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Economic Panel Report

Montreal Protocol on Substances that Deplete the Ozone Layer

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It should be noted that neither the U.S. nor the Japanese analysis considers the amount of actual depletion that has already occurred, but are both based on pre-Montreal projections of ozone depletion.

5.4 Issues affecting global benefit analyses

This section reviews some of the key issues affecting the quantification and monetization of benefits as a result of global reductions in the use of CFCs. The first section discusses some of the scientific uncertainties, followed by a discussion of the problems encountered when attempting to value the impacts in monetary terms. The last section discusses some of the basic problems encountered when attempting to quantify and monetize the benefits of reduced CFC use when these benefits are enjoyed by all people in the world and by future generations.

5.4.1 Scientific Uncertainties

As presented above, there is a limited amount of information on which to quantify the benefits of reduced use of CFCs. There are several types of difficulties encountered. First, the dose-response relationships on which the impacts are based are not fully understood. They have been determined from a limited number of scientific analyses, which has made it difficult to resolve uncertainties concerning the magnitude of the dose-response relationships and the action spectra on which the potential impacts are based. Also, because much of the evidence is based on laboratory or limited epidemiologic studies, the full-scale applicability to a real world setting cannot easily be quantified. Second, uncertainty over the exposure pathways makes it difficult to ascertain how widespread the impacts might be. For example, while certain agricultural crops appear to be adversely affected by increases in UV-R, other crops (in many cases, even different cultivars of the same crop) do not appear to be damaged. These uncertainties make it difficult to identify which species are likely to be most affected by stratospheric ozone depletion. Third, the geographic distribution of the human health and environmental impacts is difficult to gauge due to global variations in the extent of UV-R increases and warming impacts and the possibility that the dose-response

Table 5.1. Quantification of Effects on U.S. Economy from Global Implementation of Montreal Protocol. (Based on Effects on Population Born Before 2075)[a]

Effect	Measure	Quantity Assuming No Depletion	Additional Quantity Assuming No Controls	Additional Quantity Assuming Protocol	Quantity Avoided (Relative to (No. Controls)[b]	Value of Benefit (Billions of 1985 U.S. Dollars
Nonmelanoma Cancer	Million Cases	160.1	178.0	5.1	172.9[c]	73
Nonmelanoma Deaths	Thousand Deaths	Not Available	3,528.1	80.6	3,448.1	3,216[d]
Melanoma Cancer	Thousand Cases	4,230.	839.3	45.9	847.4	1
Melanoma Deaths	Thousand Deaths	1,200.	211.3	10.8	200.5[e]	224[d]
Cataract	Million Cases	182.2	20.1	0.9	19.1	3
Fish Harvest	Decrease	-	> 25.0%	0.0	> 25.0%	7
UV-Induced Crop Decline	Decrease	-	> 7.5%	0.6%	> 6.9%	27
Tropospheric Ozone-Induced Crop Decline	Decrease	-	variable[f]	variable	variable	15
Polymer Damage	Avoided Stabilizer	-	> 25.0%	7.6%	> 17.4%	4
Sea Level Rise	Cm. of rise avoided	-	99.6	87.0	12.6	5-12[g]

Source: U.S. Environmental Protection Agency, Regulatory Impact Analysis: Protection of Stratospheric Ozone, August 1, 1988.

[a] Although the effects will be incurred by people of all generations, the highest effects are incurred by people born later in the period

[b] Recent evidence suggests that ozone levels have already declined by about 3 percent from the levels preceding the development of CFCs. The number of additional cases (relative to zero ozone depletion) if ozone levels were stabilized at the current depletion level (3 percent) has also been estimated: Cases of nonmelanoma skin cancer, 11.2 million; deaths from nonmelanoma skin cancer, 179,000; cases of melanoma skin cancer, 98,000; deaths from melanoma skin cancer; 23,000; cases of cataracts, 19.7 million.

[c] the increased incidence of non-fatal cancers in the Netherlands is estimated to be about 750 to 7,500 cases per year, assuming no restrictions on CFCs and considering only the effects of CFC-11 and CFC-12 (Jansen, 1989).

[d] Value of human mortality reductions estimated as $2 million per unit mortality reduction, in 1985 dollars.

[e] The increased mortality in the Netherlands is estimated to be about 16 - 60 cases/yr, assuming no CFC restrictions and considering only the effects of CFC-11 and -12 (Jansen, 1989).

[f] Crop impacts vary depending on specific crop and local levels of tropospheric ozone increase avoided.

[g] Value of sea level rise depends on extent to which the rise is anticipated and mitigatory measures are taken.

Table 5.2 Comparison of costs and benefits through 2075 by scenario, Japan only.
(Billions of 1985 dollars)

Scenario	Health Benefit by Skin Cancer	Energy Cost	Net Incremental Net Benefits (Minus Costs)	Benefits (Minus Costs)
No Controls	--	--	--	--
CFC Freeze	62	4	58	58
CFC 20% Cut	63	12	51	-7
CFC 50% Cut	66	30	36	-15
CFC 80% Cut	68	48	20	-16

Source: "A Study of the Economic Impact Analysis on Regulation for CFC/Halon", Masuhiro Sato; Environmental Science Research Institute, Inc.

NOTES:

1. Health benefits are estimated only considering the skin cancer deaths without medical treatments for skin cancer illness. In Japan benefits considering medical treatments can be negligible since the ratio of deaths to patients in the case of skin cancers is 0.8 and costs of deaths are more expensive than the medical treatment fee. The cost for each death is evaluated using a method which is adopted in the automobile insurance industry for casualties. Using this method, the average cost for each death becomes about $300,000.

2. The health benefits projected for skin cancer alone are estimated assuming no ozone depletion has occurred at the current time. The Ozone Trends panel has demonstrated 1.5% to 3% depletion. With a higher ozone depletion rate, the skin cancer estimated by models would be much higher than used in this analysis. In Japan, however, the number of skin cancers decreased as compared with ten years ago.

3. HFC-134a is assumed to have an 8% energy loss as the refrigerator's working fluid and HCFC-123 to lose 7% as the insulating blowing agent for refrigerators. HFC-134a is assumed as the new mobile source air conditioning fluid.

4. Costs are estimated considering only the decline of the energy efficiency caused by substitutes. They do not include other costs, such as the replacement costs of equipment of CFCs-users, the risk of harmfulness of

substitutes, etc. The additional energy use for HCFC-123 could be eliminated if the walls of the refrigerator were thickened.

5. The estimation is done by using the substitutions as follows: HFC-134a is used for cooling equipment; HCFC-123 is used for foams as an insulator; and HFC-134a is used for automotive air conditioning. Use of ternaries like HCFC-22/HFC-152a/HCFC-124 is not assumed in Japan because of the possible toxicity of HCFC-124 and because of the inclusion of a flammable component in a nonflammable mixture. Such uses elsewhere might save 3% energy.

6. The average size of refrigerators in Japan is projected to increase; 514.8 kwh is used as the estimated electricity use. The average number of refrigerators assumed per household is 1.2. In the future the number of refrigerators may increase in Japan.

7. The price of electricity assumed is 23 yen ($0.16) per kwh.

8. A. Increase in gas consumption when HFC-134a is substituted in automotive AC: (1) Mileage per liter: 10 km\liter; (2) Total mileage/year = 20000 km/year; (3) Season for air conditioning (May-September): 5/12; (4) Total gas consumption per year = total mileage per year/mileage per liter = 2000 liter/year; (5) Energy loss coefficient for substitution of HFC-134a = 0.33%; (6) Total increase in gas consumption per automobile = total gas consumption during air conditioning season X energy loss coefficient = 2.75 liter/year per automobile; (7) gas price in Japan from 1976-1988 was 89.9-146.6 yen/liter.
B. Total number of automobiles with air conditioning in 1985 = 32,000,000.
C. Total cost for substitution with HFC-134a = total increase in gas consumption/automobile X total number of automobiles X price of gasoline = 7.9-12.9 billion yen/year = 56.5-92.1 million $/year.

9. The method of cost estimation was to assume a 100% reduction starting in 1985 and to scale smaller reductions to that level (e.g., a 20% reduction annually costs 20% of a 100% reduction).

mechanisms may vary significantly from one region of the world to another as a result of processes that are poorly understood at the moment. Due to these various uncertainties, our ability to quantify all potential human health and environmental impacts is limited. For example:

> Exposure to UV-B radiation has been implicated by laboratory and epidemiologic studies in the U.S. to cause non-melanoma and melanoma cancers, but the appropriate action spectrum is not known and the applicability to non-Caucasian populations and populations outside of the latitudinal location of the U.S. is unknown.
>
> Studies have linked UV-B radiation to suppression of the immune response system in animals and possibly humans. This impact has been studied only for the herpes simplex virus and leishmaniasis in animals; the impact on other diseases and on humans has not been studied.
>
> Studies of the impact of UV-B radiation on plants suffer from difficulties in experimental design, the limited number of species and cultivars tested, and the complex interactions between plants and their environments, preventing firm conclusions from being made for the purpose of quantifying risks.
>
> The impact of UV-B radiation on aquatic organisms requires additional research to better understand the ability of these organisms to mitigate adverse effects and any possible implications of changes in community composition as more susceptible organisms decrease in numbers.
>
> The linkage between UV-B radiation and tropospheric ozone formation is based on only one study, necessitating additional research before any conclusions can be drawn.
>
> Generally, inadequate information exists to quantify the risks related to global warming. Although many of the potential effects have been identified, such as changes in hydrology, warmer temperatures, and increases in storm intensity, the lack of information about the regional nature of climate change makes quantification of these effects difficult.

5.4.2 Uncertainties in Economic Valuation

In addition to the difficulties of estimating the magnitude of the benefits of reduced use of CFCs, providing an economic valuation of the global effects can also be difficult. As mentioned earlier, the ideal approach would be to measure consumers' surplus, yet no data or estimation functions exist to measure it on a global basis. Other approaches may help to understand the potential magnitude of the benefits, yet it may be impossible to resolve all uncertainties. The extent of the uncertainties may depend on the benefit in question.

Human Health Impacts

The magnitude of the value of human health impacts will depend on the methodology used to determine costs to society. One approach to determine these costs is to base the value on the costs of medical treatment on the assumption that the costs associated with medical treatment represent one measure of society's willingness to pay to avoid the human health impact. There are several drawbacks with this approach, however:

- Even where people can afford the cost of medical treatment, many would place a greater value on the knowledge that such medical treatment could be avoided.
- It assumes that all human health impacts are amenable to medical treatment. This may not be the case, as with the case of increased susceptibility to diseases that do not respond to medical treatment.
- While medical treatment may be possible, not all people afflicted may choose to receive or have access to medical treatment. For example, the value of avoiding nonmelanoma may be fairly low if diagnosed early and treated. In the case of people who do not have access to adequate medical treatment, however (as in many regions of the world), the costs could be much larger.
- The costs of medical treatment differ from one region of the world to another as a result of different treatment techniques, cost of equipment used, cost of professional medical care, etc.

For human health impacts that are not amenable to medical treatment and/or ultimately result in loss of life, the problem of valuation is compounded. Valuation of these impacts often depend on the value one assigns to human life and pain and suffering. There are no reliable methods for determining such costs on a global basis. For example, in the U.S. two possible methods for assigning value to human lives lost are basing value (1) on the amount of wages lost as a result of death, and (2) the size of awards from the judicial system when liability for loss of life is attributed to one of the litigants. Both of these approaches, however, are very controversial within the U.S. and would be even more so in other regions. For example, basing the value of human life on lost wages implies that people that earn less are inherently valued less than others: such an approach is not suitable for a global valuation since many people may believe that the value should be higher or lower than indicated by this measure. These decisions are clearly value judgments that ought to be left to each society to determine. Additionally, this approach only values the outcome -- a person's death -- and not the additional risk to which each person may be exposed. Many people would value a reduction in risk to which they are exposed, yet this approach ignores the value of any reduction in risk. Among all people exposed to the greater risk the value of reducing risk could be far greater than indicated here.

Environmental Impacts on Plant and Animal Systems

The ease of valuing the impacts on plant and animal systems may depend on the commercial value of the species. For example, losses in the productivity of agricultural crops or commercial aquatic species could be valued using world market prices for the affected foods. For other impacts, however, such as wetland loss or changes in the diversity of the ecosystem, an appropriate valuation methodology would be much more difficult since markets rarely place a monetary value on such assets. Moreover, it is not clear that world market prices fully reflect the value of various commodities. In many regions of the world agricultural crops are produced and consumed without any ties to the world markets, drawing into question the true value of such commodities (the value may be higher or lower than indicated by market prices). It must also be noted that world market prices reflect the marginal value of the commodity; if large shifts in the availability of commodities occur as a result of CFC use, marginal prices are no longer an appropriate price for valuing the changes. Also, world market prices may be more indicative of "ability to pay" than "willingness to pay." Many people might be willing to pay an amount in excess of world market prices to avoid crop losses that are critical to their health and well-being, but are unable to do so because they have insufficient monies or insufficient avenues to express their desires in the world market economy. Additionally, many countries do not choose to allow the free rise and fall of prices in response to supply and demand -- it is not clear how these benefits should be valued.

5.4.3 Other Issues Associated With Global Economic Impacts

Intertemporal Valuation

In assigning a monetary worth to specific impacts avoided as a result of reduced use of CFCs, one is implicitly attempting to value the benefits of these reductions vis-a-vis the costs of achieving the reductions. One of the problems encountered with valuing many of the avoided impacts discussed in this chapter is that these impacts, in the absence of action to reduce CFC use, would be incurred over the lifetimes of people alive today as well as during the lifetimes of generations yet to come. To contend with the problem of impacts over time, one common approach is to discount future impacts using a predetermined discount rate. This discounting approach implicitly values the impacts on future generations less since the value to society today of avoiding those future impacts tends to be negligible once the discounting is done.

Since discounting often minimizes the value of impacts on future generations, it has been argued that standard social discounting procedures are inappropriate for intergenerational valuations. One concern is that it does not recognize the willingness and/or ability of future generations to assign a much higher value to avoiding the impacts because there is no method for properly registering the concern of future generations. Another argument is that social discounting does not adequately incorporate the desire of current generations to bequeath a better world to their children and successive generations. In this sense, there is value in avoiding impacts, thereby preserving options for future generations to decide how best to meet global needs.

Evaluating Large Outcomes With Small Probabilities

The nature of stratospheric ozone depletion is such that the benefits of reducing the use of CFCs are enjoyed in the longer term, i.e., many of the effects of ozone depletion would not be realized to their fullest extent for many years or decades to come, and therefore, the value of avoiding these impacts is often greatly discounted (as discussed above for intertemporal valuations). Additionally, there is some evidence that people often have a difficult time evaluating events that have a small probability of occurring (or events in which the probabilities are poorly understood), yet entail very large potential costs if the event were to occur. In these instances, the tendency is often to discount completely the likelihood of the event occurring, or to value it disproportionately since the impact is so catastrophic.

For example, in the case of stratospheric ozone depletion, it is possible that the amount of depletion which occurs may be much greater than indicated by the current state of scientific knowledge, and/or that the human health and environmental impacts may be much greater than currently estimated. Although the probability of these events occurring may be very small, the costs associated with such outcomes may be very large for the world community. Since it is often very difficult to value correctly the expected value posed by such an event, one resolution may be to avoid any attempts to quantify the overall costs, choosing only to highlight the potential outcomes for any decision making body.

This problem of correctly evaluating events with perceived low probability but catastrophic implications is particularly acute with the impacts of reduced CFC use since the effect mechanisms are often poorly understood. For example, there are a number of potential synergistic effects associated with stratospheric ozone depletion that fall into this category, including possible interactions between (1) increased UV radiation and higher temperatures, (2) suppression of the human immune response system and increased levels of oxidants in the atmosphere, and (3) biogeochemical feedbacks, such as changes in ocean circulation, chemistry, or biology and release of methane hydrates, and increased UV radiation and global warming. The quantification of these impacts are not possible at this time, but the potentially catastrophic implications require that they be seriously considered.

5.5 Conclusions

As discussed in this chapter, reducing the use of CFCs could have enormous impacts on human health and the environment. In many instances, the current state of scientific knowledge makes it very difficult to quantify the magnitude of many of these impacts. Nevertheless, the scientific evidence is mounting that the impacts could be very large indeed, including in terms of cancers avoided, human lives saved, and ecosystem effects on plants and animals, among others. In attempting to value these impacts, there are many issues associated with proper valuation procedures from one region of the world to another and between people alive today and generations to come. These issues make it inherently difficult, if not impossible, to assign a monetary worth to the impacts avoided as a result of reduced CFC use. Regardless of the specific problems encountered when attempting to quantify and monetize the benefits of reduced CFC use, however, it is clear that the overall magnitude of the benefits is very large. As a result, while additional work could be done to quantify the benefits further, this effort would not change the basic conclusion that the monetary value of the benefits will undoubtedly be orders of magnitude greater than the costs of CFC reductions.

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