

POLITICAL ECONOMY OF THE KYOTO PROTOCOL

SCOTT BARRETT
*London Business School*¹

The Kyoto Protocol, negotiated in December 1997, is the first international treaty to limit emissions of greenhouse gases. But Kyoto does not mark the conclusion to international cooperation on climate change. It is really just a beginning. This paper shows that, in the aggregate, the benefits of undertaking the Kyoto reductions should exceed the corresponding costs—provided these are achieved cost-effectively. But, although Kyoto seeks to promote cost-effectiveness, it may yet prove very costly. Moreover, the agreement may not even achieve the reductions that it promises, either because emissions will relocate to the countries that are not required to stay within Kyoto-prescribed ceilings or because “paper” trades will be promoted by the protocol’s mechanisms. More fundamentally, Kyoto does not deter non-compliance, and it only weakly deters non-participation. These flaws need to be mended, but the nature of the problem makes that an especially difficult task.

I. INTRODUCTION

The Kyoto Protocol, negotiated in December 1997, is a climate change treaty with a difference. Unlike the Framework Convention on Climate Change that preceded it, the Kyoto Protocol incorporates targets and timetables—that is, ceilings on the emissions of greenhouse gases and dates by which these ceilings

must be met. And though global emissions will continue to rise, even if the protocol is implemented to the letter, the reduction from a business-as-usual emissions bench-mark may be close to being optimal in the sense of balancing the global marginal costs and benefits of abatement. Assuming full participation and cost-effective implementation, a recent study by the Clinton Administration esti-

¹ This paper began to form in my mind at the NBER–Yale Global Change Workshop in Snowmass, Colorado, where I was able to learn from, and put my questions to, some of the leading economists working on this issue. I am grateful to all the participants for sharing their ideas, and especially to Charles Kolstad, William Nordhaus, and Robert Stavins for inviting me to participate in the workshop. I am also grateful to Wilfred Beckerman, Dieter Helm, Tim Jenkinson, Chris Riley, Stephen Smith, Robert Stavins, Peter Zapfel, and an anonymous referee for helpful comments on an earlier draft. David Pearce also provided helpful comments at a seminar presentation.

mated the marginal cost of meeting the Kyoto targets to range from \$14 to \$23/ton (Clinton Administration, 1998). Most estimates of the global marginal damage of greenhouse gas emissions are of a similar magnitude (see IPCC, 1996, ch. 6), and so it would seem that the Kyoto Protocol is a near ideal outcome for the world.

But this is only if the assumptions behind the Clinton Administration's estimates are correct: that participation in the agreement will be full and implementation cost-effective. A number of features of the Protocol will promote cost-effective implementation, including provisions for trading in the entitlements to emit greenhouse gases. However, though the details of the flexible mechanisms incorporated in Kyoto have yet to be worked out, implementation may turn out to be very costly, not least because participation is unlikely to be full. The marginal cost of implementing Kyoto could be ten times the estimates noted above. Moreover, the reduction in emissions effected by Kyoto could be less than the amount promised because of 'trade leakage'. Indeed, since leakage will be greater the greater are the between-country differences in marginal costs, the same forces causing costs to be higher will cause benefits to be lower. The Kyoto Protocol may turn out not to be such a good deal after all.

Worse, the agreement may not even be sustainable, and not just because high implementation costs could impel the parties to renegotiate the treaty. For another potential problem stalks Kyoto: compliance enforcement and free-rider deterrence. The Protocol defers discussion of enforcement to a future meeting of the parties, but it is sensible to ask: what would happen if in, say, 10 years' time, one of the parties to the agreement announces that it will not be able to comply with it? Or suppose, instead, that a party announces that it will withdraw from the agreement, because the costs of meeting it are too steep. What will prevent such a withdrawal? The treaty, at least in its present form, offers little protection from such deviations. And this is not just a problem for the future. Countries can reason backwards. If future deviations cannot be prevented, why should a country invest in abatement measures today?

Even this may not be the worst of the Protocol's problems. It is possible, maybe even likely, that the

agreement will never enter into force. In July 1997, the United States Senate voted 95–0 in favour of a non-binding resolution urging the President of the United States not to negotiate an agreement that required that only the industrial countries reduce their greenhouse-gas emissions or that would result in serious harm to the US economy, where by 'serious harm' the Senate meant, in the words of Senator Robert Byrd, a co-author of the resolution, 'capital flight and a loss of jobs in the United States'. This is important because the Senate must ratify (by a two-thirds majority) any treaty that is to be binding on the United States, and an effective climate-change treaty is sure to require US participation. There are many reasons for this, but perhaps the most obvious is that United States is the world's largest emitter. Its emissions are about 50 per cent higher than the entire emissions of the European Union.

The Clinton Administration previously endorsed the principle that the industrial countries should reduce their emissions first, and could not easily reverse out of this promise in Kyoto. And nor was Europe keen on relaxing the so-called Berlin Mandate. So the agreement reached in Kyoto clashed with the Senate's recommendation that developing countries reduce their emissions (whether implementation of the Protocol will be costly to the United States is a question requiring some analysis, and I shall return to it later). Of course, the Senate could have been bluffing, perhaps in the hope that its resolution would give President Clinton an edge in the Kyoto negotiations. Indeed, during the debate on the resolution, Senator Byrd said that the resolution would 'add strength to our US negotiating team'. But just after the negotiations ended in Kyoto, a number of senators asked that the treaty come to the Senate floor for ratification so that they could reject it. President Clinton has since said that he would not send the treaty to the Senate without 'meaningful participation from key developing countries'.

If the United States does not ratify the treaty, it is possible that the agreement will still come into force. To enter into law, and therefore to become binding on the countries that are parties to it (but not other countries), the Protocol must be ratified by at least 55 countries, responsible for at least 55 per cent of the total carbon-dioxide emissions of the so-called 'Annex I' countries (the industrial countries listed in

Table 1
Status of the Kyoto Protocol

Annex I countries	CO ₂ emissions 1990 (gigagrams)	Share of Annex I 1990 emissions (%)	Kyoto target 2008–12 (% relative to 1990 or alternative base year)	Projected emissions 2000
United States	4,957,022	36.00	93	104
European Union*	3,288,667	24.05	92	103
Austria*	59,200	0.43	92	111
Belgium*	114,410	0.84	92	n.a.
Denmark*	52,025	0.38	92	103
Finland*	53,900	0.39	92	131
France*	366,536	2.68	92	109
Germany*	1,014,155	7.42	92	90
Greece*	82,100	0.60	92	115
Ireland*	30,719	0.22	92	120
Italy*	428,941	3.14	92	113
Luxembourg*	11,343	0.08	92	67
Netherlands*	167,600	1.23	92	92
Portugal*	42,148	0.31	92	129
Spain*	227,322	1.66	92	122
Sweden*	61,256	0.45	92	104
UK*	577,012	4.22	92	102
Australia*	288,965	2.11	108	115
Canada*	462,643	3.38	94	110
Iceland	2,172	0.02	110	105
Japan*	1,155,000	8.45	94	104
New Zealand*	25,476	0.19	100	116
Norway*	35,514	0.26	101	111
Switzerland*	45,070	0.33	92	97
Liechtenstein	208	n.a.	92	118
Monaco	n.a.	n.a.	92	n.a.
Economies in Transition	3,364,259	24.60	103	81
Alternative base year	3,531,476	—	98	77
Bulgaria* 1990	82,990	0.61	107	84
1988	96,878	—	92	72
Czech Republic	165,792	1.21	92	82
Estonia	37,797	0.28	92	54
Hungary 1990	71,673	0.52	110	96
1985–7	83,676	—	94	82
Latvia	22,976	0.17	92	74
Lithuania*	n.a.	n.a.	92	n.a.
Poland* 1990	414,930	3.03	108	96
1988	478,880	—	94	83
Romania 1990	171,103	1.25	107	n.a.
1989	198,479	—	92	n.a.
Russian Federation	2,388,720	17.47	100	83
Ukraine	n.a.	n.a.	100	n.a.
Slovakia	58,278	0.43	92	84

Table 1 (continued)

Annex I countries	CO ₂ emissions 1990 (gigagrams)	Share of Annex I 1990 emissions (%)	Kyoto target 2008–12 (% relative to 1990 or alternative base year)	Projected emissions 2000
Croatia	n.a.	n.a.	95	n.a.
Slovenia	n.a.	n.a.	92	n.a.
Total 1990	13,675,067	100	95	98
Total base	13,842,284	—	94	97

Notes: Two Annex I countries (Belarus and Turkey) are excluded from the table, as they are not included in Annex B of the Kyoto Protocol. Four other countries (Liechtenstein, Monaco, Croatia, and Slovenia) are included in Annex B but not in Annex I. *Indicates that the country is a signatory to the Kyoto Protocol, as of 23 October 1998. CO₂ emissions exclude land-use change and forestry.

Source: All data are from the web page of the Climate Change Secretariat, <http://www.unfccc.de>.

the original Framework Convention) in 1990. As shown in Table 1, the United States accounts for only 36 per cent of Annex I emissions. So, if enough of the countries making up the balance of Annex I emissions ratify the agreement, Kyoto will still enter the canon of climate law.

As of October 1998, 59 countries had signed the Protocol, including the 15 member states of the European Union and nine other Annex I countries (signatories are identified in Table 1 by an asterisk). These signatories make up just over 42 per cent of total Annex I emissions, and so the minimum participation required by the treaty would seem to be within easy reach. But putting a signature on a treaty does not obligate a country to ratify and, as of October 1998, only one country has ratified the Kyoto Protocol (though this in itself signifies nothing as the treaty was only recently negotiated): the small island state, Fiji.

Ratification by the current signatories is not inevitable. If the USA does not ratify the agreement, the other Annex I countries will benefit less from participating; these countries will have to undertake the emission reductions prescribed by the treaty (and shown in column 3 of Table 1) without the benefit of substantial US abatement. It is even possible that non-participation by the USA will *increase* the cost to these countries of keeping within their Kyoto limits, because of the treaty's

trading arrangements (explained later in the paper). It thus seems likely that many Annex I countries will await US ratification before serving the Kyoto Protocol up to their own parliaments. This means that, if the USA does not ratify the agreement, then it may not enter into force.²

Why should countries negotiate a treaty that could leave them worse off, or that may never even enter into international law? The scenario seems unlikely, but it is entirely in keeping with the history of climate-change policy. As described in section II, countries have previously announced their intention to keep within self-imposed emission ceilings—and then failed to meet them. Moreover, the Kyoto Protocol is not unique in the annals of international cooperation. The Law of the Sea Convention, negotiated in 1982, did not enter into force until 1994—and participation by the major maritime powers, including the United States and United Kingdom, had to await negotiation of a side agreement which effectively rewrote key provisions in the original treaty.

Of course, predicting whether Kyoto will endure, or whether it will achieve much if implemented, depends on many details. It depends, especially, on assumptions about how the important concepts in the agreement will be interpreted, about the institutions that will be developed to support it, about the costs of taking action, and about the future evolution of the treaty. All these details are uncertain. They

² Just as it is hard to imagine a Gulf War coalition forming without the support of the United States, so it is hard to see how an effective climate-change regime could develop without American backing.

are discussed in my analysis of the agreement in section III.

In the long run, whether or not Kyoto enters into law will not matter very much. If the Protocol fails to become law, countries will attempt to renegotiate the agreement. If Kyoto does enter into law but later collapses for whatever reason, a new agreement can always be negotiated. Even if Kyoto succeeds—if it enters into law and is implemented to the last detail—a string of amendments will need to be negotiated, to say what must be done after 2012. Kyoto is really just the start of a long process, and it must be remembered that climate change is a very long-run problem. What will matter most in the future is whether countries perceive that substantial mitigation is justified, and whether the international system can muster the cooperation needed to sustain this effort. I turn to these fundamental issues in section IV. The final section of the paper pulls these different analyses together and revisits the theme of this introduction.

II. GETTING TO KYOTO

(i) Preliminaries

The so-called greenhouse gases include not only carbon dioxide (CO₂), but also methane, nitrous oxide, fluorocarbons (including hydrofluorocarbons and perfluorocarbons), tropospheric ozone (precursors of which include nitrogen oxides, non-methane hydrocarbons, and carbon monoxide), and sulphur hexafluoride.³ However, CO₂ accounts for the bulk of aggregate warming potential and, mainly for this reason, the policy debate has focused on the extent to which emissions of this gas should be limited. In 1988, a semi-political conference held in Toronto recommended that, as a first step, CO₂ emissions should be reduced 20 per cent from the 1988 level by 2005. This so-called ‘Toronto target’ was arbitrary, but the idea that countries should commit to meeting a target for emission reduction (as opposed to, say, a carbon tax or a technology standard) has

endured. It is perhaps the most important feature of the Kyoto Protocol.

In the same year that this conference was held, the Intergovernmental Panel on Climate Change (IPCC) was formed, at the request of the UN General Assembly. The IPCC was asked to report on what was known and not known about climate change, on the potential impacts of climate change, and on what could be done to forestall and adapt to climate change. The IPCC’s first assessment report, published in 1990, concluded that ‘emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases . . . [and] will enhance the greenhouse effect, resulting on average in an additional warming of the Earth’s surface’ (IPCC, 1990, p. 1). The report calculated that ‘the long-lived gases [including CO₂] would require immediate reductions in emissions from human activities of over 60 per cent to stabilize their concentrations at today’s levels’, and it predicted that, under the ‘Business-as-Usual’ scenario, global mean temperature would rise by between 0.2°C and 0.5°C, and mean global sea level would rise by between 3 and 10cm, per decade during the next century. Rather ominously, the IPCC noted that ‘the complexity of the system means that we cannot rule out surprises’.

(ii) Unilateral Pledges

Following publication of the IPCC’s 1990 report, a number of OECD countries announced intentions to reduce their CO₂ emissions.⁴ Some pledged to meet the Toronto target (Austria, Denmark, Italy, Luxembourg; New Zealand pledged that it would do so by 2000 rather than 2005). Some set a goal of stabilizing their CO₂ emissions at the 1989 level by 2000 (Norway) or at the 1990 level by 2000 (Finland, Switzerland, United Kingdom) or to reduce emissions 3–5 per cent by 2000 (The Netherlands). Germany, helped by unification, set the most ambitious target: to reduce CO₂ emissions 25–30 per cent from the 1987 level by 2005. Australia pledged to reduce its emissions of all greenhouse gases not

³ Other halocarbons, including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), are also potentially important from the policy perspective, but are being controlled by the Montreal Protocol and its associated amendments. Moreover, it is now known that the direct warming effect of these gases is partly offset by a cooling effect caused by the reduction in stratospheric ozone.

⁴ The International Energy Agency (1992) has compiled a comprehensive listing of climate-change policies, and I am drawing here from this report.

controlled under the Montreal Protocol (that is, excluding CFCs and HCFCs), while other countries (Canada and the United States among them) set a target of stabilizing the emissions of all greenhouse gases, including those covered by the Montreal Protocol. France and Japan pledged to stabilize their CO₂ emissions at the 1990 level by 2000 but only on a per-capita basis (allowing emissions to increase as population increased). Spain, a relatively poor OECD member, set the goal of limiting its growth in CO₂ emissions to 25 per cent. Finally, some countries merely promised to play a part in achieving a collective target. In October 1990 the European Community (EC) announced its intention to stabilize Community-wide emissions at the 1990 level by 2000, a target to which all its member states were collectively bound. Members of the European Free Trade Association, including Iceland and Sweden, were in turn bound by a separate agreement jointly to meet the EC target.

All this may give the impression that much was being done, but the reality was different. Few countries put into place policies that would contribute to their targets being met, and there seemed little need to do so. For some of these targets were intended merely as goals, while others were conditional on other countries taking similar action (this was true of Britain, for example, under the Thatcher government). Though New Zealand set for itself an ambitious goal of reducing its CO₂ emissions 20 per cent from the 1990 level by 2000, it simultaneously insisted that any policy adopted should have a net benefit for New Zealand. Several countries claimed to be 'committed' to achieving a particular emission ceiling, but none truly was committed. If a country learned later that its interests would be badly served by meeting its target, then there would be nothing to stop it from failing to meet it. Indeed, it would be hard to argue that a country would even be morally bound to meet a target which it had set for itself, especially when other countries were at the same time failing to meet *their* targets.

The EC's climate policy was especially important, partly because of the Community's relatively large share of global emissions and partly because of the way the Community's target was framed. When the target was agreed in 1990, no decision was made as to how it would be met, and as it was a collective target, no country was individually responsible for

meeting it. A collective policy for meeting the target was needed. The European Commission proposed meeting the target by means of an energy conservation programme coupled with a fiscal measure, a carbon tax. The tax, which was to be set at a rate equivalent to \$3 per barrel of oil, rising over time to \$10 per barrel, would probably have been enough to meet the stabilization target (see Barrett, 1992). But in May 1992, shortly before the Rio Earth Summit convened, the Community announced a number of modifications to the original tax proposal.

The first of these was to supplement the carbon tax with an energy tax (the combined tax would be equivalent to the per-barrel tax noted above). Ostensibly, the intention was not just to reduce carbon-dioxide emissions but also to conserve energy. But the real reason was to dilute the advantage that a pure carbon tax would give nuclear energy and countries with high shares of nuclear electricity generation (such as Belgium and France). A second modification was to exempt the main energy-using industries from having to pay the tax. This was to stop these industries from suffering a 'competitive disadvantage', relative to non-EC countries. The final modification was to make implementation of the EC tax conditional on other OECD countries (especially the United States and Japan) adopting the same tax. As the chances of this were nil, this meant that Europe was not prepared to implement the policy needed to achieve its own target.

(iii) To Rio

The Community's policy was being mapped out just as negotiations on the Framework Convention on Climate Change were coming to a close. Throughout these negotiations, Europe tried to persuade the United States to fix a date for stabilizing its CO₂ emissions. The United States refused, however, and the final text of the Framework Convention, which was signed by over 150 countries at the Rio Earth Summit in June 1992, did not commit any signatories to meeting specific targets and timetables (contrary to reports one often reads in the newspapers). Article 4 says that developed country parties recognize 'that the return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases' would be desirable. It also says that these parties should devise policies 'with the aim of returning individually

or jointly to their 1990 levels of these anthropogenic emissions'. But in contrast to the Kyoto Protocol, no country was required by the Framework Convention to meet any particular target by any particular date. Indeed, it was precisely for this reason that this agreement was ratified by so many countries and came into force so quickly (in December 1993).

(iv) After Rio

The IPCC revised its earlier predictions in 1995, partly to take account of the effect of aerosols on radiative forcing. Aerosols are tiny airborne particles, released when fossil fuels are burned, and result in a local cooling effect (unlike some greenhouse gases, which can persist in the atmosphere for decades, even centuries, aerosols have an atmospheric lifetime of about a week). Once aerosols were included in the climate models, the IPCC predicted more modest change: an increase in global mean temperature of about 0.14–0.28°C per decade, as compared with an increase of 0.16–0.36°C per decade when the effects of greenhouse gases alone were considered. Aerosols were also predicted to limit mean sea level rise to about 2–8cm per decade.

Though inclusion of aerosols lowered slightly the predicted consequence of climate change, it also increased confidence in the estimates of climate models. When aerosols were included, the predicted changes accorded better with the historical record. Partly for this reason, the IPCC (1995, p. 22) was able to warn that, 'the balance of evidence suggests that there is a discernible human influence on global climate'. Still, even today the science of climate change is riddled with uncertainties: about the extent and timing of climate change; about regional variations; about whether small changes in atmospheric concentrations could, beyond some point, trigger a discontinuous change in some important climate feature.

(v) From Berlin to Kyoto

At the first Conference of the Parties to the Framework Convention, held in Berlin in 1995, the industrialized parties agreed to negotiate emission limits within specified time frames, such as 2005, 2010,

and 2020. These quantitative ceilings were to be included in a new protocol that might be ready for signing by the end of 1997. Importantly, developing countries were not expected to limit their emissions. It was this differential treatment of industrialized and developing nations in the so-called 'Berlin mandate' that the US Senate later objected to and that ultimately came to be embodied in the Kyoto Protocol.

It is as well to recall, however, that at this time most countries had still not devised, let alone implemented, effective policies for meeting the targets they had set unilaterally years before. Some countries, including Norway and Finland, conceded that they did not expect to meet their targets (Grubb, 1995), despite having imposed hefty carbon taxes. The few countries that did expect to meet their targets were only able to do so for reasons of fortuitous circumstance (in Britain, the 'dash for gas'; in Germany, unification), not determined policy. Most importantly, the European Union (EU) signally failed to devise a policy sure of meeting its 'commitment' to stabilize emissions at the 1990 level. In a letter to the chairman of the European Parliament's environment committee, leaked on the eve of the Berlin conference, Jacques Santer, the President of the European Commission, conceded that 'a single tax . . . applicable in all member states [was] no longer conceivable'.⁵ At the same time, the Commission had not developed an alternative collective policy for meeting the EU's target. Evidence supplied to the European Commission suggested that at most three of the EU's 15 member states would stabilize their own CO₂ emissions at the 1990 level by 2000.⁶ And, yet, when Europe's diplomats headed for Kyoto, they were hoping to tighten up on the earlier targets, to secure an agreement that would reduce emissions (of the three main gases, carbon dioxide, methane, and nitrous oxide) 7.5 per cent by 2005 and 15 per cent by 2010.

III. ANALYSIS OF THE KYOTO AGREEMENT

As noted in the Introduction, the Kyoto Protocol specifies maximum emission levels for the so-called Annex I countries (see Table 1), and dates by which

⁵ *The European*, 17–23 March 1995, p. 1.

⁶ *Ibid.*

these ceilings (calculated relative to 1990 emission levels) must be met. Just as significant, the emissions of developing countries are entirely unconstrained by the protocol. These twin features fulfil the promise made at the First Conference of the Parties in Berlin in 1995, and in this sense made Kyoto a success. Ultimately, however, whether Kyoto succeeds will depend on how it becomes implemented, and especially on whether implementation can be made cost-effective.

A variety of so-called 'flexible mechanisms' are built into Kyoto, and they have the *potential* of supporting a cost-effective final allocation of climate-change mitigation. It is hard to say, however, to what extent this potential will be realized. The data are sketchy in places and analyses of some features of the agreement have not yet been undertaken. Much will also depend on how the flexible mechanisms take shape and how countries devise their own policies. We can say something about certain bench-mark cases, and problem areas can be pointed out. But that is about as far as our analysis can go. It happens, however, that this is enough to support the warning that introduced this paper.

(i) Cost Implications of the Emission Limits

Suppose that the limits negotiated in Kyoto were met exactly, with no potential for arbitrage across countries. That is, suppose that the EU kept its emissions to 92 per cent of its 1990 level, that the USA limited its emissions to 93 per cent of its 1990 level, that China emitted as much as it pleased, and so on. Then the marginal cost of climate-change mitigation would vary from country to country. It would be zero in China, where emissions were unconstrained (and growing rapidly), and high in Europe and the United States. How high? According to one study (Nordhaus and Boyer, 1998), the marginal cost of implementing the individual targets in the protocol could be \$125 per ton of carbon by around 2010. Another study (Manne and Richels, 1998) predicts that marginal costs could be \$240 per ton of carbon in 2010. This difference in marginal cost (\$0 in the developing countries compared to \$125 or \$240 in the OECD countries) in turn implies that the total cost of achieving any given emission ceiling will be excessive. Shifting just one ton of abatement from the OECD countries to the developing countries would save the world at least \$100,

perhaps much more. Shifting more abatement would save even more money (though of course the marginal cost saving will fall as more abatement is shifted). Total costs will, of course, be minimized where the marginal cost of abatement is everywhere equal.

As noted earlier, estimates prepared by the Clinton Administration suggest that a cost-effective agreement—that is, an agreement which reduced global emissions by the same amount as required by the Kyoto Protocol, but which did so by distributing the burden of abatement such that marginal costs were everywhere equal—could lower marginal costs to around \$14–23 per ton, about one-tenth the level that would be needed to implement the individual emission ceilings in the protocol. This is a huge difference, and one that is reflected also in other studies. For example, Nordhaus and Boyer (1998) estimate the marginal cost of a cost-effective Kyoto Protocol to be \$11/ton in 2010. Manne and Richels (1998) obtain a much higher figure—\$70/ton in 2010—but one that is still low in comparison with their estimate of marginal costs when the Kyoto Protocol targets are met exactly.

Estimates of reductions in total costs are of a similar relative magnitude. According to the Clinton Administration's analysis, the total cost to the USA of implementing Kyoto could be just \$7–12 billion per year, if the agreement is implemented cost-effectively, but perhaps ten times as large otherwise. Manne and Richels (1998) predict that cost-effective implementation of Kyoto would cost the USA around \$20 billion or 0.25 per cent of GDP in 2010, but perhaps four times as much if implemented without trading. (Would this cause 'serious harm' to the US economy? Ask the Senate.) Nordhaus and Boyer (1998) estimate that the total cost of implementing Kyoto without trading (in present value terms) would be about seven times the cost-effective level.

But this is to compare extremes. As detailed below, the Kyoto Protocol offers a number of mechanisms intended to lower total implementation costs. As also explained, these mechanisms will not work perfectly, and so will not mimic the cost-effective outcome. The costs of implementing Kyoto are likely to lie somewhere between the bench-marks given above.

Note, however, that we cannot even be sure of this. For example, the estimates of marginal and total costs given above assume that domestic implementation by every nation is cost-effective—that the marginal costs of abatement are everywhere equal *within* each country. This is unlikely to happen. It is certainly not a feature of most environmental policies that have been adopted in the past. The carbon taxes adopted by most Nordic countries, for example, vary by sector, with households having to pay more than industry (partly out of a concern for trade leakage). Until we know the policies that countries will develop to meet their targets—and these have not been spelled out yet—we will not know how costly it will be to meet the Kyoto targets.

(ii) Flexible and Market Mechanisms

Net emissions targets

The extent of climate change will depend on atmospheric concentrations (though with a lag) of greenhouse gases, and changes in these concentrations depend on the removal of CO₂ from the atmosphere as well as gross emissions. CO₂ removal depends in turn on land use: growing trees absorb carbon from the atmosphere; the standing forest stores carbon (if burned, trees release carbon back into the atmosphere). So if trees are planted and the standing forest is prevented from being burned, concentrations will fall (all else being equal), and these activities should be encouraged just as emissions are discouraged. The emission limits specified in the Kyoto Protocol do this. They allow deductions for ‘removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990’. In other words, the Kyoto targets limit *net* emissions.⁷

Will including carbon sinks reduce the costs of meeting the Kyoto limits substantially? The Clinton Administration’s (1998, p. 24) analysis suggests that it could. ‘Promoting afforestation and reforestation,’ the report maintains, ‘may reduce atmos-

pheric concentrations of CO₂ at much lower costs than reducing emissions of greenhouse gases resulting from industrial activity.’ At the margin, assuming that only abatement of gross emissions is undertaken, this must surely be right. However, Stavins (1998b) finds that the marginal cost of carbon sequestration rises steeply—more steeply than marginal gross abatement costs for the United States. So the aggregate cost savings from carbon sequestration may not be all that large.

Measurement problems are also bound to be rife. The Protocol insists that the changes in net emissions be ‘measured as verifiable changes in carbon stocks’, but such changes cannot be measured with the same precision as the carbon emissions resulting from fossil fuel consumption. And how is one to interpret whether an action constitutes a ‘direct human-induced land-use change’? Would the recent fires in Indonesia count? Settling these matters is a subject of ongoing negotiations.

Comprehensive emissions targets

The Protocol’s net emission limits apply to a bundle of greenhouse gases and not just carbon dioxide. The other gases include methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.⁸ These are bundled up with carbon dioxide into an aggregate measure, with the weights attached to individual gases reflecting their ‘global warming potentials’. Abatement of a ton of nitrous oxide, for example, is equivalent to abatement of around 315 tons of carbon.

This ‘comprehensive approach’ to climate change mitigation was championed by the Bush Administration, and is to be welcomed. In allowing for trade-offs between different types of gases, the total cost to climate-change mitigation will be lowered.

By how much will this mechanism lower costs? I have not seen any estimates, though in a statement before the US House of Representatives,⁹ Janet Yellen of the Council of Economic Advisers noted

⁷ To be precise, the Protocol allows sinks to play a role in capping emissions. It does not include carbon sinks in the emissions baseline, with one exception. If a country’s carbon sinks were a net source of greenhouse-gas emissions in 1990, then its net emissions from sinks must be incorporated into the baseline.

⁸ Note that the European Union and Japan sought to limit just three gases. It was the USA that insisted on including all six gases.

⁹ Janet Yellen, Statement before the US House of Representatives Committee on Government Reform and Oversight, Subcommittee on National Economic Growth, Natural Resources, and Regulatory Affairs, 19 May 1998, http://www.state.gov/www/policy_remarks/1998/980519_yellen_climate.html.

that ‘a strategy of reducing non-CO₂ greenhouse gas emissions by a greater percent than CO₂ emissions could lower emissions permit prices (that is, marginal costs) by as much as 10 per cent’.

‘Banking’

Kyoto does not require that the emission ceilings shown in Table 1 be met every year; it requires only that they be met by each Annex I party on average over the 5-year period, 2008–12. Moreover, parties are allowed to carry forward additional reductions to a future control period. That is, if a country reduces its emissions by more than required in the first control period (2008–12), it can ‘bank’ or carry forward the surplus to the next control period. Finally, certified emission reductions, carried out under the Clean Development Mechanism (CDM; see below) from 2000 to 2007 can also be carried forward to the first commitment period, 2008–12. This allows Annex I countries to benefit from taking early action through the CDM.

These provisions could be helpful, but they do not go far enough. In particular, Kyoto does not allow parties to shift emission reductions toward the future—that is, to ‘borrow’ future emission reductions. Of course, if abatement is shifted forward, the benefits of the abatement in present value terms will fall. But costs may fall much more. If abatement is rushed (and it will be under the Kyoto timetable), some of the existing capital stock will have to be scrapped before its useful life is up. It would be cheaper if emission reductions could be effected by incremental investments. Manne and Richels (1998) estimate substantial savings to a gradual transition to the Kyoto targets, with marginal costs being reduced by a factor of ten or more in 2010.

Emissions trading

Perhaps the most important flexible mechanism in the Kyoto agreement is the provision for trading among the Annex I countries. According to the Clinton Administration’s (1998) analysis, this provision could lower the marginal cost of implementing Kyoto by 72 per cent, and lower the total cost of implementation by 57 per cent, compared with the bench-mark of meeting the national targets unilaterally. Nordhaus and Boyer (1998) obtain a similar result. By their calculations, the present value total cost of implementing Kyoto would be reduced 45 per cent by Annex I trading.

Whether savings like these will ever be realized will depend on how the institutions supporting trading develop. If the trading arrangements allow a market to develop which provides ready price discovery and low transactions costs, then the bulk of these gains will be realized. Otherwise just a fraction, perhaps a small fraction, of these gains will be pocketed.

Europe has thus far been suspicious of the concept, believing it to be a ploy for letting the United States evade its responsibilities. This is a gross misunderstanding of the problem. As noted before, *where* abatement takes place is of no relevance to the climate. Absolutely nothing can be gained by making the United States or any other country pay more than is necessary for abatement. Indeed, it is not even obvious that the USA would gain disproportionately from trading. Calculations by McKibbin *et al.* (1998) show that Europe would gain more from trading than the United States.

‘Hot air’ trading

One reason that trading among the Annex I countries would lower marginal and total costs is that the economies in transition are allowed by Article 3 to choose an alternative base year to 1990 (subject to some restrictions). As shown in Table 1, Bulgaria has chosen 1988 as a base year; Hungary, the average of 1985–7; Poland, 1988; and Romania, 1989. The effect is to create a surplus of emission entitlements that may not be exhausted by economic growth in these countries, even by 2010. Russia must retain its 1990 base year, but it will still have a huge surplus by the year 2000, if the projections shown in Table 1 prove correct (unfortunately, projections to 2008–12 are not available).

As long as these emission ceilings do not bite, marginal abatement costs in the economies in transition will be zero without Annex I trading. Trading, however, will lower costs for all the Annex I countries for two reasons: first, by redistributing abatement within the Annex I group of countries, such that marginal costs are everywhere equal; and second, by relaxing the total constraint on Annex I emissions.

To see the importance of this second effect, consider the consequences of trading within a US–Russian umbrella. In the year 2000, the estimates in

Table 1 suggest that emissions in the USA could not exceed $0.93 \times 4,957,022 = 4,610,030$ gigagrams without trading. If the estimates in the table are to be believed, Russia will easily stay within its limits, emitting only $0.83 \times 2,388,720 = 1,982,638$ gigagrams of CO_2 in 2000. Hence, without trading, total emissions for both countries would not exceed $4,610,030 + 1,982,638 = 6,592,668$ gigagrams. But Russia is allowed to emit up to 2,388,720 gigagrams of CO_2 in 2000. So total allowed emissions for both countries under a trading regime are $4,610,030 + 2,388,720 = 6,998,750$ gigagrams. Trading thus eases the total constraint on the two countries by $6,998,750 - 6,592,668 = 406,082$ gigagrams in 2000. For reasons that should be obvious, this difference in aggregate emissions between the trading and no-trading cases is sometimes referred to as ‘hot air’.

As noted at the bottom of Table 1, the Kyoto emission constraints are expected to bind in the aggregate, even by the year 2000. Annex I emissions are projected to be 97 per cent of the adjusted base-year emissions, whereas Kyoto requires that they be 94 per cent of this level. However, the ‘hot air’ released by trading does ease the aggregate emissions constraint for Annex I emissions. Annex I trading lowers costs partly by lowering total abatement.

Note, however, that though the ‘hot air’ provision appears to be a loophole, had it not been created—had the economies in transition been given tighter emissions constraints—it is likely that the other Annex I countries would have insisted that their own emission constraints be relaxed. For in reducing the amount of ‘hot air’, the costs to the other Annex I countries of fulfilling *their* commitments would increase. When seen in the context of the negotiations, a bigger problem with the ‘hot air’ provision may be that it gave away something for nothing.

Of course, the economies in transition could be justified in putting their resources somewhere other than in climate-change mitigation (many of these countries are poorer than some non-Annex I countries). But the other Annex I countries have given these economies *more* than was needed to make their participation incentive compatible. This is not just a matter of redistributing the gains from cooperation. Had less been given away, the incentives for the other Annex I countries to participate in the

agreement would have increased, whereas the European economies in transition would still have had an incentive to participate, so long as their incentive compatibility constraints were satisfied.

Joint implementation

The Kyoto Protocol also allows ‘joint implementation’ (JI) trades among the Annex I countries. These are bilateral project-based, rather than market-based, trades, in which one country receives ‘emission reduction units’ for undertaking projects in another country that reduce net emissions.

JI trades must be individually negotiated, and so will entail transactions costs. These costs will likely be high because of the elusive nature of the commodity being traded. JI projects must provide ‘a reduction in emissions by sources, or an enhancement of removals by sinks, that is *additional* to any that would otherwise occur’ (emphasis added). Calculating this additional reduction will not be easy, because of course one is not able to observe the emissions profile that would have been realized had the trade not taken place. This must instead be inferred. Costly analyses will thus need to be undertaken. Experience with the emissions trading programme in the United States suggests that where transactions costs are high, bilateral trading will be limited.

Clean development mechanism

The JI concept is extended to include non-Annex I countries through the CDM. This allows Annex I countries to meet their emission ceilings by undertaking projects in developing countries that provide ‘additional’ and ‘certified’ emission reductions. The CDM is potentially of huge significance, for it provides the only means within the Kyoto framework of shifting abatement toward the non-Annex I countries.

But the CDM has a number of problems. One is that it is not obvious whether the CDM would be limited to emission reductions or whether it can include sequestration projects. The provisions for JI explicitly allow sequestration projects to be included, but the CDM article is silent on this question.

An even more important difference is that one of the parties to a CDM transaction will not have its emissions capped. Potentially, therefore, the CDM

could produce only 'paper' emission reductions. Moreover, as Stavins (1998a) warns, it is likely that the least beneficial CDM projects will be adversely selected by this mechanism. Indeed, the problem is doubly worrying. Not only do developing countries have incentives to offer projects that would have been undertaken anyway, but the Annex I countries have incentives also to select these projects, if they can be acquired at lower cost (this is just another manifestation of the free-rider problem).

It will therefore be a matter of interest not only to the parties engaging in a CDM transaction but also to all other parties whether a transaction really will provide 'reductions in emissions that are additional to any that would occur in the absence of the certified project activity'. And it is for this reason, in contrast to the JI provisions, that the emission reductions resulting from a CDM transaction must be 'certified by operational entities to be designated by the Conference of the Parties'.

Though necessary, certification will be costly, and the countries carrying out CDM trades will have to pay for certification (as noted in the Protocol, 'a share of the proceeds from certified project activities [will be] used to cover administrative expenses'). Moreover, Kyoto insists that a share of the proceeds from CDM trades also be used 'to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation'. This sounds like a tax. If CDM transactions are taxed, and if transactions costs are high, the volume of CDM trades will be very low.

There is no way of knowing by how much costs will be reduced by the CDM, not least because the important details have yet to be negotiated. In her statement to the US House of Representatives, however, Janet Yellen offered a guess:

The CDM cannot realistically be expected to yield all the gains of binding targets for developing countries, but it might shave costs by roughly another 20 to 25 per cent from the reduced costs that result from trading among Annex I countries.

As suggested by this statement, CDM transactions costs could have been reduced considerably had the Kyoto diplomats succeeded in negotiating emission limits for the developing countries. The issue is not whether these countries should pay to participate.

Most poor countries would have every incentive to walk away from an agreement that required them to dig into their pockets, and few people would blame them for doing so. But if developing countries had agreed to be bound by targets, then they would be able to trade with the Annex I countries and—subject to appropriate choice of their emission ceilings—be virtually sure of being better off. An earlier draft of the Protocol allowed developing countries to choose, at any time and on a voluntary basis, a level of emissions control that was appropriate to their circumstances, but the provision was subsequently expunged, apparently at the insistence of China and India (see Jacoby *et al.*, 1998). Since inclusion of developing countries in some manner is vital, the matter is sure to be on the agenda of future meetings of the parties.

'Supplemental' trading

A further problem is that JI, CDM, and emissions-trading transactions are intended to be 'supplemental' to domestic actions, a constraint reaffirmed by the G8 group of countries meeting in April 1998. According to a *Financial Times* article (6 April 1998) on the G8 summit, the virtue in this constraint is that it will prevent the leading industrial nations (plus Russia) from being able 'to evade painful domestic reductions in greenhouse gas emissions'.

This is a twisted logic. It cannot be good for the environment. If anything, the restriction on trading, in elevating between-country differences in marginal costs, will harm the environment by magnifying the leakage problem. And it cannot be sure to make developing countries any better off either.

Whether this constraint will ever bite, however, is another unknown, for the parties have not defined what 'supplemental' means. If the notion is interpreted as being qualitative, then it will easily be satisfied, for even with unconstrained trading every Annex I country will undertake *some* abatement at home. More serious would be an arbitrary, quantitative limit on trading. Unfortunately, there is some support for such a cap, especially in Europe. The European Parliament adopted a resolution in September 1998 calling for 'an agreement to have a quantitative ceiling on the use of flexibility mechanisms to ensure that the majority of emissions reductions are met domestically'.

Table 2
European Union Burden-sharing Agreement

Member state	National target (%)
Austria	-13
Belgium	-7.5
Denmark	-21
Finland	0
France	0
Germany	-21
Greece	+25
Ireland	+13
Italy	-6.5
Luxembourg	-28
Netherlands	-6
Portugal	+27
Spain	+15
Sweden	+4
United Kingdom	-12.5
Total EU	-8

'Bubbles' and 'umbrellas'

Article 4 of the Protocol allows parties to negotiate a side agreement, in which they pledge to fulfil their Kyoto ceilings jointly. This provision was important in that it made it possible for the European Union to negotiate on behalf of its 15 member states in Kyoto. The emission ceiling shown in Table 1 for the European Union is thus an aggregate ceiling. The European side agreement, establishing emission ceilings for individual member states, was negotiated in September 1998 and resulted in the burden-sharing agreement shown in Table 2.

Under the terms of the Kyoto agreement, Europe is thus treated as a 'bubble' (in the jargon of the US emissions-trading programme). As long as the total target for Europe is achieved, each member state is considered also to be in compliance. However, should the total target not be met, each member state is held individually accountable for meeting the targets it accepted in the side agreement.

Note that the concept need not be confined to Europe. A number of countries (Australia, Canada, Japan, New Zealand, Russia, Ukraine, and the United States) have discussed setting up an 'um-

brella' group of trading countries under this article, and it is likely that international trading will begin in this way.

(iii) Non-permanent Emission Caps

Another concern about the emission limits in the Kyoto Protocol is that they are not permanent (as are the limits in the Montreal Protocol and the US sulphur-dioxide trading programme, for example). Emission limits for subsequent control periods will be established by future conferences and codified in future amendments; negotiations of the second round of limits (that is, those that apply beginning in 2013) are required to begin by 2005, but Kyoto has nothing more to say about these limits.

This matters because many actions to reduce emissions involve investments with very long lifetimes. Whether these investments will be worth making will depend on the magnitude of future limits. If one believes that future limits will be very tight, then long-term carbon-saving investments will appear more attractive today. If one believes that future limits will be slack, then costly carbon-saving investments will not pass the required hurdle.

Strategy may also intrude. If a country invested more in abatement than needed just to meet its target in the 2008–12 period, then this may only increase the emission reduction that it would have to meet in the next period. The reason is that, once the costs of the investment have been sunk, the costs to this country of reducing its emissions in the next period will be lower; its bargaining position will therefore have been compromised. Turning this argument around, a country might be able to negotiate an easier target for the next control period if it invested less in reducing its abatement costs in the first control period.

But it is easy to overstate this problem. Suppose Kyoto *had* imposed permanent emission ceilings. Then a different problem would arise: the parties to the protocol would question the credibility of the ceilings, knowing that the limits could always be renegotiated. If the countries believed that the future ceilings were too tight, they would ‘under-invest’ in abatement. Of course, once they had done so, the costs of meeting the original limits would be higher, and the case for lowering these ceilings would therefore be strengthened. The belief that the initial limits were ‘too tight’ would be self-fulfilling.

(iv) Arbitrary Emission Limits

Nordhaus and Boyer (1998, p. 17) question Kyoto’s choice of emission limits, noting that they do not relate to ‘a particular goal for concentrations, temperature, or damages’. The targets certainly should take account of damages (see especially section V); at the very least they should provide a benefit (measured in terms of the damages avoided by the mitigation) that exceeds the cost of meeting the targets. But they should not take direct account of concentrations or temperature (even though these will be linked to damages).

One reason for this is that it is very hard to say by how much emissions should be limited. For example, though the Framework Convention requires that concentrations be stabilized at ‘a level that would prevent dangerous anthropogenic interference with the climate system’, no one knows what this level is.

But there is a deeper reason, too. For suppose that such a level could be identified. Then, if parties to the agreement pledged to ensure that this level was not exceeded, every party would have a strong incentive to withdraw from the agreement (or not to accede to it in the first place). The reason is that, if a party withdrew and increased its emissions, the remaining parties would have to reduce their emissions to ensure that the aggregate concentration target continued to be met. In a sense, the withdrawal would be rewarded. Similarly, if a country acceded to the agreement, the burden of meeting the aggregate target would be spread more widely, and, as a consequence, the original signatories would presumably be allowed to reduce their abatement levels—at the expense of the additional party having to increase its abatement. Accession would essentially be punished. An aggregate target thus exacerbates any incentives that may already exist for countries to free ride. That Kyoto does not specify an aggregate target is a virtue.

So, how should the targets reflect damages? Obviously, if the concern were with limiting total damages, then the effect would be the same as just described. However, suppose parties to the agreement were concerned only with maximizing their own collective pay-off (the difference between their total benefit and cost of mitigation). Then the incentives would be better aligned. If a country withdrew from the agreement, the remaining parties would reduce their abatement (since the aggregate marginal damage for the parties to the agreement would fall with the withdrawal); the withdrawal would be punished. If a country acceded, the countries that were already parties to the agreement would increase their abatement (since the aggregate marginal damage for parties would increase); the accession would be rewarded.¹⁰

(v) Quantities vs Prices

Setting quantitative targets may seem to be the obvious remedy, and it has been at the forefront of negotiations ever since the Toronto conference. But it has problems.¹¹ One problem is that the link between actions and outcomes, as measured in

¹⁰ This is the basic mechanism underlying the self-enforcing agreements studied in Barrett (1994).

¹¹ Hahn (1998) summarizes a number of alternative prescriptions. See also Nordhaus (1998).

emissions relative to an historical base year, is tenuous. Carbon-dioxide emissions were 7 per cent lower in Britain in 1995 compared with 1990, even though Britain has not adopted a radical policy for reducing emissions. Similarly, emissions in Germany fell 12 per cent between 1990 and 1995. Emissions in Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, and Slovakia fell by even more—by up to 50 per cent over this same period, without any of these countries adopting radical climate change mitigation policies. By contrast, emissions in all the countries that imposed carbon taxes in the early 1990s (Denmark, Finland, The Netherlands, Norway, and Sweden) were 4–15 per cent *higher* in 1995 than in 1990.

Another problem is uncertainty. There is, of course, great uncertainty about the magnitude of climate-change damages. But there is uncertainty also about the costs of climate-change mitigation, and in a seminal paper Weitzman (1974) showed that the latter kind of uncertainty can have important implications for the choice of policy instrument (emission limit versus carbon tax). If a quantitative limit were fixed, marginal costs would be uncertain. If a tax were fixed, emission reductions would be uncertain. Weitzman showed that the tax is superior if the marginal cost curve is steep relative to the marginal benefit curve. Essentially, the tax ensures that marginal costs and benefits do not differ by much.

Pizer (1998) has calculated that taxes would be much more efficient than quantity limits for climate-change mitigation (in his simulations, the net benefits to using the tax are five times the estimate for a quantity control). A combination of policies can do even better (Roberts and Spence, 1976), though Pizer (1998) finds that a hybrid policy is unlikely to improve much on the pure tax scheme in the case of climate change. The essential point is that, even if the Kyoto targets were met cost-effectively, an alternative policy that leaned more in the direction of controlling marginal costs directly (carbon taxes) would be even better.

(vi) Leakage

Because participation in the Kyoto Protocol is not full, there is a potential for ‘leakage’. As the

Annex I countries reduce their emissions, comparative advantage in the greenhouse-gas-intensive industries will shift towards the non-Annex I countries. This trade effect will be reinforced by the workings of the energy market; as demand for the carbon-intensive fuels in the Annex I countries falls, world prices for these fuels will fall, and consumption in the non-Annex I countries will therefore increase. Consequently, emissions outside the Annex I countries will increase; the environmental benefits of the agreement will be reduced. Potentially, if leakage is strong enough, the agreement would only succeed in redistributing global emissions. The effort to negotiate and implement the agreement would have been wasted.

How significant a problem is ‘leakage’? The Clinton Administration (1998, p. 72) maintains that, with cost-effective implementation, the Protocol ‘would likely have little impact on competitiveness’. Maybe so. But if implementation is not cost-effective—and as I have already explained it could be far from this mark—then the consequences could be different. Bernstein *et al.* (1998) find that leakage could be significant: for every 100 tons of carbon abated by the Annex I countries, non-Annex I emissions could rise 5–10 tons (global emissions would thus fall by only 90–95 tons). Manne and Richels (1998) and Nordhaus and Boyer (1998) also predict significant levels of leakage.

These levels may not appear high, but they will certainly be politically visible.¹² Leakage would damage particular industries, and these will surely lobby for protection. The Senate resolution drew attention to the problem, and the proposed EC carbon tax was modified partly to take account of the concerns voiced by the energy-intensive industries about a possible loss in ‘competitiveness’. It is no surprise that unilateral carbon taxes within countries vary by sector, with industry—and especially the energy-intensive export industries—always paying the lowest amount. When the EU burden-sharing rule was being negotiated, a number of countries (Austria, Denmark, The Netherlands, Spain, and Finland) wanted to make meeting the national targets conditional on the introduction of EU-wide emissions-control measures. These countries were concerned that, as they reduced emis-

¹² Previous studies have shown that leakage could be more substantial (IPCC, 1996, ch. 11).

sions, perhaps by imposing steep carbon taxes at home, output in the sectors most highly taxed would shift elsewhere within the Union. The Danish minister said that, though he accepted that Denmark's –21 per cent target was unconditional, Denmark would only be able to achieve –17 per cent without EU-wide measures being adopted.¹³

This links up with a point made in the Introduction: that concerns about leakage provide another reason for wanting to encourage trading. In reducing the between-country difference in marginal costs, trading reduces leakage. Trading therefore lowers costs and increases benefits.

IV. COMPLIANCE ENFORCEMENT AND FREE-RIDER DETERRENCE

Assume the best: that enough countries ratify Kyoto that it comes into force and that the flexible mechanisms in Kyoto allow abatement to be cost-effective. Then we can ask: Will the parties to Kyoto actually comply with the agreement? Will they stay within the limits prescribed by Tables 1 and 2?

It is a remarkable fact that non-compliance with international agreements is extremely rare. And, when it does occur, the reason is usually that the deviant was for some reason unable to comply, rather than that it chose not to comply.

But why do parties comply? One reason is that they are expected to by customary of international law. And it is obvious why custom demands compliance. If states could not be relied upon to act as they said they would act, then what would be the point of entering into agreements?

But does this mean that compliance is not a problem? If it does, then it should not matter that the Kyoto Protocol does not (yet) include any provisions for punishing non-compliance. As Chayes and Chayes (1995, pp. 32–3) note, the authority to impose sanctions 'is rarely granted by treaty, rarely used when granted, and likely to be ineffective when used'. So Kyoto's failure to enforce compliance by sanctions may be an irrelevance.

However, the facts are open to a different interpretation: that

both the high rate of compliance and relative absence of enforcement threats are due not so much to the irrelevance of enforcement as to the fact that states are avoiding deep cooperation—and the benefits it holds whenever a prisoners' dilemma situation exists—because they are unwilling or unable to pay the costs of enforcement (Downs *et al.*, 1996, p. 387).

This last interpretation may seem cynical and unconvincing. After all, as we have seen, Kyoto does strive to sustain 'deep' cooperation—a treaty that imposes a cost measured as a fraction of GDP can hardly be described as 'shallow'. But, then again, Kyoto has not even entered into force yet, let alone been implemented. So we cannot really choose between these different theories.

Indeed, it would not even be sensible to choose between them because neither quite gets to the heart of the matter. The Chayeses consider the need to enforce compliance as being independent of the need to deter free-riding—something that they dismiss as being of little practical importance. Downs *et al.*, by contrast, conflate the two problems. Compliance enforcement and free-rider deterrence are related problems and should be analysed jointly.

It is important to note that customary law does *not* require that states be parties to a treaty. Sovereignty means that countries are free to choose to participate in a treaty or not as they please (Barrett, 1990). So if free-riding is to be deterred—if participation in a treaty is to be full—then some kind of treaty-based mechanism must provide the right incentive. It must correct for the harmful incentives that otherwise condemn countries to the fate of the famous prisoners' dilemma.

Suppose that an agreement exists, that it consists of a certain number of parties, and that it requires that these parties undertake some action. The required action (climate-change mitigation) is costly to the parties that undertake it, but provides a benefit that is shared by parties and non-parties alike (climate-change mitigation is a public good). So each party will have an incentive to withdraw from the agree-

¹³ 'EU States Agree Kyoto Emissions Limits', *ENDS Environment Daily*, 17 June 1998, <http://www.ends.co.uk/subscribers/envdaily/articles/98061701.html>.

ment, for in doing so each can gain more from avoiding steep mitigation costs than it loses from its own small slice of greenhouse-gas abatement.

If a party is to be deterred from withdrawing—which it is entitled to do under international law¹⁴—then it will need to be punished for withdrawing, and punished severely. It will be up to the other parties to the agreement to impose the punishment, but they may be reluctant to do so. The reason is that it is very hard to punish a deviant without also harming oneself. For example, suppose the punishment is that, in the event of one country withdrawing (and therefore cutting its abatement substantially), the other parties reduce their mitigation. Then the countries called upon to impose the punishment will be shooting themselves in the foot, so to speak. The punishment may not be credible.

Let us suppose, however, that a credible punishment can be found to deter some level of free-riding. Then it can be shown that the same punishment can be relied upon to enforce compliance (deter non-compliance); see Barrett (1998a). The reason is intuitive. Suppose a party contemplates ‘cheating’ on the agreement, perhaps by reducing its emissions by less than required by the agreement. To be deterred from cheating, it must face a punishment, and the punishment must be sufficiently severe that the country is made better off by not cheating. The larger the deviation from compliance, the larger must be the punishment which deters non-compliance. But the larger the required punishment, the larger will be the harm self-inflicted on the countries asked to impose it. If a punishment becomes too large it will cease to be credible and non-compliance will not be deterred.

Recall, however, that I have assumed that there exists a credible punishment that can deter (further) withdrawals from the agreement. The worst harm that a signatory could do by not complying would be for it to choose an emission profile that matched

what it would do if it withdrew from the agreement. Hence, if every signatory is deterred from withdrawing, each also is deterred from not complying. The binding constraint on international cooperation is free-rider deterrence, not compliance enforcement. Once free-riding can be deterred, compliance can be enforced free of charge.

The example of the Montreal Protocol is relevant here. This agreement, which is phasing out the use of ozone-depleting chemicals world wide, is among the great successes of international cooperation. It is also often held up to be a model for future agreements. Like Kyoto, the Montreal Protocol did not initially incorporate a mechanism for punishing non-compliance; choice of such a mechanism was to be deferred to a future meeting of the parties. So failure by Kyoto to include a mechanism for enforcement might seem not to matter. However, there is a big difference between the two treaties. The Montreal Protocol *did* offer incentives for countries to participate in the form of a trade sanction between parties and non-parties in the substances controlled by the treaty and in products containing these substances. And this device has succeeded in making participation in the Montreal Protocol virtually full.¹⁵ It has also been invoked to enforce compliance with the agreement.¹⁶ When seen in this light, compliance enforcement is a problem for Kyoto because the agreement does not employ a mechanism to deter free-riding.

Actually, the minimum participation clause may provide some assistance in deterring free-riding. You can think of it this way. Suppose more than 55 countries have ratified the treaty, and Annex I participation falls just a tiny bit short of the 55 per cent minimum required for entry into force. Then, if one more Annex I country ratifies, and so makes the minimum participation clause bind on all parties, it will have a non-marginal effect on the behaviour of others—the other Annex I parties will now have to fulfil their obligations under the treaty. This might

¹⁴ The Kyoto Protocol allows a party to withdraw 3 years after the Protocol has entered into force for a party, upon giving 1 year’s notice.

¹⁵ A provision was also made for controlling trade in products made using these substances, but this was never implemented.

¹⁶ The biggest challenge to the Montreal Protocol came when Russia declared that it would not be able to comply by 1996. The Implementation Committee threatened to invoke sanctions—and the combination of this threat and the sweetener of financial assistance was enough to compel Russia into preparing a plan for eventual compliance. The carrot of financial assistance was justified, by the way, since the original Montreal Protocol was negotiated by the Soviet Union in 1987, before its collapse. See Barrett (1998b).

just provide the incentive for the marginal ratification, and push the treaty over the minimum participation threshold.¹⁷

However, this trick is not sure to work—and even if it did succeed, it provides absolutely no incentive for *successive* accessions to the treaty. To see this, notice that the next country to ratify will not alter the behaviour of the existing parties one little bit. So why should it accede? The Kyoto Protocol does not provide any incentives for more than the minimum of participation. This is in sharp contrast to Montreal, which provides ample incentives for full participation.

Let us suppose, however, that Kyoto's minimum participation level is met and that the agreement enters into force. Could full implementation then be relied upon? The answer is not obvious. Suppose just one country foresees that it will fail to comply. Then it could withdraw from the agreement, upon giving sufficient notice, and so avoid having to deviate from the custom of compliance. Of course, its withdrawal would be penalized if it brought about the collapse of the agreement, as required by the minimum participation clause. But the other parties may not want the agreement to collapse, even taking as given this country's withdrawal, perhaps because, having previously sunk money into abatement investments, the cost of sticking with the agreement would be low. But if this is true—if a country cannot expect to be punished for deviating, then every party would have an incentive not to try very hard to comply with the agreement.

A more likely scenario is that a number of countries will wait to undertake substantial investments in abatement until others have already done so. The risk is that, with everyone behaving in this way, the policies and investments needed to implement Kyoto will not be made. The Protocol seems to have anticipated this problem, for it requires that every Annex I party demonstrate progress in achieving its target by 2005. But this will not suffice. If enough of these parties have made little progress, then none can be singled out for having acted unusually. Anyway, if no penalties can be applied, a lack of progress by all parties, or a large enough number of parties, would only provide a reason for renegotiat-

ing the agreement. To compound these problems, delay in implementing Kyoto will raise the costs of sticking to the Kyoto timetable, and so increase the incentives not to stick to this timetable.

The solution to all these problems may seem obvious: invoke the kind of sanctions used by the Montreal Protocol. However, production of every good has implications for greenhouse-gas emissions. Should *all* trade between parties and non-parties be banned? The threat to do so would almost certainly not be credible. Should trade in a select range of products be banned? That might be credible, but it might also threaten the stability of the multilateral trading arrangements. The answers are not obvious. But perhaps the questions should be asked (I was told that the subject never came up in Kyoto).

V. SUMMARY

If there is one lesson to draw from this analysis it is this: the Kyoto Protocol must produce for its parties a favourable benefit–cost ratio or else it will either never enter into law or it will collapse.

As I noted in the opening paragraph of this paper, the overall reductions in emissions contained within Kyoto probably could provide a benefit–cost ratio for the world in excess of one. However, actually realizing this potential gain will not be easy. The overall level of abatement prescribed by Kyoto would have to be achieved cost-effectively—and this will require that abatement be undertaken in non-Annex I countries. Participation by the non-Annex I countries could potentially be achieved through the Clean Development Mechanism, but this would be sufficient only under the most favourable of assumptions. It seems more likely that emission caps would also need to be negotiated for the developing countries. Let me repeat here that this does *not* imply that the non-Annex I countries would need to pay for this abatement themselves. The reason for broadening participation is not to redistribute costs so much as to lower the total bill. There is an important precedent for this. The Montreal Protocol capped emissions of ozone-depleting substances in developing countries, and these countries did not have to pay to stay within these limits;

¹⁷ This is what I call a 'linchpin' equilibrium. See Barrett (1998a).

the 'incremental costs' of their compliance were paid for by the industrialized countries.

Achieving a favourable benefit–cost ratio implies not just that costs must be kept low, but also that benefits must be kept high. As noted earlier, lowering implementation costs will actually raise benefits by lowering leakage. But there is another problem: one way of lowering costs is to approve CDM transactions that may not ultimately yield reductions in net emissions (so-called paper trades). Shaving costs in this way would ultimately ruin the agreement. This is yet another reason why Kyoto should be revised to include emission caps for the developing countries.

If these requirements can be met (and that is a big if), then the US Senate's objections would fall away, and the Kyoto Protocol could then enter into force. The problems of non-compliance and free-riding would at the same time be eased. If the costs of participation were lowered (and the benefits increased), then the incentives to deviate in these ways would be reduced.

However, these incentives to deviate would not be eliminated by cost-effective abatement. Achieving a favourable benefit–cost ratio is only a necessary condition for achieving global cooperation; it is not sufficient (Barrett, 1994, 1998a). And it is not obvious how the required sanctions could be made credible. So Kyoto has two mountains to climb. The first—achieving a favourable benefit–cost ratio—is challenge enough. The second—detering free-

riding and non-compliance—has not yet come into view, but it may prove the harder climb.

POST SCRIPT

After this paper was written, the parties to the Framework Convention met in Buenos Aires (in November 1998). The issues raised in this paper were not resolved at this meeting, but a Plan of Action was agreed, with deadlines for finalizing the Protocol's flexible mechanisms. For the first time, the issue of how compliance should be enforced was raised, though to my knowledge no mechanism for enforcing compliance was proposed. At the meeting, the United States became the 60th country to sign the Kyoto agreement. Another small island state, Antigua and Barbuda, became the second to ratify it. Argentina, which hosted the meeting, announced its intention to adopt an emission limit voluntarily, and Kazakhstan said that it would join the group of Annex I countries and accept, in the words of the press release, a 'legally binding target' (adding more 'hot air'?).

These developments are to be welcomed, but the fundamental problems raised in this paper remain. The press release issued at the start of the Buenos Aires talks concluded by noting that the agreement would not become legally binding until the minimum participation requirements had been met. 'It is hoped,' the statement reads, 'that this will happen in 2001.' It is regrettable that we cannot anticipate with more confidence an event of such importance.

REFERENCES

- Barrett, S. (1990), 'The Problem of Global Environmental Cooperation', *Oxford Review of Economic Policy*, 6(1), 68–79.
- (1992), 'Reaching a CO₂ Emission Limitation Agreement for the Community: Implications for Equity and Cost-Effectiveness', *European Economy*, Special Edition No. 1, 3–24.
- (1994), 'Self-Enforcing International Environmental Agreements', *Oxford Economic Papers*, 46, 878–94.
- (1998a), 'A Theory of Full International Cooperation', *Journal of Theoretical Politics*, forthcoming.
- (1998b), 'Montreal vs. Kyoto: International Cooperation and the Global Environment', in I. Kaul, I. Grunberg, and M. A. Stern (eds), *Global Public Goods: International Cooperation in the 21st Century*, New York, Oxford University Press, forthcoming.
- Bernstein, P. M., Montgomery, W. D., and Rutherford, T. F. (1998), 'Trade Impacts of Climate Policies: The MS-MRT Model', paper prepared for the Yale–NBER Workshop on International Trade and Climate Policy, Snowmass, CO, 12 August.
- Chayes, A. and Chayes, A. H. (1995), *The New Sovereignty*, Cambridge, MA, Harvard University Press.

- Clinton Administration (1998), 'The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis', White House, Washington, DC, July.
- Downs, G. W., Rocke, D. M., and Barsoom, P. N. (1996), 'Is the Good News About Compliance Good News About Cooperation?', *International Organization*, **50**, 379–406.
- Grubb, M. (1995), 'The Berlin Climate Conference: Outcome and Implications', Briefing Paper No. 21, London, Royal Institute of International Affairs.
- Hahn, R. W. (1998), *The Economics and Politics of Climate Change*, Washington, DC, American Enterprise Institute for Public Policy Research.
- International Energy Agency (1992), *Climate Change Policy Initiatives*, Paris, OECD.
- IPCC (1990), *Climate Change: The IPCC Scientific Assessment*.
- (1995), *IPCC Second Assessment: Climate Change 1995*, WMO and UNEP.
- (1996), *Climate Change 1995: Economic and Social Dimensions of Climate Change*, Cambridge, Cambridge University Press.
- Jacoby, H. D., Prinn, R. G., and Schmalensee, R. (1998), 'Kyoto's Unfinished Business', *Foreign Affairs*, July/August.
- McKibbin, W. J., Shackleton, R., and Wilcoxon, P. J. (1998), 'What to Expect from an International System of Tradable Permits for Carbon Emissions', mimeo.
- Manne, A. S., and Richels, R. G. (1998), 'The Kyoto Protocol: A Cost-Effective Strategy for Meeting Environmental Objectives?', mimeo.
- Nordhaus, W. D. (1998), 'Is the Kyoto Protocol a Dead Duck? Are There Any Live Ducks Around? Comparison of Alternative Global Tradable Emissions Regimes', mimeo, Department of Economics, Yale University.
- Boyer, J. G. (1998), 'Requiem for Kyoto: An Economic Analysis of the Kyoto Protocol', paper prepared for the Energy Modeling Forum meeting, Snowmass, Colorado, 10–11 August.
- Pizer, W. A. (1998), 'Prices vs. Quantities Revisited: The Case of Climate Change', Resources for the Future Discussion Paper 98–02.
- Roberts, M. J., and Spence, M. (1976), 'Effluent Charges and Licenses Under Uncertainty', *Journal of Environmental Economics and Management*, **5**, 193–208.
- Stavins, R. N. (1998a), 'What Can We Learn from the Grand Policy Experiment? Lessons from SO₂ Allowance Trading', *Journal of Economic Perspectives*, **12**, 69–88.
- (1998b), 'The Costs of Carbon Sequestration: A Revealed-Preference Approach', *American Economic Review*, forthcoming.
- Weitzman, M. L. (1974), 'Prices vs. Quantities', *Review of Economic Studies*, **41**, 477–91.