2 *Formulas for quantitative emission targets*

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We are sorely in need of ideas as to how to proceed to address the emission of greenhouse gases (GHGs):

(1) Global climate change (GCC) is a huge and genuine problem, as is now more widely recognized than even a few years ago.
(2) The Kyoto Protocol, and the United Nations Framework Convention on Climate Change (UNFCCC) within which it sits, constitute the only multilateral framework we have to address the problem.
(3) The Protocol, as actually negotiated in 1997 or as it went into force in 2005, is inadequate in three important ways: its goals could be costly to achieve if interpreted literally, neither the largest nor the fastest-growing emitters have signed up, and it would have made only the tiniest dent in global GHG concentrations even if it had entered into force with good prospects for compliance and even if all countries had participated.

Few American economists support the Kyoto Protocol.[1] I have spoken and written in support, at least, of the Clinton–Gore version of it, perhaps because I was (one of many) involved in its design during 1996–1999. My claim is that – given the combination of political, economic, and scientific realities as they are – Kyoto is a good foundation, a good first stepping stone on the most practical path if we are to address the global warming problem more seriously, as we should. Nobody would say that the text negotiated in Kyoto is ideal. But, as I phrased it in the title of a recent article, "You're Getting Warmer: The Most Feasible Path for Addressing Global Climate Change Does Run through Kyoto."[2]

The author would like to thank Joe Aldy, Robert Stavins, and Jonathan Weiner for useful comments.

[1] Goulder and Pizer (2006) survey recent economists' research.

[2] Frankel (2005). For another defense of Kyoto as a good foundation, see Sandalow and Bowles (2001).

In this chapter I will try to take a constructive approach, by asking what are the desiderata, the requirements, for a second step in the process, a successor to the Kyoto regime of 2008–2012, one that would build on what is good about it and fix what is most lacking.[3]

What are necessary requirements for the next multilateral treaty?

I see a list of requirements that any new agreement must meet. They are: *More comprehensive participation, Efficiency, Dynamic consistency, Robustness under uncertainty, Equity, and Compliance*.[4]

The first big desideratum: ***More comprehensive participation***, specifically getting the United States, China, and as many other developing countries as possible to join the list of those submitting to binding quantitative commitments.[5] The absence of the developing countries is probably the most serious and most intractable shortcoming of the Kyoto Protocol, except perhaps for the absence of the United States – which is to some extent a function of the competitiveness fears generated by the absence of the developing countries. We need to get developing countries into the system for three reasons:

(1) The developing countries will be the source of the big increases in emissions in coming years according to the business-as-usual path (BAU), that is, the path along which technical experts forecast that countries' emissions would increase in the absence of a climate change agreement. China, India, and other developing countries will represent up to two-thirds of global carbon dioxide emissions over the course of this century, vastly exceeding the expected contribution of the Organisation of Economic Co-operation and Development (OECD) of roughly one-quarter of global emissions. Without the participation of major developing countries, emissions abatement by industrialized countries will not do much to mitigate global climate change.

(2) If a quantitative international regime is implemented without the developing countries, their emissions are likely to rise even faster than

[3] This extends the ideas in Aldy and Frankel (2004) and Frankel (1999, 2005).

[4] Stewart and Weiner (2003) have a similar list.

[5] As pointed out by Barrett (2006), Nordhaus (2006), Olmstead and Stavins (2006), Victor (2004), and just about all other Americans who have written on the subject. Even the Clinton–Gore Administration would not have submitted the treaty to US Senate ratification without meaningful participation by developing countries.

the BAU path, due to the problem of *leakage*. Leakage of emissions could come about by relocation of carbon-intensive industries from countries with emissions commitments under the Kyoto Protocol to nonparticipating countries, or by increased consumption of fossil fuels by nonparticipating countries in response to declines in world oil and coal prices. Estimates vary regarding the damage in tons of increased emissions from developing countries for every ton abated in an industrialized country. But an authoritative survey concludes "Leakage rates in the range 5 to 20 percent are common" (IPCC 2001: 536–544).

And (3) the opportunity for the United States and other industrialized countries to buy relatively low-cost emissions abatement from developing countries is crucial to keep the economic cost low. This would increase the probability that industrialized countries comply with the system of international emissions commitments.

The second big category of concern is ***Efficiency***, which I would argue in this particular context must come down to cost-effectiveness: an attempt to minimize the economic costs of achieving an environmental goal. The critics of Kyoto sometimes fail to give it credit for the market mechanisms and flexibility that were built in to the treaty. They are the primary reason why I think it a positive first step on which to build. Yet they could just as easily not have been in the treaty. Most obviously, there is the international trading of emissions permits ("where flexibility"), which is critical. The Clinton Council of Economic Advisers (CEA) reported to Congress in its 1998 Administration Economic Analysis[6] estimates of sharp cost reductions from trading (80 percent, if key developing countries are in the system). These estimates were similar to the independent estimates of Edmonds *et al*.[7] But there is also some scope for smoothing over time ("when flexibility") in the form of averaging over a five-year period, and the possibility of banking credits. And insufficiently appreciated is "*what* flexibility" – scope for substituting across the six GHGs, not just

[6] *The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis*. Summaries included Yellen (1998) and Frankel (1998).

[7] Edmonds, Pitcher, Barns, Baron, and Wise (1992) and Edmonds, Kim, McCracken, Sands, and Wise (1997). We at the CEA made adjustments for the effect of the six-gas objective, as the existing economic models focused on carbon dioxide alone. Joe Aldy was the CEA staff economist who implemented the model.

carbon dioxide, or between the GHGs and sequestration through forestation ("sinks"). These kinds of flexibility not only reduce the expected value of the economic cost but also ease response to fluctuations in the price of carbon.

My definition of efficiency was cost-minimization for a given environmental goal. But that is not the same as the full benefit-cost optimization that is favored by economists. The cost-minimization approach takes the quantitative goal as given, rather than determining the optimal plan by weighing up environmental benefits of more or less stringent paths against the economic costs. Economists argue that the optimal path involves shallower cuts in the earlier years and deeper cuts late in the century. This is the result that usually emerges from the integrated assessment models that Nordhaus (1994) inaugurated and others have emulated and extended.[8] For example, it is the strategy suggested by the Manne and Richels (1997) research.[9]

The Kyoto Protocol itself failed to address future periods. Because the problem is the stock of cumulative concentrations of GHGs in the atmosphere, not the flow as in most other kinds of pollution, an agreement that does not specify long-term measures seems to accomplish little. Most of those participating in the Kyoto negotiations (though not all) understood that the cuts under discussion would make only minute contributions to reducing greenhouse gas concentrations, temperatures, and sea-level rises later in the century. We estimated that if participation were limited to the countries undertaking commitments at Kyoto, then the effect of the agreement would be to reduce the temperature in 2050 by only roughly one-tenth of one degree Celsius (relative to a baseline increase of 1.15 degrees). Even so, the longest journey begins with a single step.

It is true that it would be optimal to save the deep cuts for later in the century, within the terms of those models. Scrapping coal-fired

[8] For example, Nordhaus (2006) wants the numbers to be derived from "ultimate economic [and] environmental policy objectives." Olmstead and Stavins (2006) also argue for "moderate targets in the short term to avoid rendering large parts of the capital stock prematurely obsolete, and more stringent targets for the long term."

[9] CEA found the Manne–Richels model to be the most useful of all that existed as of early 1997, for the specific purposes of planning for Kyoto. Subsequently, Hammett (1999) estimated that the least-cost emissions path for stabilizing at 550 (parts per million) lies below the fully optimizing path of cost-benefit analysis, until 2024, and then crosses above it.

power plants today is costly, while credibly announcing that the goals will be stringent fifty years from now would not be as costly, because it would give businessmen and consumers, and scientists and engineers time to plan. But I believe that benefit-cost maximization, though obviously right in theory, is in this case the wrong logic in practice for two reasons. First, the uncertainties are so great – not only regarding unknown future technologies, but even more so regarding the probabilities and nature of tremendous global catastrophes and what is the appropriate discount rate for events centuries into the future – as to make benefit-cost estimates worthless. It is impossible to put probabilities on the catastrophe scenarios (an end to the Atlantic circulation pattern, melting of the Antarctic ice shelf, an unstable feedback loop through release of methane from thawing permafrost, and so on). Just the range of uncertainty about the appropriate discount rate can give every answer, from large immediate cuts to a path that begins with no cuts.[10]

Of course economic costs have substantial uncertainties too, but nothing to compare with the uncertainties on the side of the benefit of mitigation. Surely, you will say, the existence of uncertainty does not change the logic that we should "take our best shot" at estimates of the optimal path of emission reductions. Here comes the second reason why I believe the benefit-cost approach is not practical in this context.

Dynamic consistency. Governments cannot bind their successors. Call it institutional or political myopia, if you will. But nobody knows what the objective scientific, technical, economic, and political realities will look like in the future. Thus it is rational and sensible that the system is unable to commit to specific targets for the rest of the century. If the designers of a treaty specify a path for steep future reductions, their successor governments will not likely be willing to pay the high economic costs necessary to follow through when the time comes. Those making investment decisions today – from power-plant construction, to housing, to technological research – know that tomorrow's policies will not be consistent with today's promises and will act accordingly. This is the definition of dynamic inconsistency, a term I am borrowing from

[10] E.g., Cline (1992) and Dasgupta (2001). For a general review of the timing issues, see Aldy, Orszag, and Stiglitz (2001).

monetary economics where it refers to the problem of noncredible anti-inflation announcements by central banks.[11]

In considering the desiderata for a successor to Kyoto, another aspect of dynamic consistency belongs on the list: the importance of standing by precedents so as to avoid the incentive for countries to stay out of an agreement as long as possible or to ramp up emissions in the meantime, so as to be able to negotiate from a higher base. This is the principle well recognized in legislating tax-law changes, even in so dysfunctional an institution as the US Congress, that the date on which (e.g.) investment tax credits take effect is (retroactively) the date that the legislation is first proposed, not the date it passes. This principle was recognized in the 1997 treaty when 1990 emission levels were chosen as the overall baseline, even while concessions were made to subsequent facts of life (e.g., allowing the US target to cut less deeply below the baseline than the European target, because US emissions even by then had been growing more rapidly). I think whatever framework is established now to negotiate targets for 2013–2017 and beyond, there should not be 100 percent forgiveness of the rapid increases that countries like the United States and China have incurred in the meantime, i.e., the Europeans should get some credit for the cuts they have made. Otherwise, whatever countries are the last holdouts at any particular stage have even less incentive to join.

Others, to be sure, have come to recognize the importance of dynamic consistency. The answer, from Olmstead and Stavins (2006), is that "once national governments have ratified the agreement, implementing legislation within respective nations would translate the agreed long-term targets into domestic policy commitments . . . This represents a logical and ultimately feasible chain of credible commitment." I am afraid I just do not agree that this is politically feasible. Bringing up politics is problematic, because every analyst can simply pronounce the proposals of others politically infeasible, and there is no way of verifying which of them are in fact more or less infeasible than others. But none of the country delegations at Kyoto proposed specific

[11] I want to be clear that it still makes sense for academic models often to work in terms of long-term paths. But it is also important to realize that no given policymaker gets to choose a long-term path. The job of each, at most, is to choose the size of one link in the chain. The economic adviser who insists on talking about 100-year paths is making the common mistake of refusing to answer the question that the policymaker has hired him to answer.

policy measures that went beyond 2012, and it was not because many of us were not acutely aware of the unpleasant reality that the cuts for the first budget period were but a drop in the bucket in terms of effect on climate. Perhaps there is a reason for this empirical fact, a reason that governments cannot in this context bind their successors, that is not readily apparent to academics.[12]

Let me try a new analogy: the regular fiscal budget process. My guess is that almost all policymakers in the United States or Europe or other countries would agree that the budget ought to be roughly balanced over the business cycle, or in countries where debt is too high that it ought to run surplus on average to undo steadily over time the excess accumulation of debt in the past. And yet budgets are almost always passed by politicians at a one-year horizon. Occasionally a country sets a "medium-term fiscal path" of budget consolidation over ten years, or a "social security fix," or adopts an institutional constraint like Europe's Stability and Growth Pact or the Gramm–Rudman legislation of the 1980s. Usually these are failures. Even where they succeed, the regime at the very most lasts a decade. Has anyone proposed to legislate a 75-year path of budget deficits or surpluses to achieve long-run fiscal sustainability? The idea is not practical. There is too much genuine uncertainty and too many imperfections in the political process to make such a thing feasible.

President Clinton would have been laughed out of town if he had announced in 1997 that his administration's climate change proposal was to do almost nothing until 2050 and then institute tough emission cuts in the second half of the twenty-first century. Certainly there would have been no rush by the engineers to develop new technologies to be ready for the big day in 2050 when the price of carbon would abruptly rise, because nobody would have believed it.

In climate policy, as in fiscal policy or monetary policy, an announcement of future plans is not in itself credible. Nor can lock-in institutions take us as far as our models sometimes make it sound. Problems of genuine unpredictability and political legitimacy (under democracies, elected legislative bodies have to decide how money is spent), even leaving aside the possibility of myopia or excessively high discount rates, mean that the quantitative stringency of targets will have to be

[12] McKibbin and Wilcoxen (this volume) also seek to address the long-term credibility problem.

set one political term at a time. The bottom line is that there is a good reason for policymakers to try to begin with a "down payment," a more aggressive first step than would be implied by an "optimally" calculated path as might be found in a standard forward-looking integrated assessment model. To pursue the analogy of monetary policy, one way central bankers can address the problem of dynamic inconsistency and attain credibility is by establishing reputations for monetary discipline. Both Paul Volcker and Alan Greenspan did this by raising interest rates *at the beginning* of their terms as Chairman of the Board of Governors of the Federal Reserve System.

If Americans were collectively to decide, hypothetically in 2008, that they wanted to get serious about addressing global climate change, it would be far too late to sign on to the quantitative targets agreed to at Kyoto, which pertain to the budget period 2008–2012. These targets are no longer attainable. Thus it is a matter of setting emission targets for the subsequent budget period, which begins in 2013. Given that most of the rest of the world has gone ahead without us, we might have to begin by establishing some credibility, by taking some dramatic short-term action – if not agreeing to substantive short-term cuts, then passing a big national gas tax or carbon tax.[13]

The conventional wisdom has always been that big energy taxes are as politically unacceptable to the American public as Kyoto itself.[14] After the fiasco of the proposed BTU (British Thermal Unit) tax and gas tax in the first year of the Clinton Administration, one could not even mention the word "tax" out loud in a discussion of GCC options in the late 1990s. But that should not stop us academic economists from talking about it. Political realities change. If we had had true leadership

[13] The spirit is the same as Pizer's (2006, p. 9) "Recognizing the evolutionary nature of a global climate policy. . . useful near-term steps should be the priority and should be viewed in the context of ongoing negotiations to refine the international framework."

[14] Some take encouragement from results such as a *New York Times* / CBS News Poll conducted February 22–26, 2006, with 1,018 respondents. Whereas 85 percent oppose an increased federal gas tax when the question is posed unconditionally and only 12 percent favor it, the number in favor rises to 55 percent (with 37 percent opposed) if the question is preceded by "What if the increased tax on gasoline would reduce the United States' dependence on foreign oil. . ." and to 59 percent (with 34 percent opposed) if preceded by "What if the increased tax on gasoline would cut down on energy consumption and reduce global warming. . ." But it is not clear that the latter formulations are necessarily the more politically relevant.

in the White House on September 11, 2001, we could have had such taxes adopted, in a bid to reduce dependence on oil from the Middle East, with the proceeds going either to cut other taxes or to fight a war on terrorism or both. I suggest we should be ready with such a plan on the shelf for the next shock (whether it is a 9/11 with unconventional weapons, a loss of oil from the Gulf, or the replacement of governments in Pakistan or Saudi Arabia by radical anti-Western regimes, etc.).

Robustness under uncertainty. Two defining aspects of Kyoto merit particular support. The first is the desirable market mechanisms.[15] Second is the adoption of quantitative targets for countries.

Cooper (1998), Nordhaus (2006), and other economists prefer price targets to quantity targets. More specifically they prefer a global carbon tax. Their arguments are as valid as they are familiar. One of the most important is robustness under uncertainty. But let me pick one major problem with the beloved global harmonized carbon tax (e.g., Nordhaus, 2006): what is to determine the baseline? Lots of countries already have lots of government policy measures governing energy and the environment. Europe has long had very high taxes on petroleum products. Britain phased out coal in the 1980s. Others have phased out subsidies. Many signatories are currently undertaking major further steps. It is neither "fair" nor intertemporally consistent to say that they must add a new carbon tax at an internationally unified rate. What if their existing array of policies already comes very close to a carbon tax? Are they then exempt? It's not that these problems are totally insoluble; the point, rather, is that they are on the same order of magnitude as the practical problems with agreeing quantitative targets that the critics like to point out. With one difference: the signatories at Kyoto have already demonstrated (surprisingly) that they can in fact agree on differentiated national quantitative targets.

The main point is that harmonizing taxes internationally seems to me infeasible while agreeing quotas internationally is feasible, however

[15] I am not, however, a big fan of the Clean Development Mechanism (CDM), Joint Implementation (JI), or other project-based credits. I think the problems of baselines and "additionality" are nearly insurmountable, and the use and abuse of such provisions will probably only undermine the respectability of international trading of emission permits – for countries that have agreed to baselines – where there is at least a hope of compliance because there is at least something to comply with (as opposed to deals to buy pieces of paper with no property rights).

countries choose to implement their commitments domestically. A carbon tax would still be my first choice for US domestic implementation, if it were politically acceptable.

I agree with many others that a good way to increase robustness with respect to uncertainty is a hybrid system such as an escape clause, also called a safety valve. This would be a tradable emissions permit scheme plus a promise to sell additional permits at a pre-specified price threshold, thus easing the quantitative limit, if the price of an emissions permit threatens to rise above that cap. In effect it would be a sort of insurance policy against unexpectedly high costs in a tradable permit policy.[16]

Equity. The developing countries point out that it was the industrialized countries, not they, who created the problem of global climate change, and they should not be asked to limit their economic development to pay for it. The developing countries are said to have contributed only about 20 percent of the carbon dioxide that has accumulated in the atmosphere from industrial activity over the past 150 years.[17] Moreover, in contrast to richer countries, they do not have the ability to pay for emissions abatement. Developing country governments consider the raising of their people's economic standard of living the number one priority. Achieving this objective requires raising market-measured income as well as improving the local environment, particularly reducing air and water pollution.

In their more unrealistic moments, spokesmen for developing countries argue that equity requires setting quantitative targets at equal amounts per capita. (This has long been India's position.) It is true that equity in itself suggests moving in this direction. In fact this proposal would not even take into account that the industrialized countries have done most of the emitting to date while the environmental damage falls disproportionately on the already-hot, largely agrarian, poor countries. But the rich countries would never accept the huge effective transfer of wealth from them to the poor that is implicit in the per capita formulation. The status quo of high emissions from rich countries

[16] E.g., Pizer (1997) or Kopp, Morgenstern, Pizer, and Toman (1999).

[17] It has been estimated that if one accounts for the contribution of land use change and deforestation to the atmospheric build-up of CO_2, developing countries are in fact responsible for about 43 percent of all CO_2 in the atmosphere now. Austin, Goldemberg, and Parker (1998).

cannot be ignored, because the status quo is the fall-back position when international negotiations fail (the "threat point" in the language of game theory).

Compliance. No country will agree to a treaty that can be expected to impose disproportionate economic costs on it. If a country somehow agrees to a plan that turns out to have this consequence *ex post*, it will subsequently back out. Whatever other carrots or sticks can be dreamed up – trade sanctions, moral suasion, or penalties in the form of steeper cuts in the future (this last being almost comically impractical, in my view) – minimizing the chances of substantial economic loss is the sine qua non of assuring compliance.

Insuring countries are not hurt *ex post* by having signed up is harder than ensuring that they are not hurt *ex ante*. It brings us back to the question of robustness under uncertainty. Even before we get to an escape clause, we can tinker with the Kyoto framework in future rounds to make it more robust with respect to unknown future developments in the desired degree of stringency, arising from growth surprises, technology surprises (e.g., will fuel cells work?), climate surprises (whether their importance lies in the changing state of scientific knowledge, popular priority on the question or both), and so forth. We now turn to specific proposals for the architecture, which include provisions to maximize the probability that no country pays a disproportionately high cost, either *ex ante* or *ex post*.

Proposed architecture for quantitative emissions targets

So what is the answer? What could be the next step after Kyoto, an architecture that balances the needs for comprehensive participation, efficiency, dynamic consistency, robustness under uncertainty, equity, and enforceability?[18] I offer my own proposed architecture. It would be built upon the principles of quantitative emission limits and international trading, the foundations laid at Kyoto. Unlike Kyoto, it seeks realistically to bring in all countries and to look far into the future. But to look into the future does not mean to pretend that we can see with as fine a degree of resolution at the century-long horizon as at the five-year horizon. We consider different horizons in turn.

[18] Aldy, Barrett, and Stavins (2003) and Victor (2004) review alternative proposals.

The century-long horizon: building confidence within a long-range framework

The entire path of emission targets for the twenty-first century cannot be chosen at once, because of the problems of uncertainty and dynamic inconsistency discussed above. It would be too constraining to write down a complete set of numerical targets for each country from now to 2100, and expect them to hold.

Rather we need a sequence of negotiations, all of which fit within a common framework. The framework, like the US Constitution, would ideally be flexible enough to last a century or more. An example of such a framework in another policy area is the postwar General Agreement on Tariffs and Trade, which gave us fifty years of successful rounds negotiating trade liberalization, culminating in the foundation of the World Trade Organization, whose rules are more binding. Nobody at the beginning could have predicted the precise magnitude or sequence of the cuts in various trade barriers. But the early stages of negotiation worked, and so confidence in the process built, more and more countries joined the club, and progressively more ambitious rounds of liberalization were achieved.

Another analogy would be with the process of European economic integration, culminating in the European Economic and Monetary Union.[19] Despite ambitions for more comprehensive integration, nobody at the time of the founding of the European Coal and Steel Community, or the subsequent European Economic Community, could have forecast the speed, scope, magnitude, or country membership that this path would eventually take. The aim should be to do the same with the UNFCCC.

When the United States (and Australia) are politically ready to join, it will also be time to set a standard for participation of developing countries. The threshold for expected participation in any multilateral agreement could be something like two tons of CO_2 emissions per person from fossil fuel use.[20] (Not an income threshold. Why penalize

[19] Tom Heller raised this analogy at the May 2006 Architectures for Agreement Workshop hosted by the Environmental Economics Program at Harvard University.

[20] This threshold would include Brazil and China, but not yet, for example, India, Pakistan, Indonesia or most African countries (Baumert, Herzog, and Pershing 2005: Figure 4.1, p. 22). I have deliberately chosen the metric of carbon dioxide

economic growth, if it is clean?) But declaring a threshold will not be sufficient to persuade countries to join if its economic incentives are strongly against accepting the targets demanded.

How should the sequence of quantitative targets be set? Since fixing targets a century ahead is impractical, I would propose doing it a decade at a time. I have little to say about how to set the decade targets for the global or aggregate level of emissions. For the reasons I have said, I don't think an optimal trade-off of the economic costs and the environmental benefits is practical. How ambitious national leaders turn out to be will be determined by the extent of popular support, which will in turn be influenced by such unpredictable vicissitudes as weather disasters (which may or may not be scientifically attributable to global climate change) and any new 9/11 tragedies or instability in the Persian Gulf (which alone would generate the political will in the United States to reduce oil consumption). The key attempted contribution of this chapter is, rather, to propose how the framework would allocate the relative targets *across* countries. Table 2.1 attempts to adumbrate how the sequence of formulas would produce decade-by-decade allocations across countries of emission reductions.

The decade horizon: formulas for setting targets

The proposal is to allocate quotas across countries in any given budget period according to a nested sequence of formulas for emissions. The formula would be very general for the distant future, and become increasingly specific as the budget period in question draws close. Viewed at the horizon of one decade, the formula for emission limits would be phrased as cuts from the expected business-as-usual path (BAU). The BAU baseline entails, for example, rapid increases in emissions for such countries as China and India. Thus, even with cuts relative to the baseline, we are talking about "growth targets" for such countries, not cuts in the absolute levels of emissions as were agreed by the industrialized countries at Kyoto. The formula for targeted reductions would include among its determinants the following variables:

rather than including land use for two reasons: measurability, and to make sure that we are capturing only countries that have begun the industrialization process.

Table 2.1 ***Proposed framework for emission targets and timetables***

A sequence of formulas setting country targets as functions of income, population, and lagged emissions.

Proposed time table	*Europe and Japan*	*US and Australia*	*China and other developing countries*
2008–2012	Cuts below 1990 levels, agreed at Kyoto (as illustrated in Fig. 2.1 relative to BAU)	BAU, as estimated at the date of joining	No targets
2013–2020	Further cuts (relative to BAU estimated in the year of negotiation, say 2008). Bigger cuts for richer countries, analogously to pattern in Fig. 2.1	Targets put less weight on 2008 levels and more on 1990 levels, to move in direction of Europeans	Targets = BAU as estimated at the date of joining, say 2008
	Targets partially indexed to income within the decade (though perhaps numbers to be fixed in 2015, to facilitate trading as part of settling up during 2016–2020)		Partially indexed to income (though perhaps intensities are fixed in 2015)
2021–2030	Weights on 1990 emissions vs. 2008 emissions begin to converge (so that USA is not unduly rewarded for staying out). Bigger cuts for richer countries, analogously to pattern in Fig. 2.1		First cuts, relative to BAU, steeper for those having attained higher income, analogously to pattern in Fig. 2.1
	Targets are again partially indexed to income within the decade		
2031–2040	Weight on population starts to increase, relative to weights on lagged emissions and income. Partial indexation within the decade		

A sequence of formulas setting country targets as functions of income, population, and lagged emissions.

Proposed time table	*Europe and Japan*	*US and Australia*	*China and other developing countries*
2041–2050	Weight on population continues to increase, weights on lagged emissions and income continue to diminish, with weight on 1990 emissions vanishing altogether Partial indexation within the decade		
. . .			
2091–2100	No weight on lagged emissions. Countries with higher income still get higher targets, but much less so than early in the century		
Infinitely long run	Equal per capita emission targets		

- 1990 emissions
- emissions in the year of the negotiation
- population
- income, and
- perhaps a few other special variables like whether the country in question has resources like coal or hydroelectric power.

A uniform formula would in a sense apply to all countries. But the straitjacket must not be too rigid if it is to be applied uniformly to all. The presence of lagged emissions on the list recognizes the reality that no country, neither the United States nor developing countries, will agree to a costly sharp reduction relative to the status quo. Other special circumstances would also be recognized. For example, at Kyoto the eastern European transition economies were in effect given an extra adjustment, the target for Iceland recognized its abundant hydroelectric and geothermal resources and related plans for aluminum smelting, and the target for Australia (would have) recognized its abundant coal deposits.

One property of the proposed sequence of formulas would be that a country joining the commitment regime for the first time would agree to a target for the subsequent budget window given by its estimated

BAU path. In the first year of membership, that level is very close to what the country had been emitting in the previous year. (In "year zero," the year of negotiation, the weights on "emissions in the year of negotiation" is 1.0 and the weights on the other factors enumerated above are zero.) This assures that the country is not being asked to take on a large economic cost the moment it joins, in which case it will not agree. Rather, the joiner can only *gain* in the short run, by the right to sell permits in the first budget period, thereby giving it an economic incentive to join. Existing members gain economically from the right to buy cheap reductions from the joining developing countries. The world environment benefits as well, by pre-empting leakage even within the first budget period, aside from the benefit of having the country in the system for the longer term. For the United States, 2008–2012 would (retroactively) be considered the first budget period, i.e., the period in which the United States is asked for no more than to limit its emissions to the BAU path. This recognizes the reality that large cuts relative to what in 1997 appeared to be the US BAU path – as are implicit in the Kyoto numbers for 2008–2012 that the United States has since rejected – would by now be far too costly to make. In this sense, the United States would in the near term be treated more as a developing country than on a par with Europe and Japan.

In the second budget period of participation, countries are asked to make more serious cuts: their target cuts relative to BAU assign less weight to emissions in the year of negotiation, and more to 1990 levels. The reason for giving at least some weight to 1990 levels in the medium term is to assure the Europeans that the United States is not being unduly rewarded for having dropped out of Kyoto and "ramping up" its emissions over the period 1990–2008 to a much higher level from which to negotiate any future reductions. The weight on 1990 in the medium-term targets could be relatively larger or smaller, depending on the relative bargaining position of the United States versus Europe.

Persuading developing countries to join a system of quantitative targets

To entice developing countries, who fear being made to ask larger cuts in the long run, the framework of a nested sequence of formulas could include the possibility, at least at a rhetorical level, that the target for emissions in the limit as the year under consideration approaches

infinity puts zero weight on income or past levels of emissions, and complete weight on population. In plainer English, in the very long run, the developing countries would notionally achieve their equity-based demand for equal levels of emissions per capita. Lest this sound outlandish, it is worth considering that by the twenty-second century, China could well have caught up with Western countries in income per capita (other Asian countries like Singapore have already done so), in which case the proposal that the emission targets should put all weight on population gives an answer similar to putting all weight on any combination of population or income.

Rhetorical promises regarding the twenty-second century will not go far to convince poor countries today. But even in the shorter term, if quantitative emission commitments are set for developing countries in a very careful way, they can address their concerns, at the same time as addressing the concerns of the rich countries. Three important principles should guide the formulation of such targets:

- gains from trade
- progressivity, and
- protection against inadvertent stringency.

The remainder of this chapter elaborates on how an agreement on targets under such principles can bring economic and environmental benefits for developing countries as well as for rich countries. Thus everyone should be able to agree that these targets represent an improvement, relative to the alternative of not having developing countries in the system. This is true regardless of how much weight one wants to put on the economic interests of poor countries versus rich, and regardless of how much weight one wants to put on environmental goals versus economic goals.

The gains from trade

If developing countries were to join a Kyoto-like system of targets-with-trading, it would not only have environmental and economic advantages for the rest of the world; it would also have important environmental and economic advantages for the developing countries themselves. For the sake of concreteness, consider a plan under which developing countries do no more in their first budget period of participation than commit to their BAU emission paths and then join the trading system.

A climate regime with a BAU emission target would not hurt developing countries. These countries would have the right to emit whatever amount they would have emitted anyway in the absence of an international climate change policy. They need not undertake emission abatement unless a foreign government or foreign corporation offers to pay them enough to persuade them voluntarily to do so. Importantly, however, by constraining their emissions to business as usual, these commitments would forestall emissions leakage and improve the environmental effectiveness of emissions abatement efforts in industrialized countries.

Developed countries' governments and private firms would likely offer to pay developing countries enough to persuade them voluntarily to reduce emissions below their BAU paths. How do we know this? It would be expensive for the United States, Europe, and Japan to reduce emissions below 1990 levels if the reductions are made only at home. The cost of emission abatement would be far lower in many developing countries, and so rich countries could offer terms that make emission reductions economically attractive to them. The economic theory behind the gains from trading emission rights is analogous to the economic theory behind the gains from trading commodities. By doing what they do most efficiently, both sides win. Table 2.2 illustrates.

Table 2.2 ***If developing countries accept targets and trade, everyone wins***

Gains if poor countries join and trade	*Economic gains*	*Environmental gains*
Gains for developing countries	Price received for emission cuts > cost to poor country	Auxiliary benefits: less air pollution
Gains for industrialized countries	Price paid for emission permits < cost to cut only at home	Precludes leakage of emissions to non-members

Why is it so much cheaper to make reductions in China or India than in the United States? One major reason is that, in industrialized countries, one would have to prematurely scrap coal-fired power plants in order to replace them with natural gas facilities or other cleaner

technologies. This would be expensive to do, because it would mean wasting a lot of existing capital stock. In rapidly growing countries, by contrast, it is more a matter of choosing to build cleaner or more efficient power-generating plants to begin with. When contemplating large increases in future demand for energy, it is good to be able to plan ahead. The benefits include learning from the mistakes of others that have gone before, and taking advantage of their technological advances.

An extreme example of how measures to reduce carbon emissions can have low costs in developing countries is the case of subsidies to fossil fuels. Energy subsidies run as high as 58 percent for Venezuela and 80 percent for Iran. Even oil importers subsidize energy: 11 percent for China and 14 percent for India.[21] Eliminating such subsidies would create substantial immediate benefits – fiscal, economic, and environmental – even before counting any benefits under a Kyoto agreement. Subsidy cuts within a target-and-trade system would pay developing countries twice over – once in the form of the money that is saved by eliminating wasteful expenditure, and then again in the form of the money that is paid by a developed country for the claim to the resulting emission abatement.

Progressive emissions commitments

Developing countries fear that they will be asked to accept emission targets that are more stringent than BAU, and perhaps lower than current or past emissions (such as what the industrialized countries accepted in the Kyoto negotiations). It would not be reasonable for the rich countries, however, to insist that the poor accept targets that fail to allow for their future economic growth. It is useful to begin by expressing all possible emission targets as relative to BAU, as already suggested. Any proposed emission abatement is relative to BAU, not relative to the past.

A reasonable lower bound for developing country emission targets would be the "break-even" level. This is the level that leaves them neither better off nor worse off economically than if there had been no treaty at all. In other words, it is a level where they have to make some

[21] These statistics are from International Energy Agency (1999: Table 6, p. 64), which estimates that elimination of the subsidies among a sample of eight developing countries would yield annual economic efficiency gains of 0.73 percent of GDP and would reduce CO_2 emissions by 16.0 percent.

low-cost reductions from the start, but where sales of emission permits at an intermediate price are sufficient to compensate them for their marginal reduction. The aim should be to fall somewhere in the range that is bounded above by BAU and bounded below by the break-even level. As long as the target is above the break-even lower bound, the developing countries benefit economically from the arrangement. Developed countries still enjoy the opportunity to invest in low-cost emissions abatement in developing countries and the lower global emissions of such an arrangement. Everybody gains from having taken the first step to fight global climate change.

There is probably a moderately large range between business as usual and the break-even point. What would constitute a "fair" emission commitment within this range? To give some reasonable degree of progressivity, targets for emission per capita would also assign some weight to income per capita. A fair target for developing countries might be one that fits the pattern that in retrospect holds among the existing targets agreed at Kyoto, which are illustrated in Figure 2.1. Even though the emission targets agreed at Kyoto reflected the outcome of political negotiations, rather than economists' calculations of some definition of optimality, retroactively it is possible statistically to discern systematic patterns in the targets. This approach turns out to allow some *progressivity*, with richer countries committing to larger emissions abatement efforts than poor ones. Yet it does not go nearly so far as the massive redistribution of wealth that some poor-country representatives unrealistically ask for, based on a tabula rasa notion of equity.

Out of thirty industrialized countries' targets agreed at Kyoto (those with adequate data, including some that have not subsequently ratified the agreement), the average reduction from BAU was 16 percent. For the less-rich half of the countries, the average reduction was 5 percent below BAU, which shows the progressivity in a very simple way. The progressivity of the Kyoto system was also revealed within the EU's "bubble" allocation: wealthier countries such as Germany and the United Kingdom accepted emission targets much more stringent than the EU-wide commitment (1990 minus 8 percent), to allow less wealthy countries such as Portugal and (at the time) Ireland to have less stringent targets.

Further statistical analysis can help illustrate the progressivity of the targets. Controlling for countries' projected BAU emission growth,

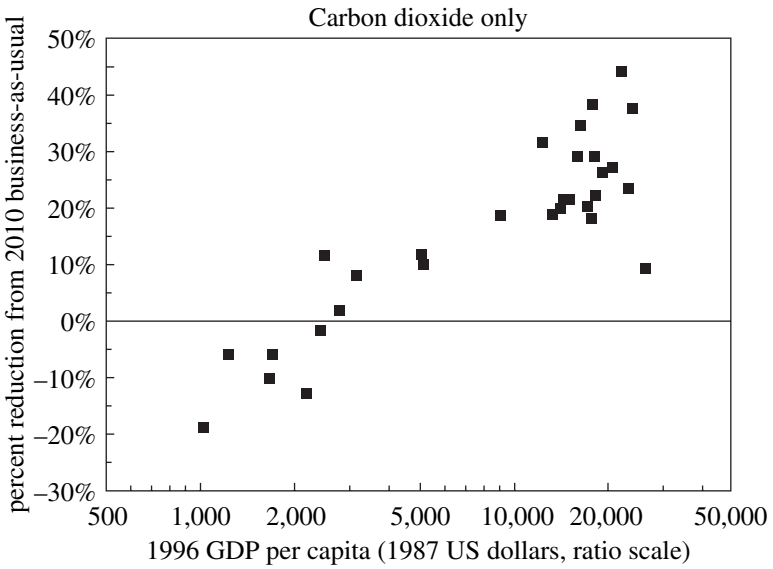

Figure 2.1. Emission reduction vs. GDP per capita

Sources: The World Bank, US Energy Information Administration, national communications to the UNFCCC

their coal intensities, and whether they are beginning the transition from central planning, we estimated that a 1 percent increase in per capita income implied a target of 0.11 to 0.17 percent greater emissions abatement from BAU.[22]

As an illustrative example, when this pattern was extrapolated to China, looking forward from 1998, the projected target was about 5 percent below BAU. This emissions level happened to lie inside the desirable range: below BAU but above the break-even point (based on a number of global energy-economic models). In other words, if China accepted such a target, economic benefits would accrue both to it and to the rich countries that would pay China to reduce emissions further. As a rough guideline, 5 percent is not an unreasonable benchmark for other developing countries as well. To repeat, it still allows for growth.

[22] The graph and estimates are based on the data that was publicly available as of the end of 1997, when the Conference of Parties met at Kyoto. The regression line fits almost as well, but not quite, when subsequently revised data are used – Frankel (1999). But it is more appropriate to use the original data if the attempt is to discern the degree of progressivity that the negotiators implicitly decided was "fair."

Resolving concerns about unintended target stringency

One important objection concerns uncertainty regarding how stringent given numerical targets would turn out to be during the course of a given decade. Calculations regarding the BAU path or the cost of deviations from it are subject to great imprecision and unpredictability. Poor countries worry that uncertainty surrounding their forecasted economic performance is so great that they cannot now risk adopting an emission target that would be binding five or ten years in the future. Even if a particular numerical target appears beneficial *ex ante*, it might turn out to be something different *ex post*. If the country turns out to achieve unexpectedly rapid growth, the last thing it wants is to have to put a stop to it because the accompanying emissions threaten to overrun its target. A response to this concern would be to structure international agreements regarding these countries' targets so as to reduce the risk of being inadvertently stringent.

Symmetrically, environmentalists have also expressed a concern on the other side that a target may turn out *ex post* to be too lax. They fear that such a target might fail to result in environmental benefits in terms of actual emission reductions relative to what would have happened in the absence of a treaty. If, for example, Korea or Thailand had accepted targets at Kyoto in 1997, the sharp slowdowns that began in East Asia in the same year would have turned out to imply that they might have been paid for emission abatement (relative to *ex ante* BAU) that would have happened anyway. This is the so-called "hot air" problem. Thus it is desirable to mitigate the risk of inadvertent laxity while also mitigating the risk of inadvertent stringency – to narrow the variability of the effective stringency of the target without relaxing or tightening the intended target itself.[23]

One solution is indexation of the emissions target. The general notion is to agree today on a contract under which the numerical target depends in a specified way on future variables whose values are as yet undetermined.[24] Future economic growth rates are probably the biggest source of uncertainty, especially in developing countries. A simple approach would index a country's aggregate emissions to future

[23] See also Lutter (2000).

[24] An analogy is a cost-of-living adjustment clause in a labor contract. It specifies a given increase in the wage for every dollar increase in the Consumer Price Index – thus reducing uncertainty over *real* wages.

income alone. Other possible proposals could allow the targets to vary with other variables such as population or temperature.

More specifically, for every percentage point in GDP growth that is higher or lower than forecast, the emission target is raised or lowered by a corresponding amount.

A special case of indexation is "intensity targets," which the Bush Administration has talked about. An intensity target is a target for the ratio of energy use or emissions to GDP. Not only are emissions indexed to GDP, but the indexation is full, i.e., the relationship is fully proportionate. This has the advantage of simplicity over my formulas.[25] I would still argue that from the year when a country negotiates entry into the system until the year before the budget window starts (whether it is a five-year or ten-year budget window), the emission target should be indexed to GDP in a *less-than*-proportionate way. For example, every 1 percent of extra growth might call for an automatic 0.7 percent increase in the target. Or the coefficient could be 0.5, which would make the formula into a simpler "square root" rule.[26] The proposal would require countries that are doing a bit better to contribute more than those that are not, maintaining principles of progressivity and insurance, without penalizing them unduly for their success.

A China that turns out to grow at 10 percent a year for six years has raised its standard of living 77 percent. It should not be unduly penalized for its growth by failing to allow an increase in the numerical target (i.e., there should be some indexation). But neither should it be allowed a fully proportionate increase over this six-year period. Rather, it is capable of making a larger reduction relative to GDP than had been anticipated six years earlier, and it should do so (i.e., the indexation should be less than proportionate).

Indeed a shortcoming of the proposal to set intensity targets, i.e., to have fully proportionate index, is that it actually asks *less* sacrifice of countries that have experienced the good fortune of an unexpected economic boom, and more sacrifice for those that have suffered an

[25] Was simplicity the Bush Administration's motive for preferring emissions efficiency targets? An alternative possible motive is rhetorical: a plan that involves "gradual reductions in emissions per GDP" sounds better – even though that also describes the BAU path – than a path that allows rising emissions.

[26] The Argentine government proposed an emission target indexed to the square root of its economic growth at the 1999 Conference of Parties in Bonn, Germany.

unexpected slowdown. The reason is that even in the absence of policy measures, energy use and emissions tend to rise less rapidly than GDP.[27]

There is a separate question as to whether the target levels should be finally fixed numerically at the beginning of the budget period, or whether there should also be indexation *within* the budget period. An argument for continuing to index is that it would make it more feasible for a government to hit its emission targets in the face of economic fluctuations. An argument for setting the numerical targets at the beginning of the budget period is that it would facilitate international trading of emission permits because each country would know exactly what its targets were. The important point is that approaches that explicitly account for at least some of the uncertainty that characterizes emission abatement would make it more likely that the target will turn out to fall within the range intended, where it brings benefits – economic as well as environmental – to developing countries and industrialized countries alike.

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