The 'successful' ozone-layer negotiations

Are there any lessons to be learned?

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It is important to distinguish between a problem and the problem-solving capacity invested in its solution. Applying this perspective to the global ozone cooperation process it is shown that evolving knowledge about ecological, technological and economic aspects of the ozone problem revealed that actors faced a quite 'benign' political problem. While the ozone-layer negotiations constitute a valuable example of international cooperation, ignoring problem characteristics may result in misleading conclusions about the applicability of any lessons learned.

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[1]David L. Feldman, *Managing Global Climate Change Through International Cooperation: Lessons From Prior Resource Management Efforts*, Global Environmental Studies Center, Oak Ridge National Laboratory, Oak Ridge, TN, July 1990, p 37.
[2]See Richard E. Benedick. *Ozone diplomacy – New Directions in Safeguarding*
continued on page 293

It is frequently claimed that depletion of the ozone layer parallels other global environmental issues, such as anthropogenic global warming.[1] Hence, the 'successful' ozone negotiations are viewed as a model for coping with other global problems. Some of the most widely cited contributors have emphasized, among other factors, the role of skilful diplomacy and creative bargaining, transnational knowledge-based networks of influential people, political power, and the role of the United Nations Environment Programme (UNEP) as an effective coordinator.[2] Embedded in these approaches and conclusions is, it seems, the notion that ozone cooperation has been a success largely because of the problem-solving capacity invested in the negotiation process.

Our alternative proposition is that the ozone reduction decisions made in 1987 and 1990 became feasible largely because science revealed a problem that was increasingly 'benign' in political terms. The extent to which skilful bargaining in the crafting of effective institutions, and political and scientific consensus, can have a significant effect on substantive problem-solving, will depend heavily on the malignancy of the problem. The aim of this article is to demonstrate the importance of analysing problem characteristics carefully. However, let us start this discussion by introducing an analytical framework for understanding environmental cooperative 'successes' and 'failures'.

Problem types and problem-solving capacity[3]

To cope with great international challenges like global warming and loss of biodiversity, we must be able to learn why some resource and environmental cooperative efforts 'succeed', while others 'fail'. Two main explanations are examined here.

First, the degree of success will probably vary with differences in types of problem. Some problems are harder to deal with than others, particularly due to differences in 'intellectual' and 'political' characteris-

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tics. Intellectual characteristics may influence the actors' ability to identify their interests, and develop adequate solutions. This ability will first and foremost depend on the degree of scientific certainty and consensus about ecological, technical and economic aspects of the problem. Political characteristics may influence the actors' ability to reach an adequate solution. Such characteristics are mainly types of collective goods and the type of interdependence mechanism at work. For instance, it is not possible for states to distribute 'clean air' in the same way that they have shared mineral and fishery resources. The air is non-exclusive: no state can be excluded from either consumption, or externalities caused by other states. International conflicts over global air pollution will therefore more often arise because of the skewed distribution of 'pollution export' and abatement costs, than because of the allocation of the resource itself. Some of these 'non-exclusive' problems are characterized by 'benign' cost–efficiency relationships which are expected to generate identical or compatible state preferences. Such problems may be solved by perfect information and coordination. Other problems are 'malign' in the sense that they generate different incentives, due to asymmetry in affectedness by the problem and/or asymmetry in abatement costs which may influence international competitiveness. These problems are expected to generate incompatible preferences and call for 'incentive correction' in order to be solved. However, 'pure' empirical examples of benign and malign problems may be hard to find. Thus, in the real world the malignancy of problems is a matter of degree.

Secondly, it is reasonable to assume that degree of success will be influenced by the problem-solving capacity related to the problem. Some efforts may be more successful than others because more powerful institutional tools are being used. Given that production of knowledge is important to the identification of solutions to all environmental problems, the functioning of the scientific/technological complex will play a crucial role. In addition, some problems may be approached with greater skill and/or energy. In this context, leadership may be critical in establishing scientific and political consensus.

While bearing in mind that the 'problem type' and the 'problem-solving capacity' approaches are complementary rather than competing, this article stresses the importance of distinguishing between them to enable relevant lessons to be transferred from one global problem-solving effort to another.

What was achieved in Vienna, Montreal and London?

Depletion of the ozone layer as a potential environmental problem first made its appearance on the international agenda at the UN Conference on the Human Environment in Stockholm 1972.[4] In 1974, US chemists discovered that chlorofluorocarbons (CFCs) could destroy the ozone layer.[5] CFCs are a family of chemical compounds containing chlorine, fluorine and carbon. They are widely used in refrigeration, air-conditioning, as blowing agents, aerosol propellants and in solvents for cleaning electronic parts.

In 1981, UNEP formed a working group to draft a global framework convention for the protection of the ozone layer. Four years later, the Vienna Convention on the protection of the ozone layer was signed by 20 countries, as well as by the European Community (EC) Commission.

Our Planet, Harvard University Press, Cambridge, MA, 1991. Benedick relates the outcomes largely to skilful diplomacy and creative bargaining. Peter M. Haas has focused on the key role of 'epistemic communities', or transnational knowledge-based networks, but at the same time emphasized the need for a multivaried explanation of the ozone case, that also includes technological opportunities and political power. See the following contributions: 'Ozone alone, no CFCs: Ecological epistemic communities and the protection of stratospheric ozone', paper presented at Conference on Knowledge, Interests and International Policy Coordination, Wellesley College, 17–19 February 1990: 'Policy responses to stratospheric ozone depletion', *Global Environmental Change*, June 1991, pp 224–234; 'Banning chlorofluorocarbons: Epistemic community efforts to protect stratospheric ozone', *International Organization*, Vol 46, No 2, January 1992, pp 187–224. Lessons from the ozone negotiations which are more directly applied on the global warming issue can be found in the World Resources Institute publication, *Greenhouse Warming: Negotiating a Global Regime*, World Resources Institute, Washington, DC, 1991.

[3]This section is based on a research project conducted by the Fridtjof Nansen Institute, the University of Oslo and the Institute of Marine Studies, University of Washington. For a more detailed outline of the analytical framework, see E. Miles, S. Andresen, J. Wettestad, B. Fløistad and A. Underdal, *A Research Prospectus: Science, Technology and International Collaboration – Conditions for Effective Global and Regional Action Concerning the Problem of Global Climate Change*, 5th revision, September 1989, Seattle and Oslo; Arild Underdal, 'International cooperation: Transforming needs into deeds', *Journal of Peace Research*, Vol 24, No 2, 1987, pp 167–183; Arild Underdal, *Negotiating Effective Solutions: The Art and Science of 'Political Engineering'*, first draft, Department of Political Science, University of Oslo, January 1990; Jørgen Wettestad and Steinar Andresen, *The Effectiveness of International Resource Cooperation: Some Preliminary Findings*, R:007 – 1991, The Fridtjof Nansen Institute, Lysaker, 1991.

[4]At preparatory meetings for the Stockholm Environment Conference in 1971, initial discussions concerning supersonic transports and fertilizers dangerous to the ozone layer took place. However, these discussions were not motivated by CFCs (Feldman, *op cit*, Ref 1, p 39.

[5]Mario Molina and Sherwood Rowland at the University of California discovered theoretically that CFCs did not break down in the lower atmosphere, but migrated slowly up to the stratosphere. There, the CFCs would react with, and break down ozone molecules and consequently deplete the ozone layer which filters ultraviolet lightwaves (UV-B).

The Vienna Convention was a typical framework convention which did not include any specific controls but emphasized the need for information exchange and further studies through more systematic research and monitoring.

In 1987, 24 countries and the EC Commission agreed on the Montreal Protocol which specified a 50% reduction of CFCs and halons.[6] The Protocol entered into force in January 1989, and the parties declared at their first official meeting in May their intention of phasing out CFCs and halons by the year 2000. On 29 June 1990, 58 parties to the Montreal Protocol, accounting for over 90% of estimated world production and consumption, met in London and adopted this amendment which substantially revised and expanded the Protocol.[7] Since then, many countries have decided on an earlier phase-out.[8] At the third official meeting in Nairobi, Kenya in 1991, the parties asked the assessment panels to study an earlier phase-out to be adopted at the fourth meeting scheduled for autumn 1992 in Denmark.

Thus, within the first regime ever designed for coping with a truly global ecological problem, the parties decided to have the problem eliminated 16 years after the first hypothesis on the depletion of the ozone layer was presented. It is too early to assess the impact of these decisions and it is uncertain to what extent they will be sufficient to protect humans and the environment against adverse effects from increased ultraviolet radiation (UV-B). Nevertheless, it seems safe to conclude that international cooperation to reduce the problem of stratospheric ozone depletion has so far been a political success.

Looking through 'the veil of uncertainty'[9]

It is difficult to identify and develop adequate solutions for complex environmental problems because of ecological, technological and economic uncertainties. Reducing these uncertainties will in most cases be a necessary precondition for effective problem-solving. Knowledge about alternatives, and the causes and effects of the problem is crucial for the actors' ability to identify and develop effective solutions. Increased knowledge about the distribution of costs and benefits may on the other hand actually hamper the political feasibility of reaching solutions by revealing 'winners' and 'losers'. However, in the ozone cooperation process this did not happen. This section seeks to show how evolving scientific knowledge revealed that most actors would gain, and no actors would lose, from phasing out ozone-depleting substances.

Intellectual problem characteristics

Reduction of scientific uncertainty. The 1974 findings were described as 'an economic as well as an environmental bombshell', and the scientific community reacted almost immediately.[10] Extensive research programmes were launched at national and international levels. Comprehensive national assessment reports were conducted, most notably in the USA. International summary reports were written by UNEP's Coordinating Committee on the Ozone Layer (CCOL), the EC Commission, the Organization for Economic Cooperation and Development (OECD). In addition, comprehensive international reports were issued by the World Meteorological Organization (WMO).[11] However, the science was all but stable. Model projections of global-average ozone depletion 50–100 years in the future varied between 3% and 15% from 1974 to 1985.[12]

[6]According to Article 2, the Protocol divides ozone-depleting substances into the most threatening 'Group I' substances (fully halogenated CFCs 11, 12, 113, 114, 115) and the less threatening 'Group II' substances (halons). Production and consumption of these substances is to be cut by 50% of the 1986 level by 1999 for developed countries. According to Article 5, developing countries are subject to the same restrictions, but with a ten-year delay in implementation.

[7]In addition to a stepwise phase-out of the substances regulated in the Montreal Protocol, ten new CFCs were included in Group I, and two new groups of substances were included: carbon tetrachloride (CT) and methyl chloroform (MC). Furthermore, 34 hydrochlorofluorocarbons (HCFCs) were included as 'transitional substances', which implied that they would be subject to future control and should be used with discretion.

[8]For instance, Australia, Austria, Belgium, Canada, Germany, Liechtenstein, the Netherlands, New Zealand, Switzerland and the Nordic countries have declared a phase-out no later than 1997. At the European Community's Council of Environment Ministers' meeting on 20–21 December 1990, the ministers agreed to ban the use of CFCs by June 1997 and to cut production of CFCs by 85% by 1995.

[9]This concept was developed by James Buchanan. The point is that an individual who faces a choice of alternatives due to increased rules becomes more uncertain about the effects of alternatives on his or her own position. This uncertainty may actually facilitate efforts to reach agreement (see Oran R. Young, 'The politics of international regime formation: Managing natural resources and the environment', *International Organization*, Vol 43, No 3, Summer 1988, pp 361–362). However, it is argued that to what extent uncertainty actually facilitates agreement depends on what actors actually see behind 'the veil of uncertainty', especially concerning the distribution of costs and benefits.

[10]Benedick, *op cit*, Ref 2, p 11.

[11]For a short review of ozone assessment activities, see, for example, *Atmospheric Ozone 1985: Assessment of Our Understanding of the Processes Controlling its Present Distribution and Change*, World Meteorological Organization, Geneva, Global Ozone Research and Monitoring Project, Report No 16, Vol I, pp 4–5.

[12]Jessica T. Mathews, in *Greenhouse Warming: Negotiating a Global Regime*, World Resources Institute, Washington, DC, 1991, p 4.

An important reason for the fluctuating predictions was that efforts to reduce environmental uncertainty took place at the frontiers of science. The ozone problem was extremely complex and not well understood even by chemists and atmospheric scientists. Research was based on computer models simulating future reactions and on satellite and rocket-based monitoring or remote gases measured in parts per trillion.[13] Due to lack of empirical proof, high uncertainty also persisted until 1985. Measurements of ozone had gone on for about thirty years but had not yet demonstrated any statistically significant loss of total ozone.

In late 1984, a major international programme of WMO and the US National Aeronautic and Space Administration (NASA) was launched and 150 scientists agreed to cooperate in order to 'provide governments around the world with the best scientific information currently available on whether human activities represent a substantial threat to the ozone layer'.[14]

Two months after the adoption of the Vienna Convention in 1985, Joe Farman and his research team from the British Antarctic Survey published a scientific paper in *Nature* on the discovery of what would become known as the Antarctic ozone 'hole'. Even though it was far from clear that CFCs were involved and competitive theories were put forth to explain the ozone loss, this discovery represented the first empirical indication that something was wrong with the ozone layer.[15]

Just after Farman published his findings, the WMO/NASA programme published its results. In addition, UNEP and the US Environmental Protection Agency (EPA) published a four-volume report on the *Effects of Changes in Stratospheric Ozone and Global Climate.*[16] While these reports stressed that uncertainty remained, they represented an international scientific consensus which indicated that the problem was real, and that adverse effects on humans and the environment could be expected if preventive action were not taken.

In March 1988, a report from the Ozone Trends Panel, including 100 scientists from 10 countries, was released. This included results from recent Antarctic expeditions and concluded that the evidence 'strongly indicates that man-made chlorine compounds are primarily responsible for the observed decrease in ozone'.[17]

According to the Montreal Protocol, a revision was scheduled in light of new scientific results. Four assessment panels were established, composed of almost 500 scientists and other experts. One of their conclusions was that a complete phase-out of all major ozone-depleting substances was 'of paramount importance in protecting the ozone layer'.[18] Thus, 15 years after the problem was discovered, policy makers received a clear recommendation from scientists about the kind of actions needed to cope with the problem.

Reduction of technological uncertainty. Technological uncertainty was mainly related to the prospects of developing alternatives and substitutes to CFCs and halons. CFCs were discovered by General Motors in 1931 and they have found wide application because they are inert, non-toxic, non-carcinogenic and non-flammable. In 1978, the USA banned the use of CFCs as aerosol propellants in non-essential applications. Alternatives were soon on the market, principally hydrocarbons like butane.[19] The chemical industry, and especially Du Pont which produced 25% of the global market, had been working on developing

[13] Benedick, *op cit*, Ref 2, pp 9–11.
[14] WMO, *op cit*, Ref 11, p 4. Participating agencies and institutions were NASA, NOAA, the US Federal Aviation Administration, UNEP, WMO, the EC Commission, and the West German Ministry for Research and Technology.
[15] Some theorists saw the Antarctic ozone hole as a result of anthropogenic release of CFCs, while other hypotheses were based on natural mechanisms. See 'The endangered ozone layer', *Environment*, Vol 29, January/February 1987, pp 40–44.
[16] *Effects of Changes in Stratospheric Ozone and Global Climate, Vol 2: Stratospheric Ozone*, EPA/UNEP, October 1986.
[17] Benedick, *op cit*, Ref 2, p 110.
[18] *Ibid*, p 133.
[19] 'In search of safe CFCs', *New Scientist*, 26 May 1988, p 57.

less ozone-depleting or non-ozone-depleting substitutes for existing CFCs since the 1970s. Two prime candidates were identified: CFCs 123 (for 11) and 134a (for 12).[20] However, these substitutes were expected to cost more than 'hard' CFCs. All in all, then, the barriers for developing and applying substitutes and alternatives were economic and political, rather than technological.

The first wave of political pressure eased at the end of the 1970s, and the chemical industry wound up most of its research programmes on alternatives and substitutes.[21] After the adoption of the Vienna Convention the pressure increased again and in 1986 Du Pont announced that suitable alternatives could be available within five years given the right market conditions.[22] In 1987, the industry received clear signals that the existing CFC market would be cut in half by a fixed date and industry representatives from many countries started to exchange information and coordinate research. Four months after the Montreal negotiations, several hundred industry representatives met in Washington to exchange information and stimulate research on alternatives to CFCs.[23] A year later, it was generally accepted that a reduction of at least 50% of CFCs and halons could be achieved relatively quickly and at little cost.[24]

Following the Montreal Protocol, a technology review panel consisting of over 100 international experts was established to review the technological progress. Their 1989 report concluded that, based on the current state of technology, CFC consumption could be reduced by more than 95% by the year 2000. There are no substitutes for halons in certain applications, but other techniques can offer equivalent fire protection.[25] Thus, a drastic cut in ozone-depleting substances became technologically feasible within a short time following the Montreal conference.

Reduction of economic uncertainty. No studies comparing the costs and benefits of CFC reduction were undertaken before 1985. Europe and North America were the principal producers and consumers. CFCs were produced by only 17 companies which operated in 16 countries. In 1986, about 3 billion lb were produced: 35% in the USA; 36% in Western Europe; 8% in Eastern Europe including the USSR; 3% in Latin America; and 18% in Asia and the Pacific.[26]

In 1987, the EPA published a report showing that the benefits from control were far higher than the costs, by a factor over 150 in most scenarios.[27] Similar studies were made to estimate the costs and benefits in other countries. A Canadian study, based on the assumption that the country would implement the Montreal Protocol, supported the EPA study.[28] A Nordic study conducted in 1988, which does not venture to quantify the benefits of ozone protection, concluded that considerable reductions in CFC use were possible for the Nordic countries, even without the use of any new technology.[29] The Environmental Agency of Germany also completed a national study which concluded that 90–95% reduction could be achieved by the mid-1990s at reasonable cost.[30] In spite of all the uncertainties concerning cost–benefit analysis, the difference between costs and benefits, especially in the EPA study, was so great that the results could not be ignored. The economic panel report, which was published in 1989, underlined that substantial reductions of CFC and halon use were technically and economically feasible, and concluded that 'Notwithstanding the problems of quantifying the benefits, the basic conclusion is that the monetary value of the benefits

[20] *Ibid.*
[21] *Ibid.*
[22] Peter M. Morrisette, 'The evolution of policy responses to stratospheric ozone depletion', *Natural Resources Journal*, Vol 29, Summer 1989, p 816.
[23] This meeting was sponsored by the EPA, The Conservation Foundation and Environment Canada (Benedick, *op cit*, Ref 2, p 104).
[24] *Ibid*, p 119.
[25] *Technical Progress on Protecting the Ozone Layer – Report of the Technology Review Panel*, UNEP, Nairobi, June 1989, pp ii–v. This conclusion concerns the five controlled CFCs in the Montreal Protocol. The panel also concludes that substitutes exist for 90–95% of methyl chloroform uses, and for the majority of carbon tetrachlorine uses.
[26] Peter M. Haas, 'Policy responses to stratospheric ozone depletion', *Global Environmental Change*, June 1991, p 224.
[27] Anil Markandya, 'Economics and the ozone layer', in *Blueprint 2: Greening the World Economy*, Earthscan Publications Ltd in association with the London Environmental Economics Centre, London, 1991, p 64.
[28] See D.A. Smith and K. Vodden, 'Global environmental policy: The case of ozone depletion', *Canadian Public Policy*, Vol XV, No 4, 1989, pp 413–423.
[29] Nordisk Ministerråd, 'Reduktion af CFC-forbruket: Teknisk-økonomisk vurdering af relevante multigheder for Danmark, Finland, Norge og Sverige', Nordisk Ministerråd og Nordisk Industriforbund, København, 1988, p 86.
[30] *Economic Panel Report*, UNEP, Nairobi, July 1989, p 42.

is undoubtedly much greater than the costs of CFC and halon reductions'.[31] Thus, we may conclude that little remained of the 'the veil of uncertainty' in the late 1980s. The parties could clearly see through it, and what they saw revealed a technologically and economically benign problem.

Political problem characteristics

Affectedness. The problem of ozone depletion is distinct from most other transboundary environmental problems because all states will be negatively affected by increased ultraviolet radiation. This implies that depletion of the ozone layer would be perceived to produce only 'losers', in contrast to global warming or marine pollution.[32] Consequently, no nation perceived any benefits from stratospheric ozone depletion. The 1986 UNEP/EPA report concluded that ultraviolet radiation induces skin cancer, cataracts, suppression of the human immune response system and the development of some cutaneous infections, such as herpes. Plants react adversely and aquatic organisms would be adversely affected by increased UV-B radiation.[33] Studies also revealed that less developed countries (LDCs) in tropical and subtropical areas were especially vulnerable to increased UV-B radiation.[34] Decreased food production from UV-B impacts could seriously affect people in areas where shortages already exist, and eye injuries would be especially serious in tropical and subtropical areas. On the other hand, skin cancer would affect people with little protective pigment. Mounting evidence of adverse effects of increased ultraviolet radiation combined with high public awareness resulting from the identification of the ozone hole over Antarctica, probably had most influence on the perception of the problem's magnitude. The 1989 assessment panel on environmental effects confirmed previous results, and concluded that 'Even with the present state of knowledge, it is clear that some of these effects (from increased UV-B radiation) cause a significant threat . . .'.[35]

Research also revealed that the problem of ozone depletion was linked to the global warming issue. CFCs and halons were estimated to account for about 15–20% of contributions to the greenhouse effect.[36] This link made the ozone problem politically 'easier': any action taken to control CFCs would have a positive impact on preventing global warming, given that possible substitutes and alternatives contributed less than CFCs to the greenhouse effect.[37]

Abatement costs and competition. Would the distribution of costs of regulating CFCs be more uneven? Production and consumption of CFCs were concentrated mainly in the USA and EC countries – 35% and 36% respectively. It is therefore reasonable to assume that equal cuts in production across these two 'blocks' would not seriously disrupt international competitiveness. This is further underlined by two important factors. First, and of major importance, the industry was not heavily dependent on CFC production. For instance, CFCs accounted for only 2% of Du Pont's revenues in 1987 and a slightly higher percentage of profits.[38] Secondly, CFCs are not critical to the modern industrial economy.[39]

However, the chemical industry and in particular the major producers Du Pont in the USA and ICI in the UK fought a competitive battle. According to the Secretary General of UNEP, Mustafa Tolba, the difficulties in Montreal in 1987 had nothing to do with whether the

[31] *Ibid*, p 141.
[32] For an example of the possibilities of 'winners' and 'losers' in coping with global warming, see Richard E. Benedick, 'Lessons from the "Ozone Hole"', in *Greenhouse Warming: Negotiating a Global Regime*, World Resources Institute Washington, DC, 1991, p 10. In the case of marine pollution in the North Sea, the UK has been regarded as 'winner' from uncontrolled disposal because the UK is not much affected by its own and other countries' dumping due to the direction of the currents. See Jon B. Skjærseth, 'Towards the end of dumping in the North Sea – an example of effective international problem-solving', *Marine Policy*, March 1992.
[33] *Op cit*, Ref 16.
[34] *Environmental Effects Panel Report*, UNEP, Nairobi, November 1989.
[35] *Ibid*, p iii.
[36] A.D. Wirth and A.D. Lashof in *Greenhouse Warming: Negotiating a Global Regime*, World Resources Institute, Washington, DC, 1991, p 13.
[37] This theory has recently been challenged by the 1992 update of the Intergovernmental Panel on Climate Change (IPCC). The new 'zero-sum' theory assumes that the impact of CFCs on the global climate can be counterbalanced by the actual depletion of the ozone layer.
[38] Haas, *op cit*, Ref 26.
[39] Peter M. Morrisette: 'The Montreal Protocol: Lessons for formulating policies for global warming', draft of article to be published in Policy Studies Journal Symposium on Global Climatic Problems and Public Policy, 1990, p 9.

environment was damanged or not: 'It was all who was going to gain an edge over whom: whether Du Pont would have an advantage over the European companies or not'.[40] After Montreal, both Du Pont and ICI reversed their stands and supported radical measures. These new departures were brought about by a combination of market changes provided for by the Montreal Protocol, evolving scientific knowledge and consensus, and promising substitutes and alternatives.

But could CFCs and halons be phased out without any 'losers'? Between 1987 and 1990, 71 states, most of them LDCs, had ratified the Vienna Convention and signed or ratified the Montreal Protocol. However, the LDCs envisaged future production and use of CFCs. CFCs are widely used as coolants in the manufacturing of refrigerators which are important for improving living standards and sanitary conditions. CFC production was, for instance, regarded as vital for China's rapidly growing industry and the booming demand for refrigerators.[41] While the potential benefits would be the same – skin cancer is no more fun in Asia than in Europe – the LDCs perceived that they could be sacrificed on the 'green' altar. Industrialized countries consumed about 88% of CFCs with less than 25% of the world population.[42] Thus the developed countries had greatly benefited from substances which now threatened the whole world while strong measures to reduce emissions could affect the economies of developing countries. Importing countries could face higher prices for alternatives and CFC-producing LDCs could face problems with access to new technologies and patent rights. While the developed countries' interests merged, asymmetrical interests existed between them and the LDCs.

Evolving actor preferences: adapting to reduced uncertainty

In 1983, the so-called 'Toronto Group' was formed by Canada, Finland, Sweden, Norway, Switzerland and the USA. The Toronto group advocated the idea of reducing CFC emissions and called for a ban on non-essential use of CFCs in spray cans. This position represented actions already taken by the countries in the Toronto group. The EC represented the other important coalition in the pre-negotiations. EC countries argued that the effects of an aerosol ban could be cancelled out by uncontrolled further growth of CFCs for non-aerosol uses. Their proposition was more lenient: a production capacity cap on CFCs combined with a 30% cut in CFC use in aerosols. The EC coalition's proposal did not impose any controls on itself either. A 30% cutback in aerosol use was already adopted by the EC in 1980 as a response to the US aerosol ban.

These positions were developed largely in accordance with different market situations. The EC was the major exporter of CFCs while the US consumed most of the CFCs it produced. In addition, US production of CFC-propelled aerosols had disappeared due to the 1978 aerosol ban, while the EC production for aerosols represented more than 50% of these CFCs. Thus, the Ad Hoc Working Group preparing the 1985 Vienna Convention could not agree on any further international control provisions. Winfred Lang, who presided over the plenipotentiary conference in Vienna, blamed the EC industry for the failure: '. . . [they] pretend that no alternatives are available to replace chlorofluorocarbons.'[43]

In December 1986, negotiations on a protocol to the Vienna Conven-

[40]'Now it makes business sense to save the ozone layer', *New Scientist*, 29 October 1988, p 25.
[41]'Into the deep freeze', *South*, May 1989, p 76.
[42]Benedick, *op cit*, Ref 2, 1991.
[43]Benedick, *op cit*, Ref 2, p 44.

tion began. In reality, these talks were to a large extent bilateral negotiations between the USA and the EC, and the major issue was the timing and size of cutbacks. Since the Vienna negotiations, the US position had changed in favour of more radical measures. The new US position called for a short-term freeze on the production of CFCs and halons and a long-term phase-out. Canada and the Nordic countries in particular supported the US position, which also gained backing from Egypt, Argentina and Brazil.[44] The fragmented EC group, where the Federal Republic of Germany represented the most influential leader state, and the UK the principal laggard one, entered the negotiations by considering lowering their existing capacity cap. They then progressed to a freeze and 20% cutback. A few months before the Montreal conference in 1987, officials at UNEP stated that there was a real possibility of a complete breakdown in the final negotiations.[45] However, this option was not preferable to any side, and in Montreal the EC Commission gave in and supported a 50% total cut.

In 1988, the then UK Prime Minister Margaret Thatcher gave signals of higher priority to threats to the ozone layer by announcing that she intended to host an international meeting in March 1989 on the need for strengthening the Montreal Protocol. At this meeting, the EC supported the USA by declaring the total elimination of CFCs by the end of the century. Thus, 15 months after the final Montreal negotiations, the main discrepancy between the EC and the USA had vanished.

Ironically, when the developed countries' preferences merged, it became clear that not all developing countries were satisfied with the Montreal Protocol. Chinese officials stated, for instance, that 'the protocol does not address the fundamental principle that those who discharge most should reduce most'.[46] However, with claims for financial aid and technology explicitly stated, the LDCs supported in 1989 a statement that the ultimate objective was total elimination of CFCs and halons.[47] Thus, in 1989, the principal 'coalitions' – the USA, the EC and the LDCs – agreed on the kind of 'cure' that was needed, and declared their political will to cope with the problem. These positions were developed largely in accordance with the parties' increased ability to look through the 'veil of uncertainty'. Nevertheless, the LDC claims called for considerable political skill and institutional mechanisms to match 'needs' and 'deeds'.

Problem-solving capacity: crafting political and scientific consensus

Coordinating a global political process seldom runs smoothly, and excellent studies have been written on the important role of diplomacy and political 'engineering' in crafting political consensus.[48] The USA acted as a political and scientific leader and showed the way by taking unilateral action in 1978. When the leadership of the USA declined at the beginning of the 1980s due to a more anti-regulatory government, UNEP struck the ball and played it over to the international court by calling for international regulation. UNEP's Secretary General, Mr Tolba, has been regarded as an important leader who guided the complicated negotiation process through foul waters. He organized private workshops and meetings for key countries in order to create the flexibility needed to hammer out the necessary compromises.

The institutions designed in 1985, 1987 and 1990 were particularly

[44]John D. Negroponte, 'Protecting the ozone layer', *Department of State Bulletin*, June 1987, p 59.
[45]'High noon for CFCs in Montreal', *New Scientist*, 3 September 1987, p 24.
[46]*Op cit*, Ref 41.
[47]Benedick, *op cit*, Ref 2, p 123.
[48]See especially Benedick, *op cit*, Ref 2.

important in shaping the outcomes. The Vienna Convention secured access for all kinds of affected governmental and non-governmental actors, which is regarded as important to promote a robust and legitimate consensus. The Montreal Protocol's Article 6 gave the Protocol a dynamic structure by calling for periodic reviews on the basis of scientific, environmental, technical and economic assessment. The London revisions in 1990, which can be seen as a follow-up to the Montreal commitments, also established a $240 million fund aimed at coping with the asymmetrical interests and preferences between the developed countries and the LDCs.

Moreover, reduction of uncertainty and the growing scientific consensus did not evolve by themselves. The USA in particular, which controlled about 80–90% of the world's atmospheric science skills, acted as a scientific leader throughout the process. Bob Watson, who worked full time at NASA to organize the international scientific process, has been regarded as the principal scientific 'engineer' in this process.[49] He was particularly aware of the importance of including a broad scientific participation to create consensus: 'Let's go ahead and have a person from a certain country, even if that person has nothing to contribute. We might be able to get something started there, or at the very least that person might be able to take the message home'.[50]

Conclusion

The 'successful' ozone cooperation teaches several lessons about how to handle manipulative factors in complex bargaining settings. First, various kinds of political leadership were important in pushing for stronger measures and hammering out compromises. Secondly, the institutions were successfully designed to secure access for all affected actors, to integrate interests by establishing a funding mechanism, and to promote a close link between evolving science and politics. Thirdly, the scientific process was well organized to promote consensus by ensuring broad international participation.

However, the intellectual and political characteristics of the problem itself were also important. There are clear indications that the actors faced a quite benign global problem behind the 'veil of uncertainty'; a benignness which was gradually revealed by increased knowledge. Two important lessons follow. First, the role of various types of science in identifying problem 'diagnoses' is probably more important than previously assumed. Most international cooperation on environmental science has focused on reducing ecological uncertainty. The ozone cooperation shows that it is probably equally important to reduce economic and technological uncertainty. Secondly, specific diagnoses are important because different problems need different cures. A benign cost–efficiency problem should be approached by focusing on the coordination of actor preferences and behaviour. A more malign problem, such as global warming, that is characterized by asymmetrical interests and incompatible preferences, should be approached by correcting incentives and other economic allocation mechanisms. Leaving problem characteristics unchecked may result in quite misleading conclusions concerning the applicability to other problems of the lessons drawn. Applying the problem-solving instruments known from the ozone bargaining provides no automatic recipe for success in more malign issue areas.

[49]'How to use science to influence people', *New Scientist*, 29 April 1989, pp 69–70.
[50]Karen Liftin 'Ozone politics: Power and knowledge in the Montreal Protocol', paper presented for delivery at the 1991 Annual Meeting of the International Studies Association, Vancouver, BC, 20–24 March 1991 (interview with Ralph Cicerone p 6).