OZONE LAYER DEPLETION

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Summary

The Vienna Convention on the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer are the first international agreements in the history of mankind to address a truly global crisis. The ozone layer shields the Earth and its inhabitants from harmful doses of ultraviolet light. However, since the early 1930s humankind has released into the atmosphere increasing quantities of chemicals that, while extremely versatile, safe and profitable, will gradually destroy the ozone layer.

It was in order to protect the ozone layer that, in the early 1980s, negotiations started under the aegis of the United Nations Environmental Programme for the adoption of an international agreement. The Vienna Convention, adopted in 1985, laid down the basic

principles and structure of the regime, calling for a coordinated international effort to research the causes of ozone layer depletion. The Montreal Protocol to the Vienna Convention, adopted in 1989, pinpointed a series of substances (CFCs and halons) believed to be the culprits of ozone layer depletion and mandated their gradual phasing-out. Currently, the Vienna Convention and the Montreal Protocol enjoy almost universal acceptance. They are binding on 176 and 175 States respectively.

During the 1990s, the regime created by these two international agreements has incessantly grown, adding new institutions, enlarging the list of controlled substances and constantly reviewing phasing-out schedules in light of ongoing scientific research about the ozone layer and the dynamic of its depletion.

After a decade of relentless enlargement and deepening, it seems that ozone layer depletion might eventually be curbed, and pre-CFC levels of the ozone layer reached by the mid-twenty-first century. At the same time, however, the regime for the protection of the ozone layer is facing new challenges. New substances are constantly created, and while some may harmlessly replace ozone-depleting substances, others might pose new threats. Countries in transition towards market-based economies are experiencing difficulties in keeping pace with developed countries in phasing out efforts. Meanwhile, although the phasing out of ozone-depleting substances in developing countries has begun, the compliance-monitoring organs of the Montreal Protocol are strained by the limitation of funds available to finance phasing out activities. Illegal trade and incomplete and faulty reporting also threaten the effectiveness of the regime. The next decade will tell whether humanity has been able to successfully address the first global environmental crisis or resigned itself to live on a planet stripped of ozone protection.

1. Introduction

The depletion of stratospheric ozone has been a major environmental issue during the last 25 years. At first, it was only an intriguing scientific hypothesis and there was no *prima facie* case against chlorofluorocarbons (CFC). However, when a large hole in the ozone layer was detected above Antarctica in 1985, suddenly ozone depletion became a matter of urgency requiring intergovernmental action. The result has been the growth of a complex international regime for the protection of the ozone layer.

The first stone was laid in 1985 with the adoption of the Vienna Convention on the Protection of the Ozone Layer (Vienna Convention). Two years later in Montreal, the Protocol to the Vienna Convention (Montreal Protocol) gave substantial content to the institutional framework laid down by the Vienna Convention. Since then, the ozone protection regime has evolved to tackle new challenges arising from evolving scientific knowledge, the identification of new ozone-depleting substances (ODS), and mutating international political and economic realities.

The Vienna Convention and subsequent protocols are the first international agreements in the history of mankind to address a truly global crisis. In this sense, they paved the way for the adoption a few years later of the United Nations Framework Convention on Climate Change. Moreover, because the ozone regime is precautionary in nature, scientists have played a fundamental role in its evolution. Because the dynamic of the phenomenon is extremely complex and shrouded by significant uncertainty, scientific research has gone hand-in-hand with the negotiating process and the administration of the regime.

The ozone regime is the result of a series of compromises: first, the need for immediate and effective action had to be balanced against the industry interests and economic welfare. The easiest and fastest way to address the problem would have been to immediately ban any chemical substance with ozone-depleting potential (as several environmental NGOs advocate). Yet, such a decision would have not only imposed huge costs on chemical industries, but created ripple effects throughout society and the economic system at large, as substitutes to ODS were yet to be discovered.

Another compromise at the heart of the ozone regime is that between industrialized and developing countries. A few industrialized countries have massively produced and consumed ODS in the past, while developing countries, which have hitherto minimally contributed to the problem, may have a huge impact in the near future. The participation of developing countries in the ozone-protection regime is essential because ODS regardless of where they are produced and/or released into the atmosphere, could render phasing-out efforts in developed countries meaningless. To ensure universal participation, developed countries had to accept the so-called principle of ‘common but differentiated responsibility’, which translates into looser phasing-out timetables and financial help for developing countries.

1.1 The Ozone Layer: What it is and Why it is Threatened

Ozone is a simple molecule made up of three atoms of oxygen (O_3). It can be found naturally in the Earth’s atmosphere. However, ozone is very rare (averaging three molecules of ozone for every 10 million air molecules) and unevenly distributed, primarily in two regions of the Earth’s atmosphere. Approximately 90% of the ozone layer can be found 8–18 km (5–11 miles) above the Earth’s surface, extending up to about 50 km (30 miles). This region of the atmosphere is called the stratosphere and the ozone in it is commonly known as the ozone layer. The remaining ozone is found in the lower region of the atmosphere (the troposphere).

Although ozone molecules in the stratosphere and the troposphere are identical, they have opposite effects on the planet. Stratospheric ozone (i.e. the ozone layer) plays a beneficial role by absorbing most of the biologically damaging ultraviolet sunlight (i.e., UV-B) and completely screening out lethal UV-C radiation. Increased exposure to UV-B and UV-C weakens the immune systems and causes increased occurrence of melanoma and non-melanoma skin cancers and eye cataracts, reduces plant yields, damages the oceans’ ecosystems, has adverse effects on animals and deteriorates plastic materials. Moreover, by absorbing ultraviolet radiation, the ozone layer helps regulate the Earth’s temperature. Indeed, it creates a source of heat, which forms the stratosphere itself (a region where the temperature rises as altitude increases).

Conversely, at the Earth’s surface, ozone has severe toxic effects when it comes into contact with life forms. Ozone in the troposphere is the result of human activities and an important component of air pollution (the so-called photochemical smog). In sum, the dual role of ozone leads to two separate environmental issues: the increase of ozone in the troposphere and the decrease of ozone in the stratosphere. This paper will address only the latter, as it has become an issue requiring international action. The former has mainly been the object of national measures.

It was only at the beginning of the 1970s that scientists began questioning the possibility that certain chemicals could interact with and destroy the ozone layer. F. Sherwood Rowland and Mario Molina (who, together with Paul Crutzen, won the 1995 the Nobel Prize in Chemistry for their discovery) hypothesized that CFCs introduced into the troposphere were capable of slowly rising unaltered into the stratosphere via air currents. CFCs would be dissociated by ultraviolet light, releasing chlorine atoms, which would act as catalytic agents in the dissociation of ozone molecules. In particular, free chlorine atoms (Cl) decompose ozone into oxygen (O_2), and are regenerated by interaction with the now free oxygen atoms (O). When chlorine is regenerated, it is free to continue to break down other ozone molecules, for as long as its atmospheric life-span (one to two years). At the end of the process one atom of chlorine can destroy as many as 10 000 molecules of ozone. Stripped of its natural shield, the Earth and its inhabitants would be exposed to the harmful effects of unfiltered sun radiation. Considering the production and consumption figures of CFCs (during the late 1960s more than one million metric tons of CFCs were produced annually) and their ubiquitousness, all the ingredients were in place for a major environmental catastrophe at the global scale.

2. The architecture of the ozone layer regime

The alarm launched by these scientists spurred a research campaign, both at the national and international levels, to verify the soundness of their theories. In the United Nations, the issue of ozone depletion was first discussed by the Governing Council of the United Nations Environmental Programme (UNEP) in 1976. A meeting of experts was convened in 1977, after which UNEP and the World Meteorological Organization (WMO) set up the Coordinating Committee on the Ozone Layer (CCOL), to periodically assess ozone depletion and bring together scientists from governments, industry, universities and international organizations.

Negotiations for an international agreement to address the presumed threat from the depletion of the ozone layer started under the aegis of UNEP in 1981, but scientific uncertainty, lack of conclusive evidence, difference of views between the EC countries and the so-called Toronto Group (Australia, New Zealand, Canada, Finland, Norway, Sweden, Switzerland and the USA) and pressure from industries delayed the conclusion of a treaty until 1985.

2.1 The Vienna Convention for the Protection of the Ozone Layer

On March 22, 1985 representatives of 43 states, including 16 developing countries, concluded the Convention for the Protection of the Ozone Layer in Vienna. Although the Vienna Convention was in itself an unprecedented accomplishment, being the international community's first formal effort to deal with an environmental problem before incontrovertible proof of its existence could be produced, it stopped short of what many had hoped it would be. Indeed, signatory states merely agreed to 'cooperate by means of systematic observations, research and information exchange in order to better understand and assess the effects of human activities on the ozone layer' and 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' (art. 2.1).

Yet, the Convention did not specify how to reach that goal. There was no mention of any substances that might harm the ozone layer, and CFCs only appeared towards the end of the annex to the agreement, where they were generically mentioned as chemicals that should be monitored. The main thrust of the Convention was to lay down a framework to encourage cooperation among States through research and exchange of information on the phenomenon. As a 'framework treaty', it set forth general principles and institutional structures—a Conference of the Parties to meet regularly, a Secretariat to act as a clearinghouse for information, and a procedure to amend the Convention (see 3.3.1, 3.3.2, and 4)—but it did not contain substantive emission reduction provisions, or list proscribed substances, control procedures or rules on liability.

2.2 The Montreal Protocol on Substances that Deplete the Ozone Layer

Less than eight weeks after the conclusion of the Vienna Convention, the journal *Nature* published a paper by a group of British scientists containing astonishing findings based on a review of land-based measurements of the stratospheric ozone in Antarctica. Those measurements were so unbelievable at first, that the scientists had delayed publication for nearly three years (while Vienna Convention negotiations were ongoing) while they reviewed the accuracy of their instruments and data. They finally concluded that ozone levels recorded during the Antarctic spring had fallen to about 50% of what they had been in the 1960s. Moreover, the amount of seasonal loss appeared to have sharply accelerated beginning in 1979. The so-called 'ozone hole' (the portion of the stratosphere in which ozone levels are greatly diminished) had expanded by 1985 to cover an area as large as the US.

The British findings were later confirmed by American satellite observations. These findings constituted the first tangible evidence of severe ozone depletion, making the need for definite measures urgent. In the meantime, an extensive research effort was launched to try to prove that chlorine was the ultimate culprit. Prompted by a strong public concern and a large mass-media campaign, negotiations intensified and, on September 16, 1987, an agreement was reached in Montreal delineating specific measures to be taken under a Protocol to the Vienna Convention (the Montreal Protocol).

The Montreal Protocol (Protocol) is the center-piece of the international regime for the protection of the ozone layer, for it enshrines the fundamental principles states should follow to curb ozone-depletion, and sets up its pivotal structures and procedures. First, the Protocol contained a list of targeted substances, along with agreed cuts and timetables. In particular, it called for a cut to 1986 levels of production and consumption of some CFCs by mid-1999 and a freeze on production and consumption of certain *halons* (used primarily in fire extinguishers) to 1986 levels. Moreover, the Protocol banned trade in ODS with non-parties. In this way, it created a disincentive for free riders, discouraged relocation of ODS production facilities to non-parties, and created an incentive (particularly for developing countries) to join.

Second, the Protocol was endowed with a mechanism to constantly review control measures on the basis of evolving scientific, environmental, technical and economic information, through a process of adjustments and amendments (see 4). Without this feature, the Montreal Protocol would inevitably have been left behind by rapid advancements in science and study of the ozone layer, condemning it to irrelevance.

Third, in Article 5, the Montreal Protocol introduced the principle of 'common-but-differentiated responsibilities'. Recognizing that developing countries had hitherto contributed only in minimal part to ozone depletion, but, at the same time that their potential CFC and halon use was enormous, developed countries agreed to grant developing countries preferential treatment. 'Article 5 States' (i.e. developing countries, defined as those countries whose consumption of controlled substances was less than 0.3 kg per capita upon entry into force of the Protocol) could benefit from less strict phasing-out schedules and a ten-year delay in compliance with CFC and halon elimination. In addition, they were allowed to increase consumption during this period, as long as the 0.3 kg per capita calculation was not exceeded and base levels were calculated by using either the 0.3 kg per capita limit or the average of the annual consumption of the country for the years 1995–1997, whichever was lower. Finally, developed countries (i.e. 'Non-Article 5 States') agreed to help developing countries phase-out ODS through aid, credits, guarantees and technology transfers (see 3.3.4).

It should be noted that former communist countries ('economies in transition') do not qualify for developing country treatment under the ozone regime. Currently, twenty-seven such states: the successor states of the USSR and Yugoslavia, and those central and eastern European states which once were part of the Soviet bloc. The ozone regime (designed when the collapse of communist countries was unimaginable) uses the criterion of 0.3 kg per capita consumption of ODS upon entry into force of the Protocol as the only divide between developed and developing countries. However, since the beginning of the 1990s and the entry into force of the Montreal Protocol, most of these countries have experienced deep recessions, with plummeting economic indicators. Many of them have struggled to comply with phasing out schedules for developed countries, with mixed results (see 4.3).

2.3 The institutional structure and decision-making process

In addition to the Secretariat, the Montreal Protocol created a set of organs to study and collect data on the production and consumption of controlled substances, introduced data reporting requirements, with indications on how to calculate control levels, and provided for the future establishment of a procedure to address eventual non-compliance: the so-called non-compliance procedure (see 3.3.3).

With the passage of time, further progress researching the scientific, technological, economic and political aspects of ozone-depletion, and the rise of new potentially damaging substances, the institutional structure laid down by the Montreal Protocol has been tailored to service the needs of the parties and ensure the regime's functionality. This approach is far from original, since, to differing degrees, some traits of it can be found in the regime set up by the 1979 Long-Range Transboundary Air Pollution Convention. However, it has proved a model for similar environmental treaties, such as the Climate Change Convention.

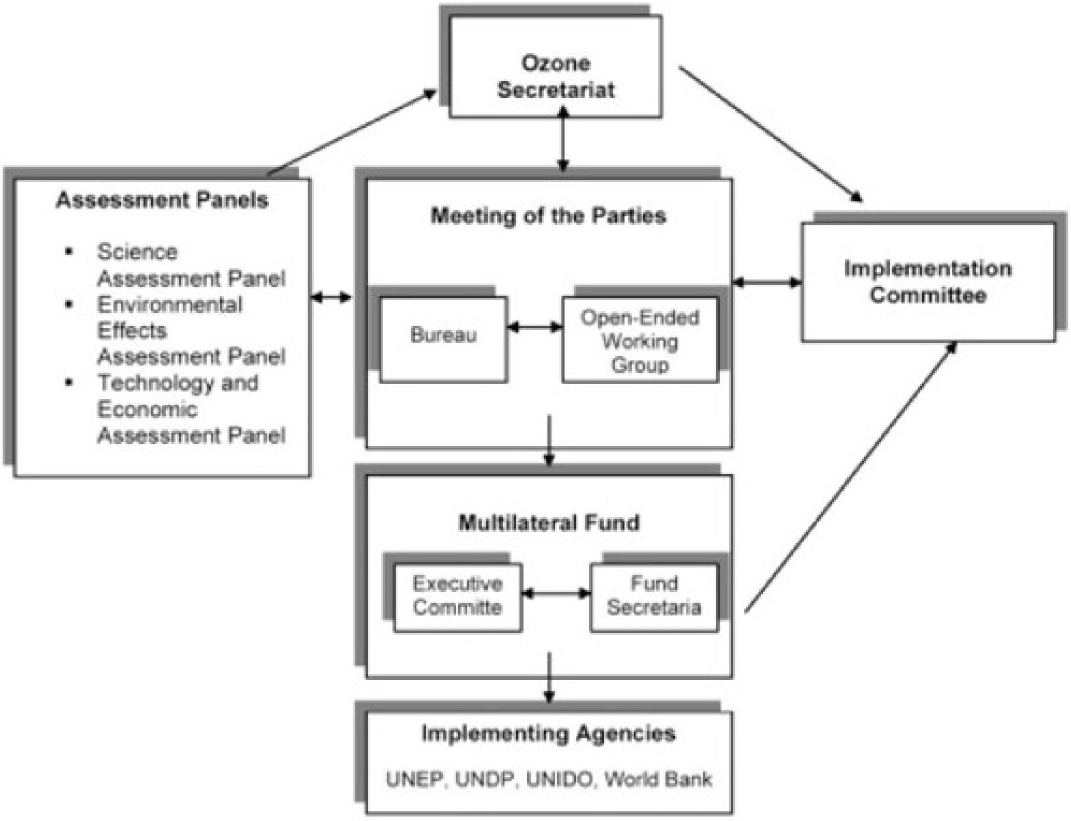

Figure 1: The Montreal Protocol Institutions

2.3.1. The Meeting of the Parties

At the center of the institutional structure is the Meeting of the Parties to the Montreal Protocol, which combines executive, quasi-legislative and quasi-judicial functions in a supreme decision-making body. Both the Vienna Convention and the Montreal Protocol provide for convocation of the parties to the agreements. The convocation of parties to the Vienna Convention is called the 'Conference of the Parties', while that of the Montreal Protocol is called 'Meeting of the Parties'. Yet, the difference between the two is minimal and the real engine of the ozone-layer regime is the Meeting of the Parties.

Indeed, for the sake of efficiency and expediency and as required by the Montreal Protocol, the gatherings of the parties to the Vienna Convention and the Protocol take place simultaneously in the same location. The difference between the two assemblies is that only the parties to the Montreal Protocol have voting rights on adjustments and amendments (see 4). Moreover, only they can be Executive Members of the Multilateral Fund, the disbursing agency of the regime (see 3.3.4).

Regardless of this, the number and identity of party states to the two agreements is currently almost identical. Currently, 176 states are parties to the Vienna Convention and 175 to the Montreal Protocol (only Equatorial Guinea is party to one and not the other).

The same was not necessarily true in the past. Until 1993 there was some discrepancy in the number of parties to the Convention and the Protocol, as some national parliaments lagged behind in the ratification process.

Furthermore, because the number of states that have ratified the various amendments can vary (see 4) within any given Conference of the Parties/Meeting of the Parties, there are usually further informal sub-groupings of parties to the various amendments. Meetings of the Parties are also open to non-party states, UN agencies, and other intergovernmental institutions and NGOs, which can all participate in discussions without voting power.

The Conference of the Parties to the Vienna Convention takes place every two years, while the Meeting of the Parties to the Montreal Protocol is held every year. To date there have been five Conferences and 11 Meetings of the Parties. Meetings usually last one to two weeks, with states often represented at the ministerial level. A new set of officers (a president, three vice-presidents and a rapporteur) is elected each time on the basis of equitable geographical representation.

The main function of the Meeting of the Parties is to consider and decide on adjustments and amendments (see 4) and to make other formal decisions relevant to the Protocol's obligations and operations. These include: establishing subsidiary panels and determining their terms of reference; reviewing the implementation of the Protocol and considering reports of the Implementation Committee (see 3.3.3); establishing guidelines for reporting procedures; assessing and reviewing control measures; adopting the budget for the implementation of the Protocol; and reviewing requests for technical assistance.

In their deliberations, the parties rely on reports prepared by the Open-Ended Working Group of the Parties to the Montreal Protocol (OEWG). The OEWG is a less formal negotiating body, open, to any party wishing to participate.

It reviews the bulky documentation concerning scientific, technological, economic, financial, compliance, and other issues submitted by the various regimes' organs and panels (i.e. the Scientific Assessment, Environmental Assessment, and Technology and Economic Assessment panels, and the Implementation Committee), and prepares detailed options for decisions by the Meeting of the Parties. The OEWG holds two or three meetings during the course of the year.

The Meeting of the Parties is also supported by the Bureau, which consists of a president, three vice-presidents, a rapporteur of the Meeting and Secretariat representatives. The Bureau meets before and during negotiations of the OEWG to define issues, agree on agendas and documentation, and consider other logistical and substantive preparations for the meetings.

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Useful websites

Http://www.unep.org/ozone/ [The Ozone Secretariat website, which. is the starting line for any research. It contains all the basic documents concerning the ozone regime, together with the Reports of the various regime organs. The site is also available at http://www.unep.ch/ozone/].

Http://www.unmfs.org/ [Official website of the Multilateral Fund]
Http://www.gefweb.org/ [Official website of the Global Environmental Facility]
Http://www.uneptie.org/ozonaction.html [Official website of the Ozone Action Programme of UNEP. It contains an interesting and constantly updated analysis of trends in consumption and production of ODS in developing countries]
Http://www.nas.nasa.gov/Services/Education/Resources/TeacherWork/Ozone/Ozone.homepage.html [Excellent web page made available by NASA. It provides a general overview of the ozone layer depletion phenomenon]

Biographical Sketch

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