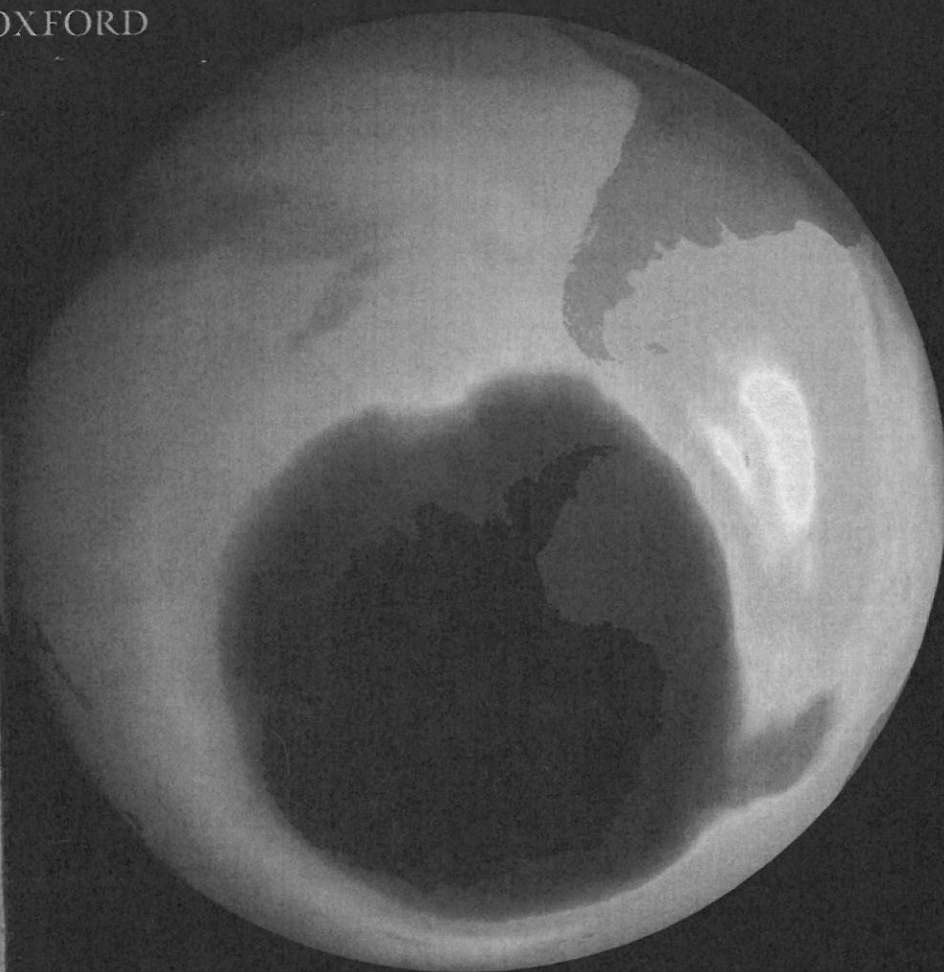


OXFORD



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ENVIRONMENT & STATECRAFT

The Strategy of Environmental Treaty-Making

time of Japan's withdrawal, all four parties were consumed by war. However, after the war, the treaty was negotiated anew—and this time, the treaty not only contained this same threat but made it more explicit. This suggests that the experience with the earlier treaty convinced all the parties of both the credibility and the utility of the threat. Recall that the history of fur seal exploitation taught the important lesson that anything short of a comprehensive agreement was largely a wasted effort.

This is what makes the Fur Seal Treaty unusual. As the Appendix to Chapter 6 shows, though all agreements specify a minimum participation level, the actual number of parties usually exceeds this minimum. The exceptions are mainly regional agreements—agreements concerning international river courses, closed seas, and regional ecosystems—for which *N* is small. Of course, it is precisely for these kinds of problems that full participation is vital to the success of a cooperation effort. If a resource is shared by only a few countries and just one chooses not to participate in an agreement seeking to protect it, the others will be materially affected. They will therefore have an incentive to punish non-participation severely. For a global resource, non-participation by just one country will normally affect all the others very little, making only small punishments credible.

Where actual participation exceeds the minimum participation level, the minimum participation clause is probably intended to coordinate behavior, as discussed in Chapter 9. However, cooperation may still be a problem. Cooperation and coordination are not mutually exclusive phenomena.

Though international cooperation can be sustained by an IEA, there is no guarantee that the best, institutionally feasible IEA will be negotiated. Given that the underlying game is a PD, non-cooperation will be an equilibrium. It may be possible to transform the situation, to sustain a measure of cooperation by restructuring the relationships among the countries that share a resource. But this will only result from conscious and deliberate reflection and careful diplomatic maneuvering. The theory developed here is thus best thought of as showing what is possible, what diplomats should aspire to achieve. It should make us marvel at the skill with which the Fur Seal and Montreal Protocol agreements were constructed. We have already learned how the Fur Seal Treaty succeeded. The full story of the Montreal Protocol's success will take longer to tell. The next chapter begins that story.

8

The Montreal Protocol

[T]he ozone agreement is, I believe, the beginning of a new era of environmental statesmanship—one that takes into account the complexities, the uncertainties, and the differences, in economic interest that in the past have limited concerted environmental action by nations. Mostafa K. Tolba, Executive Director, United Nations Environment Programme (1987).¹

8.1. INTRODUCTION

If the theory begun in the previous chapter is to be of real utility, it must be able to explain the Montreal Protocol's success. To be more precise, it must be able to explain why Montreal *appears* to have been successful. "Success," of course, is an elusive concept in this context. As we do not know what the world would have done about stratospheric ozone depletion had countries pursued only unilateral policies, we cannot be sure whether Montreal really has made a difference. This again is something that the theory should be able to tell us.

Of course, I can do no more than show that the theory is not wrong. Moreover, there are other explanations for the Montreal Protocol's apparent success; and as I proceed, I shall distinguish my explanation from these. My assessment in this chapter will also be preliminary. I have only begun to build the theory of international cooperation. I limit my focus in this chapter to providing background and to showing the relevance of the theory presented thus far. As the theory is developed in later chapters, my explanation for the Montreal phenomenon will be rounded out. It will not be completed until Chapter 13.

The discussion of the Montreal Protocol, here and in later chapters, is selective. It is meant to complement, and not to substitute for, Richard Benedick's brilliant *Ozone Diplomacy*, an insider's view of the talks and of the underlying negotiation process (Benedick was the chief US negotiator at Montreal). I shall, in particular, emphasize aspects of this treaty that Benedick gives less weight to, re-framing features of the agreement to reveal their strategic roles. Whereas Benedick (1998: xi) provides "a case study of the diplomatic craft," one that can serve "as a paradigm for new diplomatic approaches to new kinds of international challenges," I come at this topic from the opposite direction. My approach is to build a theory from first principles, and to then apply the theory to Montreal and other cases. Whereas Benedick's book is rich in detail, the theory I develop in this book is sparse. Whereas Benedick describes the

twists and turns of this negotiation, the chance events that led negotiators down one path rather than another, the personalities of the negotiators and of those seeking to structure the negotiations, the relationships they developed and the effect these had in creating a "spirit of Montreal," my explanation stresses the more fundamental forces that shape a treaty. My view is that we can best understand these problems by looking at them from both of these perspectives.

8.2. BACKGROUND

In 1974, two chemists at the University of California, Mario Molina and Sherwood Rowland, published a scientific paper with astonishing implications (Molina and Rowland 1974).² Their paper suggested that stratospheric ozone could be destroyed by releases of chlorofluorocarbons (CFCs), a class of human made chemical discovered in 1928.

CFCs were an ideal chemical: highly stable, non-toxic, non-corrosive, non-flammable, and inexpensive to produce. Everyone knows CFCs were used as an aerosol propellant. But they were also used as a refrigerant, an insulator, and a solvent. They were found in asthma sprays, fire extinguishers (halons, a related compound), and styrofoam coffee cups. They were used for cleaning microchips, as a coolant in air conditioners, and as an insulator in refrigerators. They were so attractive that new uses for them were being found all the time.

When released, however, Molina and Rowland discovered that CFCs slowly make their way to the stratosphere, between 6 and 30 miles above the earth's surface. Long exposure to solar radiation causes the CFCs to break down and to release chlorine—and it is the chlorine, not the CFCs themselves, that is the problem. The Molina-Rowland theory, supported by preliminary experimental results, suggested that chlorine would destroy ozone.

The potential consequences of ozone depletion would be life-threatening and planetary in scale. Since stratospheric ozone absorbs harmful ultraviolet radiation, depletion of the ozone layer would allow more ultraviolet-B (UV-B) radiation to reach the earth. There would be more skin cancers and eye cataracts, lower yields in agriculture and fisheries, an accelerated deterioration of plastics used outdoors, and an increase in ground-level ozone (smog).³

² In 1995, along with Paul Crutzen, another researcher in this field, Molina and Rowland received the Nobel Prize for Chemistry.

³ CFCs are also a greenhouse gas. However, depletion of stratospheric ozone has a negative effect on radiative forcing, partially offsetting the direct warming effect of CFC emissions. For this and other reasons, negotiators of the ozone and climate change agreements have tried to compartmentalize the two issues. But the separation is artificial: the problems are related. For example, in phasing out CFCs, Montreal increased the demand for hydrofluorocarbons (HFCs), a CFC-substitute that is also a greenhouse gas. The Kyoto Protocol aims to limit emissions of HFCs—but in the process would increase the costs of substituting for CFCs, and so, perhaps, undermine compliance with the Montreal controls. The two problems are also related in a different way. Though climate change would warm the atmosphere near the Earth's surface, it would cool the lower stratosphere and thereby accelerate the chemical processes that destroy ozone. Similarly, the atmospheric abundance of some greenhouse gases, as well as sulfate particles, can also affect the ozone layer.

The potential for damage was real enough: CFC use had increased substantially, and CFCs have long atmospheric lifetimes—lasting decades or centuries. CFCs were thus accumulating in the stratosphere. Even if all releases of CFCs were halted immediately, chlorine would continue to be released in the stratosphere for some time to come. If the theory were correct, some ozone depletion would be inevitable; and it would take a long time to reverse.

Exactly how much damage could CFCs cause—assuming that the Molina-Rowland hypothesis was correct? In 1976, the US National Academy of Sciences, in a follow-up study to the Molina-Rowland paper, predicted that releases of CFCs would eventually deplete stratospheric ozone by about seven percent: enough to pose a substantial risk.

Though the causal link between CFCs and stratospheric ozone depletion was still unproved, a number of countries unilaterally restricted consumption and production of CFCs, beginning in the late 1970s (EPA 1988b): Belgium, Canada, Norway, Sweden, and the United States banned the use of CFCs in aerosols; the European Community (EC) adopted measures to reduce CFC use in aerosols by 30 percent from 1976 levels and also capped production capacity; the Netherlands required that a warning label appear on all aerosol products containing CFCs; Portugal banned CFC production and established CFC import quotas; Brazil capped production; Australia reduced CFC use in aerosols by two-thirds; and Japan reduced the use of CFCs in aerosols and discouraged increases in production capacity.

Some of these measures were largely symbolic. For example, European consumption of CFCs had already fallen 28 percent when, in 1980, the Community passed a directive requiring that consumption be cut by 30 percent from the 1976 level; and the Community's definition of "production capacity" actually allowed output to increase by more than 60 percent above the current level (Benedick 1998). A few of the measures, however, were significant and costly to implement. The US ban was especially important. The US was the biggest producer and consumer of CFCs, and its unilateral ban was enough to stabilize global CFC consumption—for a time.

However, because of growth in the use of CFCs for other purposes in the United States (the share of CFC-113, used as a solvent in the manufacture of computer chips, more than doubled from 1975 to 1982; see Haas 1992) and in other countries, global consumption of CFCs increased again in the early 1980s. Around this time, countries began to feel that unilateralism had begun to run its course, and that further action to protect the ozone layer would require international cooperation.

8.3. VIENNA AND MONTREAL

In 1977, at the request of the states that had already acted unilaterally to reduce CFCs, an International Conference on the Ozone Layer was convened by the United Nations Environment Programme (UNEP). The conference recommended that a global framework convention for the protection of the ozone layer be negotiated, and work on the treaty began right away.

From this time until the early 1980s, however, CFC consumption was declining, and predictions of eventual ozone depletion were revised downwards. Actual measurements

of ozone levels also failed to show statistically significant losses. If anything, the unilateral actions taken in the late 1970s were perceived as having been an over-reaction. Though an international agreement was adopted in March 1985 (the Vienna Convention for the Protection of the Ozone Layer), it served only as a framework agreement; it did not require that any abatement be undertaken by signatories. Indeed, the Vienna Convention only mentions CFCs by name in an annex.

The greater achievement in Vienna was the adoption of a resolution to restart negotiations, with the aim of preparing a protocol by 1987 that would require real reductions in CFC emissions. The resolution also asked UNEP to convene workshops "to develop a more common understanding of factors affecting the ozone layer, including costs [emphasis added] and effects of possible control measures [that is, *benefits*], a move which proved to be the springboard for the Montreal Protocol" (Benedick 1998: 45).

Just two months after Vienna, the British Antarctic Survey reported that, over the period 1977–85, the ozone layer over the Antarctic had been reduced by 40 percent.⁴ This came as a shock; the loss in ozone recorded over Antarctica far exceeded earlier predictions.

It is a part of the folklore today that the discovery of the Antarctic ozone "hole" (a localized thinning of the ozone layer, an image of which is shown on the front cover of this book) was the catalyst behind Montreal.⁵ Richard Benedick, however, emphatically rejects this perspective. He reminds us that cause and effect had not been established at this time. Moreover, it was unknown whether ozone depletion over the Antarctic implied anything for the other continents. Indeed, Benedick (1998: 20) recalls that "Antarctica was never discussed at the negotiations," which began in earnest in December 1986. The negotiators relied instead on the evidence from the global models of ozone depletion, and from the workshops held in the spring and fall of 1986 on possible alternatives to CFCs and on the environmental consequences of adopting particular controls. "It was generally accepted that changes in the ozone layer would pose serious risks to human health and the environment," Benedick (1998: 22) notes, "the point of contention among the participating governments was the extent of international action necessary to provide a reasonable degree of protection."

More important in Benedick's view than the ozone hole was a chance event of the kind discussed in Chapter 6. The EC is represented at international meetings by the EC presidency. Also influential is a committee comprising the current president and its immediate predecessor and successor. In January 1987, the presidency rotated—as it does every six months—and Belgium replaced the United Kingdom. Then, in July

1987, the United Kingdom was removed from the EC committee, and so lost its influence. The United Kingdom had opposed strong controls. Belgium, by contrast, was one of the countries to have acted unilaterally to ban CFCs in aerosols in the 1970s. When the Montreal talks began, the other committee members were Denmark and the Federal Republic of Germany, both of which were in favor of substantial cuts. To Benedick, this was a turning point. "It is likely," Benedick (1998: 36) writes, "that this serendipitous constellation, in the right place at the right time, contributed to the EC's finally accepting considerably stronger measures than it had espoused throughout the negotiating process."

Though the discovery of the ozone hole was not as important to the negotiations as is commonly believed, it did become a flashpoint for public attention. When the agreement was adopted on September 16, 1987, it was headline news.

8.4. BASIC OBLIGATIONS

I will not describe the process of negotiating Montreal—the preparation of a single negotiating text, the "capture" of European negotiators by industry, the role of UNEP's executive director, Mostafa Tolba, in steering the negotiations, and so on. As explained in Chapter 6, the negotiation process is important; it helps to give shape to a treaty. However, these and other aspects of the Montreal negotiations are vividly described in Benedick's book. Of more immediate relevance to the theory developed in Chapter 7 is the outcome: what was actually agreed. This is what I describe below. The appendix to this chapter contains the original agreement.⁶

The main achievement of the Montreal Protocol was to require that the production and consumption of a number of CFCs be cut by half (from their 1986 levels) by 1999 and that production and consumption of certain halons (compounds used in fire protection, another class of ozone-depleting substance) be stabilized at their 1986 levels.

Choice of 1986 as a base year was carefully calculated. It was intended to short-circuit incentives for unwelcome strategic behavior. Had a future year been chosen as the base, there would have been an incentive "to expand output substantially to establish a higher basis from which subsequent cuts would be calculated" (Benedick 1998: 82; see also the section on "Tactics" in Chapter 6). Even when using a historic base year, data were falsely reported to influence negotiations. West German industry understated consumption for 1986, hoping "that indications of lower growth relative to 1985 might influence the negotiators toward weaker controls" (Benedick 1998: 180). The deception backfired. After Montreal, the West German consumption data were quickly "revised" upwards.

The Montreal restrictions applied to a basket of chemicals, each weighted by its "ozone-depleting potential." This formulation "gave countries an incentive to impose greater reductions on substances that were relatively more harmful to the ozone layer

⁴ Interestingly, the data showing the dramatic depletion of ozone had been available since 1979. However, US satellites had been programmed to disregard data which fell outside the range of existing predictive models. When the satellites were reprogrammed to analyze all the data available, they revealed the same extent of depletion observed by the British ground-based facilities. The British team was so dumbfounded by their own discovery—possibly because it conflicted with US findings—that they checked and re-checked their own measurements, delaying publication by three years. See Benedick (1998) and Rowlands (1995).

⁵ This view, incidentally, supports another hypothesis from international relations theory—that some kind of shock is needed to kick-start cooperation; see Young (1989).

⁶ The current agreement, embodying the adjustments negotiated in London, Copenhagen, Vienna, Montreal, and Beijing, can be found at <http://www.unep.org/ozone>.

as well as those whose uses were less essential to them [that is, substances that were less costly to control]" (Benedick 1998: 78). In effectively creating emission "offsets," the weighted-basket provision lowered the overall cost of ozone protection.⁷

The Montreal Protocol was designed to be flexible, "to be reopened and adjusted as needed, on the basis of the periodically scheduled scientific, economic, environmental, and technological assessments" (Benedick 1998: 99). And, as matters turned out, Montreal was adjusted and amended—several times. It is still evolving today. Every revision strengthened the original controls, but the potential existed for the Montreal controls to be slackened. Though the Protocol required that all parties reduce their production and consumption of listed substances 20 percent from their 1986 levels, the decision to reduce these levels a further 30 percent could be reversed by a two-thirds majority of the parties, representing at least two-thirds of the total consumption of all parties. And further reductions could be made by "adjusting" the treaty at future meetings, ideally by consensus but if necessary by a two-thirds majority of the parties representing at least half of the total consumption of all parties. Such adjustments would, of course, be binding on all parties, even countries that opposed them. Broadening the agreement to include *new* substances, however, would require treaty amendments. As explained in Chapter 6, these would only be legally binding on the parties that had consented to be bound by them.

8.5. MINIMUM PARTICIPATION

Participation, the focus of Chapter 7, was a key talking point in Montreal. The United States was worried that it could, "in a situation analogous to its unilateral 1978 action, find itself bound to the obligations of an 'international' protocol while its major competitors were not" (Benedick 1998: 89). The Reagan administration thus insisted on "pushing for a proportion of consumption of 90 percent or higher as the trigger for entry into force and other actions" (Benedick 1998: 89).

As explained in Chapter 7, players in the prisoners' dilemma (PD) would collectively prefer to set a minimum participation level equal to 100 percent. Doing so would ensure that full cooperation was sustained. What prevents them from choosing this level is the recognition that the threat to cooperate only if this minimum participation level were satisfied would not be credible.

Indeed, most countries objected to the US proposal. They realized that, were they to require such a high participation level, an agreement requiring deep cuts in emissions would probably never enter into force. The demand for high participation would only serve to "weaken the protocol by extracting other concessions as the price for adherence" (Benedick 1998: 89). In particular, the 90 percent threshold would require approval by the Soviet Union and Japan as well as the EC. A lower threshold, by contrast, would require approval only by the EC (as well as the United States and its ozone allies, of course). Richard Benedick told me later that he preferred a lower threshold, so that responsibility for the treaty's entry into force would rest with

Europe. He also felt that if the lower threshold were satisfied and the treaty entered into force, Japan and the Soviet Union would eventually accede. With a high threshold, on the other hand, Japan and the USSR would have more leverage, and would likely insist on a weaker treaty.

The theory developed thus far cannot accommodate this kind of flexibility. Collective rationality, as defined in Chapter 7, prevents signatories from diluting their abatement in order to sustain a higher participation level. In Chapter 11, however, I shall weaken the assumption of collective rationality just a little, and show that there can indeed be a trade-off between breadth (in terms of participation) and depth (in terms of the extent of controls). In Chapter 12 I shall explain a different feature of this treaty: why, once the treaty entered into force, more countries would want to accede. This "tipping" effect is not a feature of the analysis developed in Chapter 7.

Richard Benedick also told me later that he was actually recalled to Washington during the Montreal talks, to explain to officials in the Reagan Administration that insistence on the 90 percent threshold would scuttle the treaty. President Reagan insisted that the United States needed the treaty, even if with a lower threshold, and so Benedick returned to Montreal with a more flexible mandate.

As agreed in Montreal, the Protocol would only enter into force after being ratified by at least 11 countries, making up at least two-thirds of global consumption of the controlled substances. This minimum participation clause provided only a mild incentive for participation. As discussed in later chapters, other features of the agreement proved more important to broadening participation. Consistent with the analysis in Chapter 7, however, the Montreal negotiators understood that the agreement might not attract universal participation.

As matters turned out, the Protocol easily crossed the minimum participation threshold, and entered into force on January 1, 1989, the earliest date allowed by the Protocol. At that time, the agreement consisted of 30 parties (including the EC), accounting for 83 percent of global consumption of the listed substances (Parson 1993).

Of course, the theory developed in Chapter 7 predicts that actual participation should exactly equal the minimum participation specified in the treaty. There are a number of reasons why actual participation exceeds the minimum for this treaty, some of which are discussed in later chapters, and one of which is explained below.

8.6. OZONE PAYOFFS

Chapter 7 suggests that the values of the payoffs determine the level of cooperation that can be sustained by a self-enforcing agreement.

The payoffs to the United States of abating ozone-depleting substances (ODSs), as understood around the time of the Montreal negotiations, were outlined in a report prepared by the US Environmental Protection Agency (EPA 1988a; see also EPA 1988b); see Table 8.1. Three scenarios were studied. The No Controls scenario assumed that all countries would do nothing to reduce emissions. The Montreal Protocol scenario assumed that the controls prescribed by the Montreal Protocol would be adopted by 94 percent of developed nations and 65 percent of developing

⁷ As explained in Chapter 15, the Kyoto Protocol adopts a similar approach.

Table 8.1. Predicted implications for the United States of the Montreal Protocol and of a unilateral ozone policy

	No Controls	Montreal Protocol	Unilateral implementation of Montreal by the United States
Ozone depletion (percent)			
By 2000	1.0	0.8	0.9
By 2050	15.7	1.9	10.3
By 2100	50.0	1.2	49.0
Payoffs to the US (billions of 1985 \$US)			
Benefits	—	3,575	1,373
Costs	—	21	21
Net benefits	—	3,554	1,352

Source: EPA (1988a).

nations, with all participating nations achieving 100 percent compliance. The Unilateral implementation scenario assumed that the United States would undertake the Montreal controls unilaterally, and that no other country would do so.

The EPA study concluded that the Montreal Protocol would reduce the extent of ozone depletion from 50 percent under the No Controls scenario to only 1.2 percent under the Montreal Protocol scenario by 2100.⁸ This suggests that the Montreal Protocol offered substantial environmental protection. However, the analysis presented in Chapter 7 suggests that the No Controls scenario is the *wrong* benchmark for evaluating the contribution of this agreement. The appropriate benchmark is the non-cooperative outcome. Countries might have undertaken substantial controls unilaterally (recall that fairly substantial unilateral policies had previously been enacted beginning in the late 1970s).

Table 8.1 also indicates that unilateral action by the United States, assuming no abatement by other countries, would dampen depletion significantly in the short run but have virtually no impact by the year 2100. Thus, while unilateral action by all countries might substantially reduce environmental damage, action by just one country—even one as large as the United States—would have little long-term effect (and, yet, for reasons explained later, would still be worth taking).

A key component of the benefit of ozone layer protection is the value of the illnesses and deaths by cancer that would be avoided. The effect on cancer incidence was determined by dose-response functions relating the change in the incidence of cancer to the predicted change in radiation exposure. The study found that more than 245 million cancers, including more than 5 million cancer deaths, would be avoided by the Montreal Protocol by the year 2165. These are large numbers.

⁸ In fact, the EPA truncates depletion at 50 percent. The model employed by the EPA to evaluate ozone depletion indicated that depletion would exceed 50 percent in the No Controls case.

The Montreal Protocol

How were these avoided cancer cases valued? Non-fatal cancer cases were given a value equal to the cost of treatment. The value of avoided cancer deaths was equated to the "value of a statistical life," estimated by the EPA at \$3 million. This is also a large number, though it is in keeping with values in the literature (see, for example, Viscusi 1998).⁹

Multiplying a large number of avoided cancer deaths by a large value for each death avoided implies a huge benefit to ozone layer protection. The present value benefit from avoided cancer deaths was estimated by the EPA to be in trillions of dollars. By contrast, all the other benefits estimated by the EPA added up to only a few tens of billions of dollars in present value terms. Though one can always fuss about details, the broad story told by the EPA analysis is that the public health effects of ozone depletion were paramount.

The costs of abatement depend on the ease with which non-ODS-using products can be substituted for ODS-using products, other substances and processes can be substituted for ODS in the production of ODS-using products, and the current stock of ODSs can be reclaimed for future use. Costs also depend on the speed of substitution. Rapid substitution, forcing early obsolescence of the capital stock, would be especially costly. Innovation would require costly investments for R&D, but these investments would be justified by the expectation of lowering future substitution costs. Finally, costs would also depend on the policies used to implement the Montreal Protocol. If economic instruments were used instead of standards, for example, costs would likely be lower.

Though estimation of costs and benefits is never easy, it is the big picture that matters, and the story told by the EPA calculations is unusually clear. As Table 8.1 shows, the range of costs, in present value terms, is puny compared to the benefits.¹⁰ Even unilateral implementation of the Montreal controls yields a benefit-cost ratio of 65:1—a figure that would tower over almost every other public investment made by the United States in 1988. The basic economics of ozone policy thus implied that, for the United States—and probably for most industrial countries—the benefit of acceding to the Montreal Protocol exceeded the cost by a wide margin, irrespective of the behavior of other countries.¹¹ Accession was a *dominant strategy* for the industrialized countries.

⁹ Here is how you can think of the value of a statistical life. Suppose ozone depletion would increase the probability of a person getting a fatal cancer, and thus dying prematurely, by 1/10,000. Suppose also that the average person would be willing to pay \$300 to avoid this additional risk. Under certain conditions, the value of this small change in the probability of premature death, \$300, will equal 1/10,000 times the value of life—implying a statistical value of life equal to \$300/(1/10,000), or \$3 million. See Viscusi (1998).

¹⁰ Benedick (1998: 103) notes that the CFC Alliance, an industry association which contended that Montreal was unjustifiably stringent, "initially predicted that costs of implementing the protocol in the United States would be in the range of \$5–10 billion." Though the association later revised their estimate upwards, Table 8.1 shows that the justification for Montreal would be largely insensitive to variations in cost estimates.

¹¹ Using different data, Sprinz and Vahtoranta (1994) conclude that the US interests in reducing ozone-depleting chemicals would be intermediate as compared with other industrialized countries. Note as well that the costs to most other industrialized countries of implementing Montreal should if anything be lower relative to the benefits than shown in Table 8.1. Recall that the United States reduced its consumption and production of CFCs substantially in the late 1970s by banning their use in aerosols. To implement Montreal, the United States would thus have to substitute for CFCs in other uses—primarily in air conditioning and

This may seem a puzzle. After all, the EPA's analysis shows that unilateral action by the United States would have little long-term effect on the ozone layer. So, how could the action be justified? There are two reasons. The first is that unilateral abatement by the United States would have a pronounced effect in the short-to-medium term. As shown in Table 8.1, unilateral implementation by the United States was predicted to cut ozone depletion by a third by 2050. And so long as costs and benefits are discounted, it is the short-to-medium term, not the long term, that matters. The EPA study assumed a discount rate of two percent, implying that a dollar of avoided damage 50 years from now is worth 2.6 times a dollar of avoided damage a hundred years from now in present value terms. The second reason that unilateral action would be justified is simpler. It is that the costs of implementing Montreal were low.

Of course, costs and benefits matter to the theory. But they matter to the real world, too. Estimates of the costs and benefits to the United States of ozone layer protection were instrumental in building support for a treaty within the US administration. According to Benedick (1998: 63):

A major break in the interagency debate came in the form of a cost-benefit study from the President's Council of Economic Advisers. The analysis concluded that, despite the scientific and economic uncertainties, the monetary benefits of preventing future deaths from skin cancer far outweighed costs of CFC controls as estimated either by industry or by EPA. This conclusion, which was based on the most conservative estimates and did not even attempt to quantify other potential benefits of preventing ozone layer depletion dismayed the revisionists [individuals within the administration who opposed negotiation of a strong treaty] and helped sway some administration officials who had been watching the controversy from the sidelines.

To sum up, the economics of ozone depletion favored unilateral implementation of the Montreal Protocol by rich countries. In Olson's (1965) terminology, the industrialized countries were "fully privileged."

8.7. MONTREAL SUCCESS?

This evidence suggests that Montreal may not have been successful after all (a conclusion also reached by Murdoch and Sandler 1996). But the analysis developed so far is incomplete.

After Montreal was negotiated, the costs and benefits of ozone protection changed. They changed partly because *the treaty changed*. The agreement in force today requires deeper, broader, and faster cuts in ozone-destroying chemicals than the agreement negotiated in 1987. Each successive tightening in the treaty would have increased costs more than benefits, lowering the benefit-cost ratio.¹²

refrigeration—and this would be more costly. When Montreal was negotiated, aerosols still accounted for over half of European production. Europe could thus implement Montreal more cheaply, largely by doing what the United States had done ten years before. An implication of this is discussed in the next chapter.

¹² I am implicitly assuming here that benefits and costs are non-linear, contrary to the assumptions of Chapter 7. Little is known about the shape of the ozone depletion damage function, though it is perhaps likely that the marginal benefit would fall—atmospheric models suggest that successive increases in abatement

The costs and benefits also changed because of learning over time. As explained later, for any given level of control, costs fell and benefits increased compared with earlier expectations. Moreover, while the EPA analysis assumes that abatement costs for the United States are independent of the actions undertaken by other countries (note how the cost estimates for the United States shown in Table 8.1 do not depend on whether other countries undertake the same controls), it is likely that each country's control costs would fall as other countries reduced their emissions. As explained in Chapter 9, this kind of interdependence makes cooperation even easier.

Two other features of the problem, however, were sure to frustrate cooperation. First, the parties worried that, as the Montreal Protocol controls came to bind on them, production of ozone-destroying chemicals might shift to non-parties—a phenomenon known as "trade leakage." In the limit, if leakage were severe enough, Montreal might only redistribute production, and thus have little environmental benefit even in the short-to-medium term. Substantial leakage would similarly render unilateralism impotent. This interdependence in trade was ignored by the EPA's cost-benefit calculations, but it was a real concern to the Montreal negotiators. One of the principal tasks of the agreement was to plug this potential trade leak—a subject I discuss in detail in Chapter 12.

Second, the agreement needed also to create incentives for developing countries with a less fortunate benefit-cost ratio to undertake abatement for the global good. Though the United States had a strong unilateral incentive to implement Montreal whether or not other countries did so (ignoring the leakage problem), it also had a strong incentive to ensure that other countries undertook the same controls. In the long run, remember, the EPA study showed that unilateral abatement by the United States would achieve little (and this without even allowing for leakage). Montreal would succeed in a meaningful sense only if developing countries also participated. Providing them with the needed incentive was another great challenge to the Montreal negotiators. I discuss it in Chapter 13.

8.8. KNOWLEDGE VS AUTHORITY

Are payoffs really this important to international cooperation? It is hard to know for sure, because of the usual counterfactual problem. And I would certainly agree that payoffs, representing state interests, are only part of the explanation for international cooperation successes and failures. But they are an essential part of the story, and any theory of cooperation that suppresses their importance is likely to mislead rather than inform.

Let me illustrate this point by contrasting the theory developed here with one that sees state behavior as being influenced by a cadre of scientific experts, an "epistemic

would bring about smaller increments in avoided ozone depletion; see EPA (1988a), exhibit 6-5. Marginal costs would very likely increase, as harder-to-substitute-for chemicals, or chemicals with a lower ozone-depleting potential were phased out. In Barrett (1994a), I show that, if the marginal benefit of abatement relation is steep, and if the marginal cost of abatement function is relatively flat, then a treaty will be signed by a large number of countries, but such a treaty will improve little on non-cooperation.

community" invested with the authority to impel "the national governments in which it is strongly entrenched to adopt convergent pollution control policies and support rigorous efforts at coordinated pollution control" (Haas 1990: 64-5).

Science certainly underpinned the measures negotiated in Montreal; and scientists were deeply involved in the Montreal process. But this is to be expected by the theory developed in this book. An understanding of the science is essential to defining, measuring, and evaluating payoffs. Political scientist Peter Haas, however, claims a much greater role for the epistemic community. He claims that it "substantially determined the outcome of the ozone negotiations" (Haas 1992: 189), and that it did so "through a combination of strategies ranging from persuasion of individuals and groups to the capture of various decision-making channels" (Haas 1992: 224). Rather than help to articulate a nation's interests, the epistemic community imposed its own. To Haas (1992: 188), the signing of the Montreal Protocol "ran contrary to US domestic particularistic interests, which oppose regulation, and also differed from a contemporary assessment of the aggregate national interest."

Richard Benedick's recollection of the negotiations is different. Far from directing the negotiations, Benedick says that scientists needed to be "drawn out of their laboratories and into the negotiation process;" far from steering the negotiations, scientists were made "to assume an unaccustomed and occasionally uncomfortable shared responsibility for the policy implications of their findings" (Benedick 1998: 5).

The claim that the United States signed the Montreal Protocol even though it harmed its national interest is also contradicted by Haas's own description of the situation:

The Office of Management and Budget (OMB), under the auspices of the Domestic Policy Council, convened a series of technical briefings from February through May 1987, concurrent with the international negotiations. Most of the scientific summaries were presented by epistemic community members who had briefed [Lee] Thomas, the EPA administrator, a year earlier. The OMB economists were swayed by the cost-benefit analysis presented by the President's Council of Economic Advisers (CEA), an analysis that was based on conservative economic estimates of human health effects from ozone depletion, was drawn from the EPA's extensive 1986 risk assessment study, and concluded that stringent regulations to prevent depletion of the ozone layer would be highly cost-effective. In preparing their analysis, the CEA members had included none of the ethical and ecological considerations that had encouraged the epistemic community to support stringent controls. Nevertheless, their findings based on economic considerations supported the community's position. In any case, the CEA members had been impressed and persuaded by the thoroughness of the epidemiological presentations during the policy review, and their reputation for economic professionalism helped overcome the Reagan administration's aversion to regulation. (Haas 1992: 219.)

Haas's reading of this situation is that the national interest—as reflected in the payoffs to the United States—supported the epistemic community's position, and that it was the community's authority rather than the economics that influenced the Reagan administration's decision to support the Montreal Protocol. Plainly, however, the facts, even as Haas presents them, are open to a different interpretation.

8.9. ACTIONS vs OUTCOMES

The analysis presented in Chapter 7 assumes that cause and effect is known, and known with certainty. And yet uncertainties about the relationships underlying payoffs often loom large. In the case of the Montreal Protocol, uncertainty pervades every link in the chain of knowledge needed to calculate payoffs—the relationship between emissions and chlorine loadings, between loadings and depletion, between depletion and skin cancers, and between skin cancers and welfare.

Do these uncertainties matter? In an important essay, economist Richard Cooper (1989: 181) concludes that they matter a great deal: "international consensus about practical knowledge, along with shared objectives, is a necessary condition for close international cooperation." Moreover, Cooper argues, uncertainties about actions and outcomes interact with costs and benefits: "So long as costs are positive and benefits are uncertain, countries are not likely to cooperate systematically with one another; and so long as sharply differing views are held on the relationship between actions and outcomes, at least some parties will question the benefits alleged to flow from any proposed course of action."

Uncertainties about the effects of actions on outcomes plainly matter. But Cooper's casting of the problem may be overly stark. The costs of implementing the Montreal controls, though small, were positive; and the benefits, though potentially large, were uncertain, as Richard Benedick has recently reminded us:

We seem to have forgotten that [the case for the Montreal Protocol] was completely theoretical. Measurements did not in fact record any thinning of the ozone layer (except over Antarctica, a seasonal occurrence which scientists at the time considered a special case, and for which there were numerous theories). There was, moreover, no evidence that CFCs were responsible. Finally, there was no sign of increased ultraviolet radiation actually reaching the Earth. (Benedick 1997.)

A lesson of Montreal is that cooperation can be sustained even when there is uncertainty about the effects of actions on outcomes. More important, perhaps, is a favorable benefit-cost ratio (this you will recall is an implication of the analysis in Chapter 7). Indeed, Cooper's analysis of the reasons for the success of the smallpox eradication campaign is consistent with this view.

Smallpox, a highly infectious and lethal disease which is estimated to have killed more people than plague, cholera, and war put together, was eradicated in 1977 by an international program of vaccination, surveillance, and quarantine coordinated by the World Health Organization (WHO). The demise of this deadly disease was certainly helped by scientific knowledge, particularly about such things as the effectiveness of the vaccine, the absence of a non-human host, and the immunity afforded by previous infection. But the economics of eradication also made it attractive for countries to cooperate:

A major incentive for a smallpox eradication program was that the estimated costs of eradication could be more than recouped by savings on vaccination and quarantines against its spread. The total cost of the smallpox eradication program to WHO and other international donors came to \$112 million, plus perhaps an additional \$200 million spent by the national

governments of the countries in which smallpox was still found. WHO estimates that this \$312 million one-time expenditure saved at least \$1 billion a year in terms of vaccination programs, care of infected persons, and quarantine if smallpox existed on the scale it did in the late 1960s. Thus eradication of smallpox was not only an international public good in terms of the alleviation of suffering but it also offered a handsome return on investment by reducing precautionary expenditures worldwide. (Cooper 1989: 235.)

The eradication of smallpox stands alongside the Montreal Protocol as one of the great achievements of international cooperation. It was not just a consensus on the science that facilitated cooperation in these instances. An auspicious economic calculus helped, too. This is the central message of the theory developed so far.

8.10. LONDON NEGOTIATIONS

Shortly after the Montreal Protocol was signed, the science and economics of ozone protection took a dramatic turn. In 1988, the *Ozone Trends Panel*—a US-led research group involving more than 100 scientists from 10 countries—issued a comprehensive report concluding that the link between CFCs and ozone depletion was all but certain. The Panel also reported that the ozone layer over North America, Europe, the Soviet Union, China, and Japan had already been depleted by up to three percent (in the winter by as much as six percent). This was more than the models used to justify the Montreal controls predicted. The implication: Montreal needed to be renegotiated.

Only days after the Panel's report was released came more startling news: Du Pont, the world's largest producer of CFCs, announced that it intended to cease making these chemicals altogether (later Du Pont firm up its pledge by announcing that it would phase out production by 2000). The company warned, however, that international cooperation was essential, and that participation in an agreement to phase out CFCs needed to be as broad as possible, to avoid production by other manufacturers relocating to non-signatory states (leakage).¹³

In 1989, the assessment panels set up by Montreal reported their findings. Chief among these was that, even if CFCs were phased out, the ozone layer would continue to be depleted by increased chlorine loading from carbon tetrachloride and methyl chloroform. Another problem was growth in the production of hydrochlorofluorocarbons (HCFCs), a substitute for CFCs. HCFCs were only less damaging to the ozone layer than the substances they replaced, and the new studies showed that HCFCs would also need to be phased out if chlorine concentrations were ever to return to their "natural levels." Even then, recovery of the ozone layer would take many decades because of the huge stock of long-lived CFCs already accumulated in the atmosphere.

¹³ As explained in Chapter 9, this announcement may have been in Du Pont's self-interest. If the announcement made intervention by the US government more likely—and it probably did have this effect (and, moreover, could have been foreseen to have had this effect)—then Du Pont would have suffered losses in the CFC market. But a government-enforced CFC-ban would at the same time have created a market for CFC substitutes, and Du Pont was ahead of its rivals in substitute R&D, partly because of its reaction to the

Substitution away from CFCs proved easier and less costly than expected, partly because of dramatic advances in the development of alternatives. As the Panel for Technical Assessment reported to the first meeting of the parties to the Montreal Protocol in Helsinki in May 1989, by this time it was possible to phase out a number of ODSs by the end of the century. In February 1990, the US President's Council of Economic Advisers (1990: 210) topped even this announcement, reporting that a phase-out was not only feasible but cheap: "Preliminary estimates place the US costs of a phase-out of CFCs and halons by 2000 at \$2.7 billion over the next decade if the schedule of intermediate reductions currently incorporated in the Montreal Protocol is maintained." (Note that the Council's estimate is many times smaller than the earlier estimate of the cost of meeting the much weaker Montreal target shown in Table 8.1.) The economic assessment panel set up by the Montreal process confirmed that the impression given by the EPA study applied more broadly: "the monetary value of the benefits of safeguarding the ozone layer," the report concluded, "is undoubtedly much greater than the costs of CFC and halon reductions" (see Benedict 1998: 133).

State behavior reflected this favorable economic calculus. By 1990, the 20 percent reduction in CFC use required by the Montreal Protocol for 1993 had already been met by "virtually all industrialized countries" (Benedick 1998: 172); and, though actions speak louder than words, eight industrial countries announced that they would reduce their use of CFCs unilaterally by much more than required by Montreal. The Montreal constraint did not seem to be biting on national policymaking. Rather, it seemed that cooperation needed to catch up to the accomplishments of unilateralism.

At the second meeting of the parties, held in London in June 1990, the Montreal Protocol was adjusted and amended. The adjustments accelerated and tightened the reduction schedules for the ODSs controlled by the Montreal Protocol, and would be binding on all the Montreal parties after entering into force in March 1991. The amendment increased the number of controlled substances from eight in the original treaty to twenty, including the original five CFCs and three halons, ten additional CFCs, methyl chloroform, and carbon tetrachloride. HCFCs were not controlled by the amendment, but a non-binding resolution was passed to indicate that these "transitional substances" should be phased out by 2020 if possible and by 2040 at the latest.¹⁴ The amendment would enter into force after being ratified by at least 20 countries.

By the start of the London negotiations, 65 countries had signed the Montreal agreement. Importantly, more than 40 non-parties also attended the London meetings.

unilateral controls adopted previously by the United States. Through this chain of reactions, Du Pont may thus have gained financially from its phase-down; see Barrett (1992b). Du Pont may also have been motivated by a concern about losses—especially litigation in the event that a link between CFCs and skin cancers was proved (just think of the law suits filed against cigarette manufacturers). Officially, however, the company has maintained that its decision was based purely on the science, and this was confirmed to me in a private conversation with a former Du Pont executive closely involved in the decision.

¹⁴ HCFCs were an important substitute for CFCs. If HCFCs were phased out too quickly, industry would have little incentive to invest in the equipment to produce and use them, and the cost of phasing out CFCs would therefore increase. A consequence could be an increase in the use of CFCs, especially by developing countries.

A major ambition in London was to increase participation, with the industrial country parties offering to pay developing countries for the "incremental costs" of complying with the agreement. The London Amendments came into force on August 10, 1992, by which time important developing countries like China and India had already acceded to the agreement. This was the greatest achievement of the London negotiations. It is the subject of a detailed assessment in Chapter 13.

8.11. COPENHAGEN NEGOTIATIONS

Even this amendment seemed insufficient not long after the diplomats had returned home from London. For the first time, significant increases in harmful UV-B radiation were recorded in Europe and Australia. More importantly, ozone loss was detected in the summer months—when more people are exposed to UV-B—over North America, Europe, Asia, South America, Australia, New Zealand, and the South Pacific. The EPA had now revised its earlier calculations, doubling its estimate of the number of US deaths from skin cancer by 2050 to 200,000. A World Meteorological Organization (WMO) and UNEP assessment published in 1991 predicted that a sustained 10 percent depletion would increase the number of non-melanoma skin cancers by 300,000 and the number of cataracts by almost 1.75 million each year.

Meanwhile, the costs of phasing out the listed chemicals continued to drop. For example, and "contrary to original expectations, demand for CFC-113 and [methyl chloroform] ... plummeted as electronics and aerospace companies developed an impressive variety of new 'no-clean' technologies and substitute solvents" (Benedick 1998: 201).

Reductions in costs were helped by the design of the agreement. Montreal did not limit the use of CFCs *per se*. It limited the production and consumption (defined as production plus imports minus exports) of these chemicals. It thus created a scarcity value for the existing stock of CFCs, and so provided incentives for their collection for subsequent re-use. This avoided the need to substitute prematurely for the existing stock of CFC-using capital and posed no additional risk to the environment—only released CFCs damaged the environment.

Measures adopted unilaterally continued to advance ahead of the adjusted Montreal controls and the London Amendment. A number of European countries brought forward the dates at which CFCs, halons, and other listed substances were to be banned. Du Pont announced that it would stop making CFCs by 1996, four years ahead of its earlier phase-down date. The US Senate passed a non-binding resolution supporting a quicker phase-out of CFCs by a 96–0 majority.

The Montreal Protocol was again renegotiated—this time at the fourth meeting of the parties, held in Copenhagen in November 1992. This time the dates by which the agreed phase-out of previously listed substances was to be completed were shortened in a further adjustment (CFCs were now to be phased out by 1996), and the number of substances controlled by the agreement was increased from twenty (under the London Amendments) to ninety-four by a new amendment. Importantly, these newly listed substances included the controversial HCFCs. Use of these was to be capped and

subsequently phased out by 2030. By the time of the Copenhagen meeting, ninety-four countries had signed the Montreal Protocol. The Copenhagen Amendments entered into force on June 14, 1994.

8.12. RETURN TO VIENNA AND MONTREAL

Further adjustments to the Montreal phase-out schedules were made in Vienna in 1995, and a new amendment was negotiated, to include a scheduled phase-out for methyl bromide—a pesticide and fumigant, the only significant ozone-depleting chemical not yet regulated by the treaty. In a later renegotiation, held on the tenth anniversary of the Protocol once again in Montreal, the phase-out was brought forward to 2005. But by this time there was not much more that could be done to protect the ozone layer. Ozone depletion was expected to worsen through 2000, when the process of repair was predicted to begin, but this delay was caused largely by accumulation of CFCs emitted years before Montreal.

Instead, the negotiations entered a new phase. Concern among parties shifted from target-setting to effective implementation—how to increase participation, limit the growth in emissions by developing countries (as allowed by the original agreement), promote compliance, and control the emerging black market trade in CFCs. These issues are taken up in later chapters.

To prepare for the tenth anniversary meeting of the parties, Environment Canada commissioned a study titled *Global Benefits and Costs of the Montreal Protocol*. The results of the assessment are shown in Table 8.2. Benefits represent the damages avoided by eliminating ODSs. Costs reflect the full costs of implementing the phase-outs. As in the EPA study, no attempt was made to estimate what countries would have done had the agreement not been negotiated, entered into force, and implemented. Hence, these estimates reflect the net benefits of the phase-out schedules, not the net benefits of the agreement itself. In this sense, the title of the report is misleading.

Still, the results of the study are striking—and broadly compatible with the earlier EPA report. Costs are much higher, but of course the estimates shown in Table 8.2 are

Table 8.2. *Global benefits and costs of the Montreal Protocol phase-out, 1987–2060*

Health benefits	
Avoided cases of non-melanoma skin cancer	19,100,000
Avoided cases of melanoma skin cancer	1,500,000
Avoided cases of cataracts	129,100,000
Avoided skin cancer deaths	333,500
Monetized benefits	
Costs	\$459 billion
Net benefits	\$224 billion + non-monetized health benefits

for the entire world, not just the United States. They also reflect not only the original 1987 agreement but the subsequent amendments and adjustments. The monetary estimate of benefits is lower, but this excludes the human health benefits of ozone protection—the main component of the benefit figure shown in Table 8.1. The monetized benefit estimate in Table 8.2 is only for the avoided damages to fisheries, agriculture, and materials. The predicted number of avoided cancer cases is substantially lower compared with the earlier US study, but the time frame for this latest study is also a century shorter. It is remarkable that the Montreal phase-outs can be shown to be a good deal for the world, even when the principal benefit of the agreement and all the very long-term benefits are uncounted.

Figure 8.1 shows projections of the contributions of the different agreements in terms of stratospheric abundances. Once again, the "No Protocol" scenario presumes a kind of business-as-usual world, one that disregards the incentives for unilateral action to reduce loadings. So we cannot tell from the figure what Montreal and its amendments really will achieve. At the same time, the figure does indicate that the actions demanded by Montreal and its amendments (especially London and Copenhagen) will reduce abundances very substantially.

Figure 8.1 also shows that the later amendments mattered less than the first two. And yet the process of tightening the grip on ODSs continues. The last amendment, negotiated in Beijing in 1999, even imposes a new restriction, a phase-out of

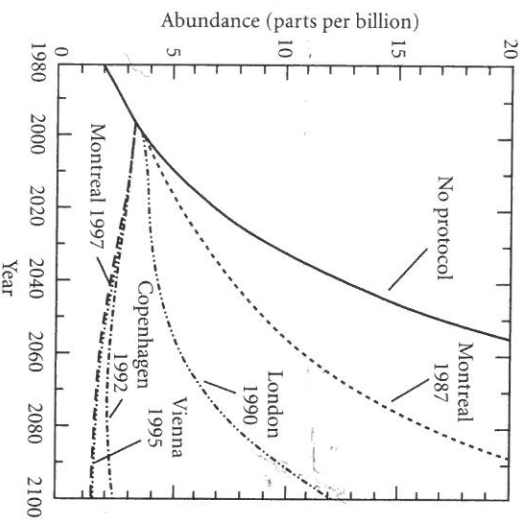


Figure 8.1. Effects of international agreements on the abundance of ozone-depleting stratospheric chlorine/bromine

Source: World Meteorological Organization (1998).

bromochloromethane. The new treaty thus increases the number of controlled substances to ninety-five.

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8.13. CONCLUSIONS

As of this writing, participation in the Montreal Protocol is virtually full. Non-participants to this treaty include Afghanistan, Andorra, Bhutan, Eritrea, Guinea-Bissau, Iraq, and San Marino. These countries are either tiny or lacking an effective government or reluctant to engage in international affairs; one is an international outcast. In the short time between finishing the first draft of this book and making minor revisions, the number of parties increased from 175 (the number included in the table in Chapter 6) to 183. The countries acceding in this period of a few months include Cambodia, Cape Verde, Nauru, Palau, Rwanda, Sao Tome and Principe, Sierra Leone, and Somalia. That even countries like these should accede to this agreement speaks to its great success. Participation in the related amendments is lower, but also increasing.

No other international agreement demands so much from so many parties as the Montreal Protocol and its related amendments, and we are already reaping the benefits. The abundance of ozone-depleting compounds in the atmosphere peaked in 1994 and is now declining.¹⁵ The rate of decline in stratospheric ozone at mid-latitudes has slowed. The maximum extent of ozone depletion is expected to be realized in the next decade or so; and thereafter the ozone layer is expected to recover. By around 2050, the stratospheric concentration of ozone is expected to have returned to its "natural" (pre-1980) level.

I have heard environmentalists protest that the Montreal agreements do not go far enough. But even ignoring the Beijing controls, a complete and immediate global elimination of all emissions of ODSs would result in the stratospheric halogen loading returning to the pre-1980 values by the year 2033. Hence, Montreal gets us to the best-of-all feasible end states, though the journey takes 17 years longer than absolutely necessary. Even leaving aside the obvious point that an even faster phase-down would be costly and perhaps offer little in the way of added benefit, the achievements of the Montreal controls are truly outstanding. It may be correct to say that the glass is a few drops empty, but that should not blind us from seeing that it is almost completely full. In a world of mainly empty glasses, Montreal is an exception.

So *The Economist* newspaper was right to call the Montreal Protocol "a remarkable treaty" (Cairncross 1992). But we should be clear in understanding the sense in which the agreement is remarkable. The economics of ozone policy played a central role in shaping the course of negotiations, and a comparison of the benefits and costs of abatement would have commended substantial abatement by the industrialized countries even if an agreement had not been reached. The truly great achievement of this agreement was that it built even more cooperation upon this privileged edifice. The story of how it did this is told in the chapters that follow.

¹⁵ The information found in this paragraph comes from the World Meteorological Organization (1998).

POLLUTION



Miscellaneous No. 1 (1998)

Montreal Protocol

on

Substances that Deplete the Ozone Layer

Montreal, 16 September 1987

[The Protocol has not been ratified by the United Kingdom]

*Presented to Parliament
by the Secretary of State for Foreign and Commonwealth Affairs
by Command of Her Majesty
January 1988*

LONDON

HER MAJESTY'S STATIONERY OFFICE

APPENDIX 8.1 MONTREAL PROTOCOL ON SUBSTANCES THAT DEplete THE OZONE LAYER

The Parties to this Protocol,

Being Parties to the Vienna Convention for the Protection of the Ozone Layer,
Mindful of their obligation under that Convention to take appropriate
measures to protect human health and the environment against adverse effects
resulting or likely to result from human activities which modify or are likely to
modify the ozone layer,

Recognizing that world-wide emissions of certain substances can significantly
deplete and otherwise modify the ozone layer in a manner that is likely to result in
adverse effects on human health and the environment,

Conscious of the potential climatic effects of emissions of these substances,
Aware that measures taken to protect the ozone layer from depletion should be
based on relevant scientific knowledge, taking into account technical and economic
considerations,

Determined to protect the ozone layer by taking precautionary measures to
control equitably total global emissions of substances that deplete it, with the
ultimate objective of their elimination on the basis of developments in scientific
knowledge, taking into account technical and economic considerations,

Acknowledging that special provision is required to meet the needs of
developing countries for these substances,

Noting the precautionary measures for controlling emissions of certain
chlorofluorocarbons that have already been taken at national and regional levels,

Considering the importance of promoting international co-operation in the
research and development of science and technology relating to the control and
reduction of emissions of substances that deplete the ozone layer, bearing in mind in
particular the needs of developing countries,

Have agreed as follows:

ARTICLE 1

Definitions

For the purposes of this Protocol:

1. "Convention" means the Vienna Convention for the Protection of the Ozone Layer, adopted on 22 March 1985¹.

¹ Miscellaneous No. 13 (1985), Cmd. 9652.