030 (millions of tons of carbon): Business-as-usual scenario	Emissions in 2030 (millions of tons of carbon): Soft-landing scenario	Emissions in 2030 (millions of tons of carbon): Emission reductions	Abatement costs: Marginal costs (1995 U.S. dollars per ton of carbon)	Abatement costs: Total costs (millions of 1995 U.S. dollars)	Abatement costs: Share of GDP (percent)
Rest of Western Europe	40	20	20	>600	6,634	1.14
Rest of Central America	88	61	27	>600	7,131	1.01
Netherlands	63	38	25	>600	6,528	0.99
Korea, Republic of	249	153	96	529.3	15,643	0.84
Ireland	16	9	7	591.7	1,361	0.65
Sweden	25	14	11	471.9	2,015	0.60
Canada	170	101	69	311.0	7,759	0.54
Greece	39	22	17	230.3	1,436	0.52
Austria	18	13	6	>600	1,666	0.49
Finland	23	13	9	266.7	966	0.43
Australia and New Zealand	158	85	74	220.5	5,217	0.42
United States	1,951	1,155	796	221.6	63,634	0.41
Denmark	17	11	7	362.0	920	0.39
Rest of Southeast Asia	921	626	295	208.8	23,207	0.31
Belgium and Luxembourg	39	28	12	286.3	1,350	0.30
France	136	94	42	409.1	7,362	0.29
Spain	91	62	28	307.3	3,326	0.26

Japan	331	259	73	322.1	10,315	0.22
United Kingdom	189	129	60	204.0	4,930	0.22
Brazil	226	181	45	212.0	4,329	0.16
Italy	116	91	25	253.4	2,440	0.13
Rest of South Asia	179	144	35	125.0	1,944	0.11
Middle East (Mediterranean)	88	74	14	115.2	694	0.09
Germany	238	194	44	118.1	2,406	0.08
Sub-Saharan Africa	587	519	68	72.1	2,105	0.08
India	1,180	989	191	65.8	5,967	0.07
Turkey	130	106	24	72.3	772	0.05
Rest of South America	210	190	20	103.5	998	0.03
Portugal	16	13	3	70.4	87	0.03
Central Europe 4[a]	184	168	15	32.3	237	0.02
Rest of Central Europe	98	91	6	34.3	104	0.02
Gulf states	473	445	28	25.1	338	0.02
China	2,395	2,122	274	32.2	4,230	0.02
Egypt	51	48	3	42.3	53	0.01
Morocco and Tunisia	26	24	2	32.4	26	0.01
Former Soviet Union	944	913	32	12.9	204	0.01
Mexico	183	188	–4	0.0	0	0.00
Algeria and Libyan Arab Jamahariya	52	55	–3	0.0	0	0.00
World	11,941	9,444	2,498	94.8	198,333	0.20

Note: Annex 1 countries are shaded.

a. Czech Republic, Hungary, Poland, and Slovak Republic.

Source: POLES (Prospective Outlook on Long-Term Energy Systems) model using ASPEN (Analyse des Systèmes de Permis d'Emissions Négociables) software.

TABLE 3

World market for emission allowances: an equilibrium price of $95 per ton of carbon

(millions of 1995 U.S. dollars unless otherwise specified)

Country or region	Emissions in 2030 (millions of tons of carbon)			Domestic reductions (percent)	Volume of trade (millions of tons of carbon)	Value of trade	Domestic cost	Total cost	Total cost without trading	Gains from trading	Cost after trading (% of GDP)
	Business-as-usual scenario	Soft-landing scenario	With trading								
Korea, Republic of	249	153	207	44	–54	5,115	1,701	6,815	15,643	8,828	0.37
Greece	39	22	28	62	–6	614	416	1,031	1,436	405	0.37
Australia and New Zealand	158	85	106	71	–21	2,015	2,059	4,074	5,217	1,143	0.33
Rest of Central America	88	61	83	20	–22	2,062	265	2,328	7,131	4,803	0.33
Canada	170	101	136	49	–35	3,326	1,316	4,642	7,759	3,117	0.32
Netherlands	63	38	57	27	–19	1,764	293	2,056	6,528	4,472	0.31
United States	1,951	1,155	1,442	64	–288	27,265	20,149	47,414	63,634	16,220	0.30
Rest of Western Europe	40	20	36	21	–16	1,480	180	1,660	6,634	4,973	0.28
Finland	23	13	18	52	–5	427	210	637	966	329	0.28
Ireland	16	9	13	38	–4	423	112	535	1,361	826	0.26
Sweden	25	14	22	29	–8	738	146	884	2,015	1,131	0.26
Rest of Southeast Asia	921	626	727	66	–101	9,590	8,319	17,908	23,207	5,299	0.24
Denmark	17	11	14	45	–4	362	125	487	920	433	0.21
Belgium and Luxembourg	39	28	34	48	–6	589	246	835	1,350	514	0.18
United Kingdom	189	129	152	61	–24	2,235	1,537	3,772	4,930	1,159	0.17
Spain	91	62	77	49	–15	1,387	563	1,950	3,326	1,377	0.15
Austria	18	13	17	26	–4	412	64	476	1,666	1,190	0.14
France	136	94	123	31	–29	2,750	560	3,310	7,362	4,052	0.13

Japan	331	259	303	39	–44	4,173	1,229	5,402	10,315	4,913	0.12
Brazil	226	181	203	52	–22	2,061	1,052	3,113	4,329	1,215	0.12
Rest of South Asia	179	144	150	81	–7	624	1,222	1,846	1,944	98	0.11
Italy	116	91	102	56	–11	1,061	590	1,651	2,440	789	0.09
Middle East (Mediterranean)	88	74	76	87	–2	174	501	675	694	19	0.09
Germany	238	194	201	85	–7	643	1,687	2,330	2,406	76	0.07
Sub-Saharan Africa	587	519	505	121	14	–1,339	3,283	1,944	2,105	161	0.07
India	1,180	989	923	135	66	–6,277	11,263	4,986	5,967	981	0.06
Turkey	130	106	101	119	5	–433	1,152	719	772	53	0.05
Portugal	16	13	13	112	0	–35	118	82	87	5	0.03
Rest of South America	210	190	191	93	–1	137	855	992	998	6	0.03
Egypt	51	48	46	167	2	–218	209	–9	53	62	0.00
Morocco and Tunisia	26	24	22	222	2	–198	153	–45	26	71	–0.01
Rest of Central Europe	98	91	83	226	8	–764	611	–154	104	257	–0.03
Central Europe 4[a]	184	168	146	244	22	–2,098	1,614	–485	237	721	–0.04
China	2,395	2,122	1,748	237	374	–35,436	27,164	–8,272	4,230	12,502	–0.04
Gulf states	473	445	392	289	53	–5,022	3,369	–1,653	338	1,991	–0.08
Mexico	183	188	151	—	37	–3,471	1,416	–2,055	0	2,055	–0.10
Algeria and Libyan Arab Jamahariya	52	55	47	—	8	–780	217	–564	0	564	–0.18
Former Soviet Union	944	913	751	613	162	–15,353	8,058	–7,296	204	7,500	–0.26
World	11,941	9,444	9,444	n.a.	–754	–71,427	104,023	104,023	198,333	94,310	0.11

— Not available.

n.a. Not applicable.

Note: Annex 1 countries are shaded.

a. Czech Republic, Hungary, Poland, and Slovak Republic.

Source: POLES (Prospective Outlook on Long-Term Energy Systems) model using ASPEN (Analyse des Systèmes de Permis d’Emissions Négociables) software.

for certain regions: $67 billion for buying countries (including $16 billion for the United States) and $27 billion for selling countries (including $12 billion for China), for a total of $94 billion.[13]

The gains in cost efficiency stem from the savings that result from the equalization of marginal abatement costs across countries and regions. Thus a world market for emissions trading produces a more efficient outcome than the no-trading approach.

Of course, the values in tables 2 and 3 are indicative. The relative levels are more significant than the absolute figures. Furthermore, the results are largely theoretical. Like most assessments of this kind, they rely on the assumption that all the potential reductions can be achieved and that the flexibility mechanisms will operate perfectly. In other words, they are based on a pure, perfect, competitive market without transaction costs. In this context the value of the tradable permit should be interpreted as a minimum or floor value, while the volume traded is a maximum volume.

That said, how does the distribution of the abatement costs interfere with the trend toward enhanced equity seen earlier?

Combining efficiency and equity

As noted, the soft-landing scenario leads toward a convergence of per capita emissions over time. When trade is allowed, it is also consistent with utilitarian justice, as it lowers the costs of providing climate stability and so increases global welfare.

Furthermore, as a group the least advantaged countries bear a smaller burden in terms of total costs per unit of GDP. This outcome resembles Rawls's notion of justice, and especially the "difference principle" (or "maximin"), which gives priority to maximizing the expectations of the least favored members of society. Again, the soft-landing scenario does not strictly apply any one notion of justice, but from the perspective of the most commonly held notions of justice, it is moving in the right direction.

Conclusion

This chapter has addressed the efficient and equitable provision of global public goods using climate stabilization as an example. But the scenario suggested here is just one possibility—other scenarios and models could be developed.[14] The accuracy of the assumptions made and constraints adopted is not the key point. Of greater relevance is that the proposed approach would allow policymakers to explore the effects of various policy choices in an incremental way and, most important, to more clearly see the final outcomes. Those outcomes could then be assessed in terms of various equity and efficiency considerations and objectives. If the first set of likely outcomes is not satisfactory, initial assumptions could be modified to move toward more desirable but still realistic objectives and policy paths. This iterative, incremental approach to policy change could ultimately generate a satisfactory outcome for negotiating parties with very different notions of justice, fairness, and equity.

Appendix. Country and Region Groups for Expected Emissions Stabilization

Group 1: In compliance with objectives defined in the Kyoto Protocol
USA: United States
CAN: Canada
PACO: rest of Pacific OECD countries
GER: Germany
RECN: rest of northern European Union
RECS: rest of southern European Union
JPN: Japan
UK: United Kingdom
ITA: Italy
FRA: France
ROWE: rest of Western Europe
CEU4: four Central European countries (Czech Republic, Hungary, Poland, Slovak Republic)
FSUN: former Soviet Union
RCEU: rest of Central European countries

Group 2: Emissions stabilize in 2015 (non–Annex 1 countries)
KOR: Korea, Republic of

Group 3: Emissions stabilize in 2030 (non–Annex 1 countries)
MIEA: Middle East
MEX: Mexico
TUR: Turkey
CHN: China
RCAM: rest of Central America
BRA: Brazil
RSAM: rest of South America
NOAF: North Africa
RSEA: rest of Southeast Asia

Group 4: Emissions stabilize in 2045 (non–Annex 1 countries)
SSAF: Sub-Saharan Africa
RSAS: rest of South Asia
NDE: India

Notes

1. The text does not refer to Annex 1 and non–Annex 1 countries in this section because some countries—such as the Republic of Korea and Singapore—that are not in the Annex 1 group could easily be part of the industrial country group based on GDP per capita and per capita emissions of greenhouse gases.

2. The Global Commons Institute refers to this proposal as "contraction and convergence" (GCI 1996). Agarwal and Narain (1991), along with the institute, were the first to propose it. Their approach is developed in Agarwal (1998) and Agarwal and Narain (1998).

3. Claussen and McNeilly (1998) consider the possibility of taking into account future emissions (rather than past emissions) when determining each country's responsibility. But even if problems in deciding how to measure future emissions are discounted, the result in terms of differentiation would be opposite to that based on past emissions and unacceptable to developing countries.

4. On this issue, see Hassner (1996, pp. 1278–85) and Hoffmann's comments on Rawls (in Rawls 1996). On the specific use of justice principles and greenhouse gas emissions, see Godard (1992), Grubb (1995), Harris (2001), Rose (1992), and Paterson (1996).

5. For example, Russia knows that it would be the main exporter of emission permits if trading were limited to Annex 1 parties, based on Kyoto targets. In the same way, Russia knows that China would be its main competitor in a world trading market.

6. As some analysts (such as Müller 2001) point out, making explicit ex ante reference to certain equity principles may help prevent disagreements in future negotiation steps. This is an important practical and political insight. The model in this chapter responds to this requirement by including consensus-based principles and rules in the scenario. In addition, negotiating parties can decide on the precise criteria that they want to see used in the ex post validation of the results.

7. Note that a per capita emissions growth rate of 3 percent corresponds to 3 percent growth in per capita GDP at a constant intensity of emissions per unit of GDP. In fact, since E/POP = (E/GDP)*(GDP/POP), a first approximation indicates additivity of the growth rates of E/GDP and GDP/POP, with negligible differences.

8. The Lorenz curve and the Gini coefficient were created to measure inequality in a population's income distribution. But they can also be used to measure equity in the distribution of other assets, such as emission allowances.

9. A Gini coefficient of 0 indicates a perfectly equal distribution; a coefficient of 1 indicates a fully unequal distribution.

10. For more information on the POLES model, see European Commission (1996).

11. The costs calculated in the POLES model are sectoral costs, or "gross" costs that relate only to the adjustments needed in the energy sector. They differ from

macroeconomic costs, which register the costs supported by a country's entire economic system. They also do not include the costs countries incur to monitor and report their emissions, although these actions would be preliminary obligations for countries accepting binding commitments.

12. According to this scenario, two non–Annex 1 regions would have emission targets slightly less stringent than their reference emissions. Although the amount of such "hot air" is fairly small, it implies that the scenario should be better adjusted for these regions.

13. Some countries and regions even achieve a net gain relative to the no carbon constraint or reference case.

14. UNCTAD (2001), for example, reviews various flexible ways for developing countries to participate in an international emissions trading system.

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