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Folder Title: "The Montreal Protocol: Alliance for Responsible CFC Policy December 1987" (3 of 3)
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Comparison of Growth vs. Montreal Protocol

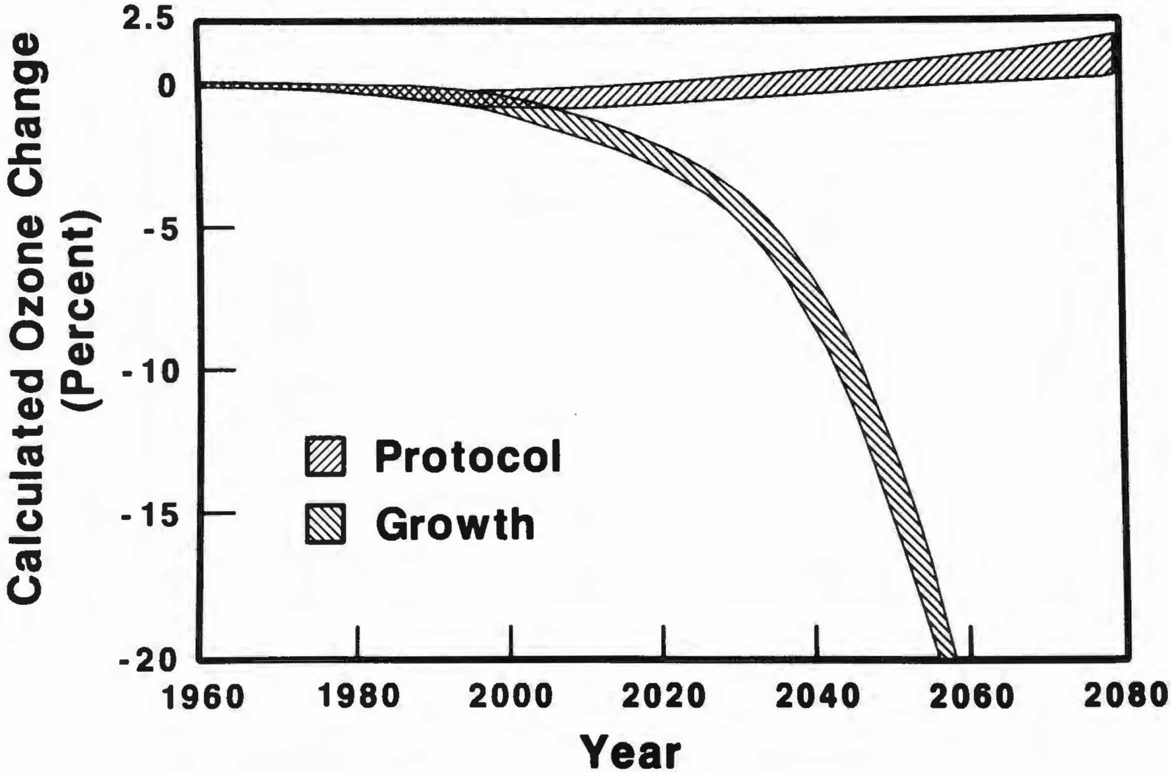


FIGURE 2

The computer model results shown in the figure demonstrate the effectiveness of the Montreal Protocol at protecting the ozone layer. Estimates of the range of model calculated ozone changes are presented for two cases: emissions of CFCs and Halons as prescribed by the Montreal Protocol and compounded growth of the compounds at 2.5 percent per year. All computer model simulations of the atmosphere predict that sustained growth in the emissions of fully halogenated CFCs could lead to appreciable ozone depletion during the next century. However, if all nations of the world comply with the provisions of the Protocol, computer model results indicate that total ozone levels might first decline slightly and then slowly increase over the next century.

Comparison of Global Freeze vs. Montreal Protocol

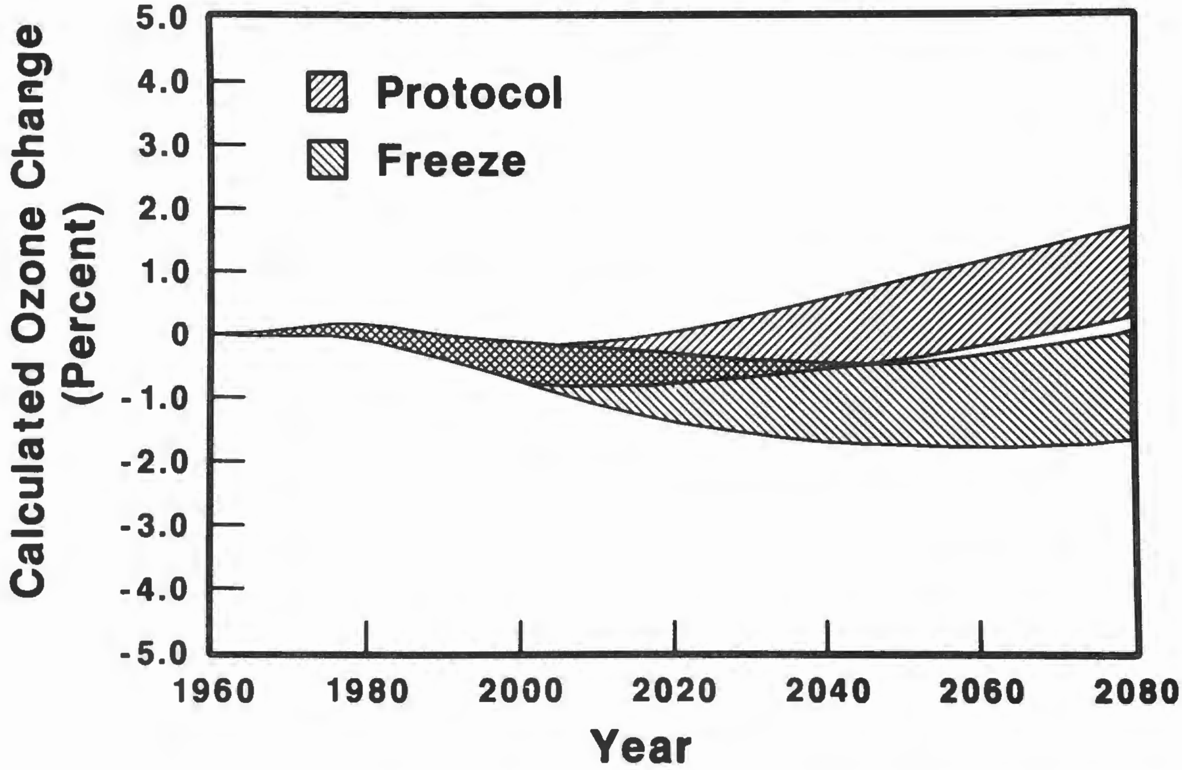


FIGURE 3

The Montreal Protocol provides a reassuring margin of protection by requiring reductions of CFC emissions. Estimates of the range of model calculated ozone changes are presented for two cases; emissions reductions as prescribed by the Montreal Protocol and a true global freeze of CFC emissions. With the emissions reductions, computer model simulations of the atmosphere predict ozone increases over the next century. Based on a freeze of emissions rates, models predict ozone changes that are smaller than the 3 percent to 4 percent changes that have been observed over the past 30 years.

Comparison of Montreal Protocol vs. Montreal Protocol Plus an 85 Percent U.S. Phaseout

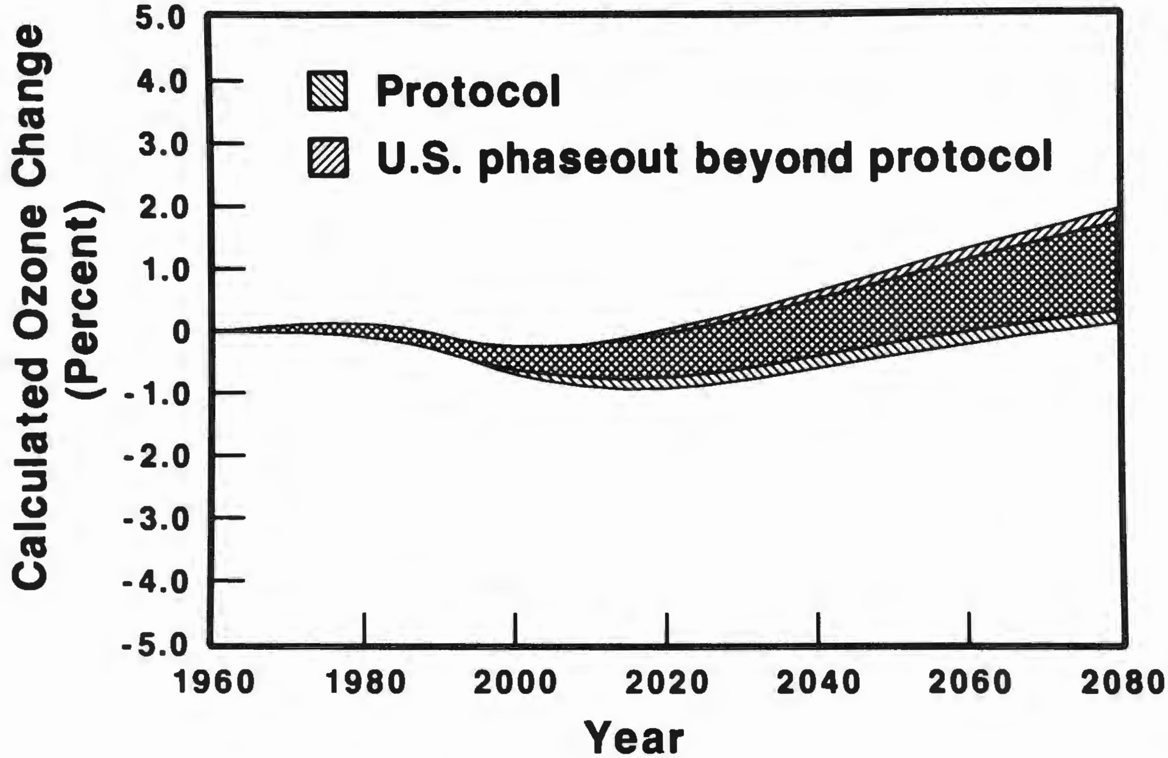


FIGURE 4

Unilateral action by the U.S. that goes beyond the Protocol is ineffective at providing additional protection of stratospheric ozone. Estimates of the range of model calculated ozone changes are presented for two cases; emissions reductions as prescribed by the Montreal Protocol and emissions reductions as prescribed by the Protocol plus an additional phaseout in the U.S. to only 15 percent of the 1986 emission rates. The results show that the marginal increase in calculated ozone resulting from the unilateral action is much smaller than the range of results that are calculated by the different models for the Protocol case.

SCIENCE ASSESSMENT

Ever since the question of whether CFCs damage the ozone layer was raised in 1974, science, industry and government have engaged in intensive efforts to determine the facts.

The research has focused primarily on the highly complex chemistry of the stratosphere. It is known that ozone acts as a giant filter to screen out some of the sun's harmful ultraviolet rays. The belief is that depletion of the ozone layer could result in increased incidence of some forms of skin cancer and damage to certain food crops and aquatic life.

Studying the stratosphere is extremely difficult, not only because of its distance from the earth (from eight to 30 miles) but also because the concentrations of ozone it contains are subject to frequent and often large natural fluctuations. However, by analysis of samples taken at various places and times through computer modeling, a great deal has been learned about stratospheric chemistry.

It appears that the amount and distribution of ozone in the atmosphere are maintained by a dynamic balance between production (from solar ultraviolet radiation), destruction (by radicals derived from several trace gases) and transport by atmospheric motion. The process is not completely understood.

It is evident, however, that industrial, agricultural and natural processes play a part in production of the trace gases. For example, carbon dioxide is increasing in the atmosphere due to increased burning of fossil fuels. Methane levels are also rising from sources thought to be natural wetlands, rice paddies and fermentation processes in cattle and other ruminants.

A 1986 report to Congress by the National Aeronautics and Space Administration (NASA) and the World Meteorological Organization (WMO) describes the current status of atmospheric science: what has been learned, what remains scientifically uncertain and what research still needs to be done. The NASA/WMO Report remains the definitive work available today on the global ozone depletion issue.

While scientists have been able to gather significant atmospheric measurements and observations during the last decade to improve their understanding of the stratosphere, much of the key analytical work is still done using sophisticated computer models that simulate the complex interactions that are theorized to occur. Discrepancies between observations and calculations limit somewhat the scientist's confidence in the predictive capability of the models.

The graphs that follow in this report represent the model calculated effectiveness of the Montreal Protocol. These calculations show that the key to future protection of the ozone layer is the limitation of the rate of growth in the use of CFCs, which the Protocol achieves. The analysis also shows that the calculated environmental benefit of the reduction steps is not nearly as great as the limitation on growth. Additionally, the analysis shows that attempts in the U.S. to go beyond the Protocol measures will produce no significant environmental benefit. (The U.S. economic impact of such unilateral action is significant, however. See Section V.) In sum, the Montreal Protocol provides a substantial margin of protection beyond what is environmentally necessary.

Two expeditions have now been completed to Antarctica to study the causes of the significant ozone reductions that have been observed during the spring season. Preliminary reports from the 1987 Airborne Antarctic Ozone Expedition have indicated that the evidence strongly suggests that both chemical and meteorological mechanisms perturbed the ozone. Additionally, it is clear that meteorology sets up the special conditions required for the perturbed chemistry."

The scientists will be analyzing this information gathered during the 1987 expedition and preparing peer-reviewed reports in 1988. These reports will be available for the first scheduled meetings of scientists in 1989 as part of the Protocol's ongoing assessment process.

The following pages summarize the current scientific understanding of the ozone depletion issue.

OZONE MEASUREMENTS

- Analyses of about 30 years of data from a globally distributed network of monitoring stations show that there has been no persistent change in the total amount of ozone.
- The 30 year data record shows that total ozone increases and decreases on time scales of days to a decade. Since 1979, total ozone amounts have been in a decreasing phase. This decrease is within the range of previously observed variability which is likely due to poorly understood natural causes.
- There are concerns about the validity of the reports of a declining trend in ozone observed by a satellite-borne instrument. A large part of the ozone decreases observed by the satellite instrument could be due to instrument degradation. Information supporting the degradation theory is provided by an analysis presented in a recently published, peer-reviewed scientific paper that shows that ozone values measured by the satellite instrument are declining compared to those measured by the ground-based network of instruments.
- A team of government, academic and industry scientists are reevaluating all ozone measurements that are now available. Their conclusions should be reported early next year.

ANTARCTIC OZONE

- Preliminary findings of the recent Airborne Antarctic Ozone Experiment indicate that a combination of meteorology and unusual chemistry is responsible for the seasonal decreases of ozone above Antarctica.
- The new information indicates that meteorology contributes directly to some of the ozone decreases. Thus, an ozone "hole" of some proportion would probably be present even if man-made chlorine compounds had never been emitted into the atmosphere.
- The unique meteorology over Antarctica established a "containment vessel" in which chemistry contributes to seasonal ozone decreases.
- It is unlikely that conditions which would duplicate the Antarctic Ozone "hole" phenomenon can exist anywhere else on the globe. Even in the most similar region of the world, the Arctic, the meteorology effectively precludes a similar situation.
- It is unknown whether any significant environmental effects can be attributed to the seasonal ozone reduction over Antarctica. It should be noted, however, that even with the measured ozone reductions, the level of UVb radiation exposure at noon on an October day in the Antarctic is less than the level of exposure at noon on a summer day in Washington, D.C.

MODEL RESULTS

The effect of the control provisions of the Montreal Protocol on atmospheric chlorine concentrations and global ozone change has been estimated based on calculations from several atmospheric models. The model results from emissions allowed under the Montreal Protocol have been compared with those from the following alternative CFC/Halon emissions scenarios: (1) the 2.5 percent compounded annual growth rate that had been assumed for a number of pre-Protocol model calculations, (2) a true global freeze of CFC/Halon emissions, and (3) the Montreal Protocol provisions plus an 85 percent phaseout of CFC/Halon emissions in the U.S.

Figure 1 depicts atmospheric chlorine concentrations and Figures 2, 3, and 4 ozone changes for the periods 1960-2080 under the several assumptions.

The best current scientific evidence supports the following conclusions:

- Calculated changes in global ozone amounts based on a true global freeze at 1986 levels are smaller than natural ozone variations that have been observed over the past 30 years.
- The Montreal Protocol provides a reassuring measure of environmental protection by imposing emission controls that go beyond what current science indicates is necessary.
- There is no need to move towards greater reduction or shorter time periods than those set forth in the Protocol.

Because uncertainties in the science remain, the Protocol requires periodic review of scientific, environmental, technical and economic information to assess the adequacy of the CFC emission controls. This review provision provides an effective mechanism to change the CFC control measures and to assure that stratospheric ozone is protected if new scientific evidence shows that a change is needed.

Chlorine in the Atmosphere

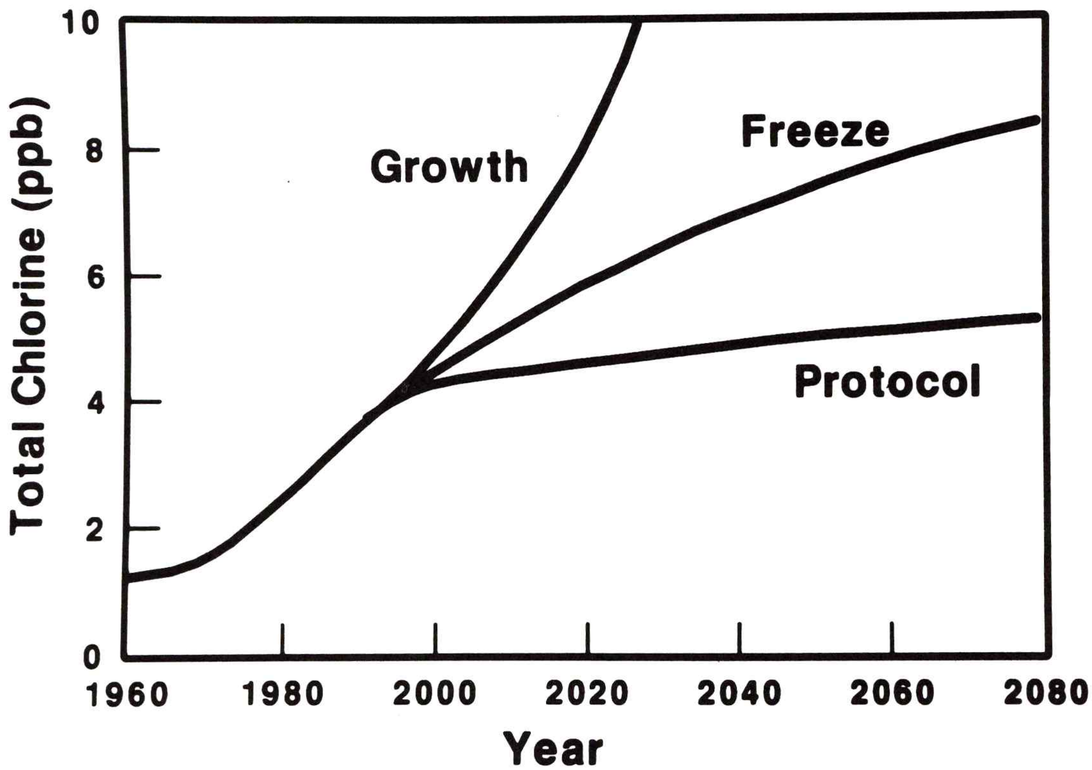


FIGURE 1

Future concentrations of organic chlorine compounds in the atmosphere are significantly reduced by the Montreal Protocol. Atmospheric concentrations of the total organic chlorine—chlorine that can reach the ozone layer—are shown for three cases:

(1) 2.5 percent per year compounded growth in global emissions of CFCs after 1986,
(2) a true global freeze of global emissions of CFCs at the 1986 rate, and
(3) global emissions of CFCs as specified by the Protocol.

Note that by the year 2025, total atmospheric chlorine for the Protocol case is only about one-half that for the growth case.

V. ECONOMIC ANALYSIS

ECONOMIC ANALYSIS

Introduction

CFCs have played an important role in many of the social, demographic, and technological changes and advancements that have occurred in the United States over the last 30 years. These compounds are very much a contributor to a high-tech economy.

Developments such as the demographic growth in the Sun Belt, an increasingly mobile population, construction of vast indoor office, retail and recreational complexes, were made possible because of the availability of relatively inexpensive climate conditioning technology made possible by CFCs. The era of computerization, and the rapid miniaturization of electronic parts, was greatly enhanced by the cleaning capabilities of CFC solvents. Additional examples are too numerous to list.

Unilateral action to control CFCs in the United States would have a significant negative impact on many key U.S. industries, industries that contribute to the quality of life in the United States and enhance our position in the global economy. Many developing nations are desirous of having the technologies that CFCs make possible, and many of our global competitors are anxious to provide these technologies to these countries and everywhere else.

The United States initiated unilateral action on CFCs in the late 1970's, singling out specific uses (aerosols), that received little support from other major CFC users around the world. A better solution was needed, one that addressed the environmental need and recognized the economic facts and produced an economic stimulus to resolve that environmental need.

The Montreal Protocol attempts to strike this balance. The following material provides the reader with an understanding of the widespread use of CFCs in our society. The economic analysis, prepared by Putnam, Hayes and Bartlett, Inc. of Washington, D.C., summarizes the expected costs of the Montreal Protocol to the U.S. economy, points out how effective the agreement will be in stimulating the development of new CFCs and CFC-utilizing technologies, and shows that any attempts to accelerate the Protocol's control measures, while providing little or no additional environmental benefit, would significantly increase the costs to U.S. citizens.

CFC Uses in the United States

By any measurement, CFCs are important to modern life:

- They help us meet basic needs—food, shelter, health care, communications, leisure, transportation.
- They contribute immeasurably to our comfort, safety and productivity.
- In the United States alone, CFCs are used by some 5,000 businesses at nearly 375,000 locations to produce goods and services worth more than $28 billion a year. CFC-related jobs total 715,000. The estimated value of installed products relying on CFCs is more than $135 billion.

Major CFC applications are described here, beginning with the one that started it all: refrigeration.

Refrigeration

$6 billion* 52,000 jobs**

The first commercial CFC was compounded in 1931, the result of an intensive research effort by a refrigerator manufacturer (General Motors) to find an efficient, safe refrigerant for home use. Ammonia, sulfur dioxide and other refrigerants then in use were considered toxic or presented other hazards.

The new compound revolutionized the industry.

The first refrigerant, ice, served well for its time. It kept foods cool so they would last longer, and iced railroad cars made possible the shipment of perishables from distant points. But ice melts and has to be replaced, and that pan under the icebox always seemed to need emptying.

Early chemical refrigerants eliminated these drawbacks and performed the cooling job more efficiently, but their toxicity was an ever-present hazard. Also, some were explosive and/or flammable and most were corrosive.

*Value of products/services, per year.
**Direct CFC-related industry employment. Refrigeration and air conditioning servicing adds $5.5 billion in value and 472,000 jobs.

CFCs captured the home refrigeration market because they are efficient, safe, stable and cost-effective. Another advantage is that they are chemically inert, so they do not damage gaskets, seals or lubricating oils in the refrigeration system. Today 75 percent of the food we eat depends upon the use of CFC refrigerants at some point in the production and distribution chain. In fact, many foods we enjoy would not be available in stores or would cost much more were it not for refrigeration.

Because of their unsurpassed cooling efficiency, CFCs are also widely used in commercial and industrial refrigeration and freezing equipment. Today, with energy efficiency a prime consideration, refrigeration engineers rely on the properties of CFCs in designing units that provide more cooling with less electric current than was thought possible a few years ago.

Air Conditioning

$12.9 billion — 150,000 jobs

Air conditioning makes the difference between comfort and misery when the weather is hot and sticky, but because we take it so much for granted, many of the other benefits it has brought us may not be evident. Consider:

- Air conditioning in hospitals and nursing homes means a more healthful, comfortable environment, more conducive to healing.
- Air conditioned offices and factories make it possible for people to perform at peak efficiency even in the hottest weather.
- A number of important industries could not operate at all without air conditioning: manufacture of pharmaceuticals and photographic and printing films, computer installations, production of electronic equipment, telecommunications.
- Businesses, theaters, shopping malls, sports arenas now operate successfully year-round, regardless of the climate or weather.
- Air conditioning in cars means not only more comfortable travel, but highway safety studies show it contributes to driving safety by reducing heat stress and fatigue.
- CFCs and air conditioning technology have led to development of energy-efficient heat pumps, solar heat systems and other heat recovery devices.

All these benefits have been made possible largely by CFCs. Air conditioning technology has been based on them, and there are no safe, suitable substitutes.

Plastic Foams

$2 billion — 40,000 jobs

CFCs are important as blowing agents in making insulating, food packaging and cushioning foams out of plastic materials.

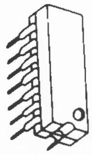
Insulating foams made with CFCs have twice the insulating value of fiberglass of the same thickness and also insulate better than foams made with other compounds. The foams are used in refrigerators and freezers, walls and roofs of houses and buildings, refrigerated railway cars and trucks, and in many industrial applications. They save substantial amounts of energy and reduce heating and cooling costs.

Because of the foams' efficiency, insulating walls can be thinner, which saves materials and provides more usable space. The foams' light weight is also a space and energy-saving advantage, particularly in insulated trucks and railway cars.

CFC food packaging foams provide insulating value for hot and cold foods and do not absorb liquids or grease. Foam meat trays are becoming familiar in supermarkets. Foam egg cartons cushion the eggs so there is less breakage than with conventional cartons.

Cushioning foams are rapidly replacing the old spring-and-padding construction of mattresses and upholstered furniture, and the lower cost and greater comfort are boons for the consumer. In cars, airplanes and trains, CFC-blown foams provide superior cushioning in seats and padded areas, such as automobile dashboards.

While other blowing agents are often used for cushioning foams, those made with CFCs provide more softness, resiliency and durability.



Cleaning Agents

Products valued in the billions of dollars. More than 10,000 jobs

As microchips and other components of electronic equipment have become smaller and more sophisticated, the need for absolute cleanliness in manufacturing has become critical. CFCs are the cleaning agents of choice, because they remove the smallest contaminants and leave a clean, dry surface. Also, CFCs are safer to use than other cleaning agents, which are more toxic and/or flammable.

In many other industries as well, CFCs are used as cleaning solvents and degreasers, providing the advantage of thorough cleaning without the volume of wastes generated by water and other solvents.

Food Freezants

$0.4 billion More than 500 jobs

The food we eat today is more varied year-round, more nutritious and better tasting than it used to be because of freezing, and CFCs deserve much of the credit. The frozen food revolution was made possible by CFCs, which made refrigerators and freezers safe for home use.

Now, CFC food freezants provide ultrafast, direct contact freezing of many foods that could not be frozen satisfactorily by the usual "air blast" method. CFCs have energy-saving advantages over other freezants, which require up to eight times the energy needed with the CFC system.

Sterilants

$0.1 billion More than 500 jobs

CFCs mixed with a sterilizing agent are widely used in hospitals and in the manufacture of medical equipment and devices. The CFCs make the sterilizing agent nonflammable without affecting its sterilizing ability. Gloves, syringes, catheters and tubing, anesthetic and respiratory equipment, pharmaceuticals and other medical supplies are made sterile by these mixtures.

Fumigants, Pesticides CFCs blended with other chemicals are used as fumigants and pesticides in granaries, warehouses and the holds of ships.

CFCs: The Benefits Are Many

The preceding section mentioned many specific ways in which CFCs benefit society.

In sum, CFCs make important contributions in a number of critical areas today:

Public safety Because CFCs are not flammable, explosive or reactive with other substances and have low toxicity, they are ideal for use in places where substitute compounds might be hazardous to the public.

Public Health A year-round supply of nutritious, healthful foods is dependent to a large extent on CFC refrigerants and freezants. Air conditioning creates more healthful indoor environments. Health care facilities and the pharmaceutical industry would be hard put to operate without the benefits made possible by CFCs.

Energy The efficient heat transfer properties of CFCs save substantial amounts of energy in refrigeration, air conditioning and insulation uses. It has been estimated that a United States ban on CFCs could, after 10 years, mean an annual energy penalty equal to 9-12 billion gallons of fuel oil, due to the forced use of less efficient materials.

The economy Besides the goods, services, businesses and jobs made possible by chlorofluorocarbons, products based on CFCs are important exports for the United States, contributing strongly to the nation's balance of trade.

Technology The availability of CFCs has led to important technological innovations, such as energy recuperators, hot water heat pumps, a solar heating system, an innovative cleaning system for electronic components, and a promising new method of cleaning coal which dramatically reduces ash and other pollutants when the coal is burned.

ECONOMIC IMPLICATIONS OF POTENTIAL CHLOROFLUOROCARBON RESTRICTIONS FINAL REPORT

Prepared for
Alliance for Responsible CFC Policy

Prepared by
Putnam, Hayes & Bartlett, Inc.
Economic and Management Counsel
Washington, D.C.
December 2, 1987

BACKGROUND

The recently adopted international protocol (Montreal Protocol) requires substantial reductions in the use of chlorofluorocarbons (CFCs) starting in 1990. In our analysis, we assume implementation of the Protocol requiring:

- A consumption freeze in 1990 at 1986 levels (consumption is defined in the Protocol as production plus imports minus exports),
- A 20 percent reduction in 1994, and
- A 50 percent reduction in 1999.

By December 1, 1987, the Environmental Protection Agency (EPA) is expected to propose regulations designed to reduce the use of CFCs in accordance with the Protocol.

Pending congressional legislation would unilaterally reduce the use of CFCs further than is called for in the Montreal Protocol.

To determine the economic and policy implications of CFC restrictions, the Alliance for Responsible CFC Policy (Alliance) retained Putnam, Hayes & Bartlett, Inc, (PHB), to evaluate the economic impact on CFC producers and consumers. This work involved:

- Estimating the timing and magnitude of future CFC price rises resulting from the restrictions called for in the Montreal Protocol;
- Determining the cost to society* of implementing the Montreal Protocol and the cost of implementing various legislative proposals to further restrict CFC usage;
- Determining the level of wealth transfer* away from consumers and user industries, which must pay higher CFC prices as a result of the regulation-induced shortages;
- Assessing the level of CFC-substitute usage under various scenarios;
- Comparing the impact of unilateral restriction on CFC usage to that of the Montreal Protocol;
- Examining the trade implications of the Montreal Protocol and various legislative proposals; and
- Comparing the economic efficiency of alternative methods for implementing the Protocol.

CFCs are used in a wide variety of products and applications, including

- Solvent applications in:
  —Electronic components cleansing
  —Metal Cleaning.
- Foam-blowing applications in:
  —Polyurethane rigid foams used in home insulation
  —Polyurethane flexible foams used in furniture cushioning
  —Polyurethane foams used in insulation and packaging.
- Refrigerant applications in:
  —Mobile (Car and Truck) air conditioners
  —Chillers (e.g., office air conditioning)
  —Commercial and home refrigerators.
- Miscellaneous applications, such as:
  —Sterilization
  —Liquid food freezing.

* See definition on page V-5

METHODOLOGY

Our methodolgy consisted of five elements (separately bound Appendix with details on the approach available):

1. Interviews and analyses conducted with numerous industry experts in 44 different CFC-using segments (more than 100 representatives of 93 companies and associations were contacted).
2. .Projections of CFC usage in each segment in the absence of regulation.
3. Evaluations of different options for reducing CFC usage in each segment, including process controls, chemical substitutes, and alternative (non-CFC-using) end products, many of which were outlined in preliminary analysis documents prepared by EPA.
4. Projections of CFC usage in each segment with regulation-induced CFC price increases.
5. General assumptions:
   - A production quota or equivalent type of regulation is used to implement the Montreal Protocol. The impact of alternative types of regulations are contrasted with a production quota.
   - CFC restrictions are implemented on a weighted basis (weights from Annex A of the Montreal Protocol).
   - The restrictions cover five CFCs: CFC-11, CFC-12, CFC-113, CFC-114, and CFC-115. In addition, uses of R-500 and R-502 (azeotropes that contain CFC-12 and CFC-115, respectively) are also restricted. The impact of separate restrictions on halons is not evaluated.
   - Social costs and wealth transfers are measures of economic impact used in this analysis. In quantifying costs and transfers, we have adopted the standard economic definitions also used by EPA:
     —* Social costs are defined as the incremental real resource costs incurred by society in order to comply with CFC restrictions; for example, the cost of process controls, more expensive chemical substitutes, or more expensive non-CFC-using alternate products.
     —* Wealth transfers represent the incremental cost of CFCs to users who purchase restricted CFCs at the higher prices that will occur as a result of restrictions.
   - Costs and prices are presented in 1987 constant dollars. Social costs are discounted at a five percent rate. Wealth transfers are also discounted at a five percent rate.

SUMMARY OF FINDINGS

1. The Montreal Protocol will require substantial reductions in CFC usage since demand for CFCs is growing rapidly. In the absence of restrictions, CFC use would grow by 48 percent from 1986 to 1999 and by 119 percent from 1986 to 2010.

2. The severity of the Protocol's economic impact is highly dependent on the timing and commercial availability of non-ozone-depleting chemical substitutes for CFCs.

3. Even under optimistic assumptions concerning the availability of potential CFC substitutes (i.e., substitutes are commercially available in 1994), the economic impact of the Protocol will be very large:
   A. CFC prices will rise significantly for user industries and consumers; for example, CFC-11 will rise from $0.50 in 1986 to almost $2.00 in 1994.
   B. In 1999, when the 50 percent reduction is required, a substantial price rise (i.e., price "spike") is expected. The price spike, which is caused by the inability of substitutes, process controls, and conservation measures to satisfy the 50 percent target level, would cause major market disruptions.
   C. Social cost to the U.S. economy will be $5.5 billion between 1990 and 2010. Over $9 billion (present value) of wealth will be transferred away from consumers and user industries between 1990 and 2010.
   —U.S. CFC consumption will be reduced by over 11 billion weighted pounds between 1990 and 2010 or the equivalent of more than 18 years of current U.S. production of these compounds.

4. If substitutes are not commercially available for widespread use by 1994 (when the 20 percent reduction is required), an economically disruptive price "spike" would likewise occur and continue until substitutes are commercially available.

5. CFC reductions induced by the Protocol will not be equally distributed among user industries. Some of the least price-sensitive users (e.g., electronic solvents, mobile air conditioning) can increase their CFC use, relative to 1986 levels, at the expense of more price-sensitive users (e.g., plastic foam users) or users that have available substitutes.

6. Substantial economic costs would be incurred if just the freeze or only the freeze and the 20 percent reduction were implemented.
   A. The price rise induced by the Protocol reduction scenario, the freeze only, and the freeze with 20 percent reduction would all induce significant price rises; however, only the 50 percent reduction step of the Protocol causes the price spike.
   B. The social costs and wealth transfers of each step are also substantial. Social costs are about $2 billion for the freeze alternative and $3 billion for the freeze with 20 percent reduction alternative.
   C. The Protocol, the freeze-only, and the freeze-with-20-percent-reduction alternatives would all spur development and high usage of CFC substitutes in response to much higher CFC prices. Since the 20 percent reduction will provide sufficient price incentives to use CFC substitutes, the costs associated with the additional 30 percent reduction in the Protocol should be considered as part of the Protocol's ongoing scientific, technological, and economic evaluation process.

7. Proposed legislation unilaterally reducing CFC usage more than required by the Protocol would substantially increase the economic cost of CFC restrictions.
   - Pending legislation calls for a 95 percent reduction by 1993. The cost of this legislation would be extraordinary and extends beyond our ability to reliably forecast CFC prices.
   - As an alternative, we examined a hypothetical unilateral action that required a 30 percent CFC reduction in 1990, increasing to 50 percent in 1995 and 70 percent by 2005. This hypothetical action to further restrict U.S. CFC usage could increase costs from $5.5 billion in the Protocol to almost $10 billion, while only reducing worldwide emissions by another 7.3 percent.

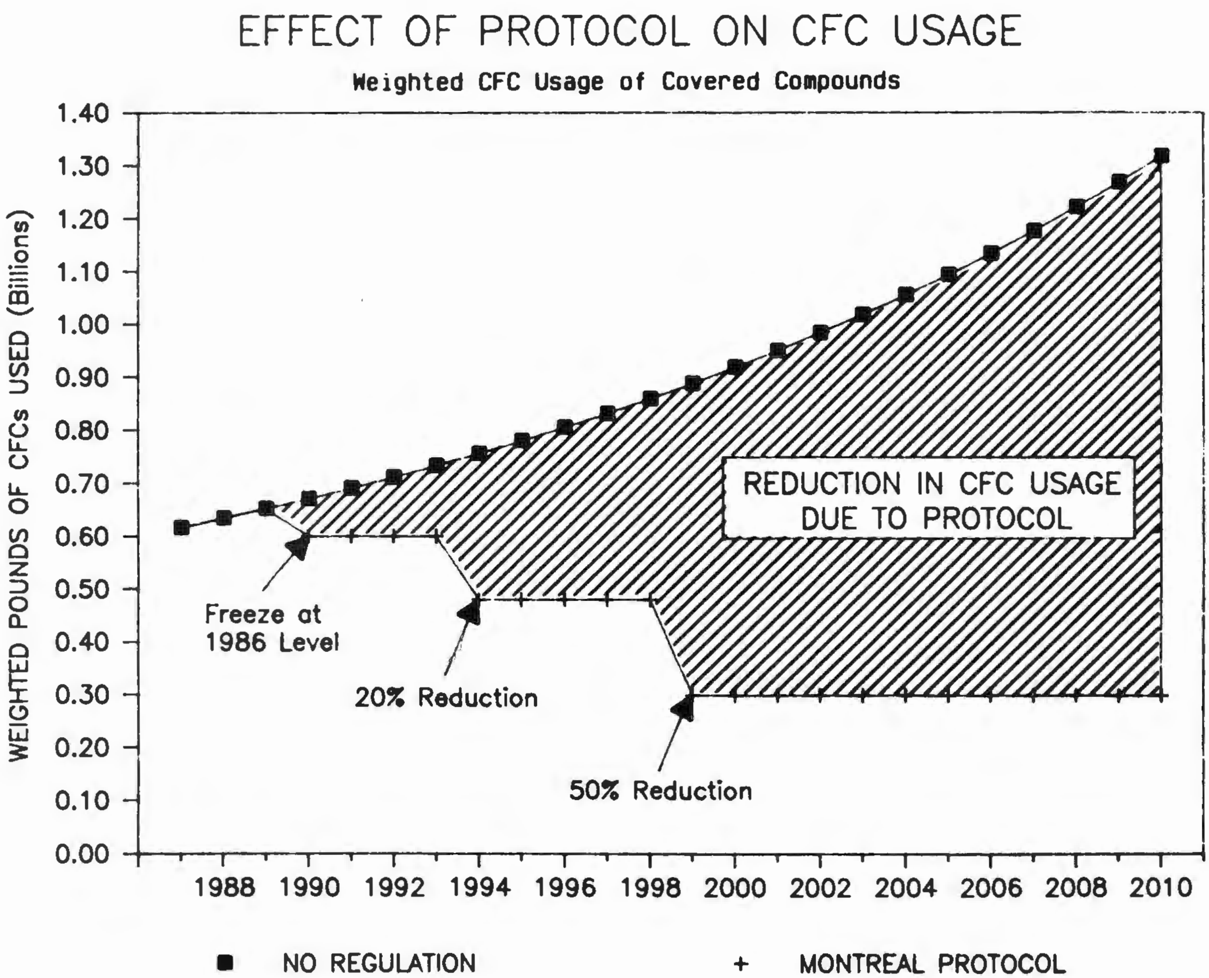
8. The impact of the Montreal Protocol on international trade will depend heavily on implementation. However, if U.S. unilateral reductions beyond the Protocol are required, then potentially severe trade impacts could occur, especially if the availability of CFCs to trade-sensitive segments is curtailed.

9. The method of implementing the Protocol in the U.S. could affect costs. Relative to a production quota, an auction-permit system could result in increased market uncertainty, higher CFC prices, and a higher-cost regulation.

   The following sections elaborate on the findings summarized above.

1. SUBSTANTIAL REDUCTIONS ARE REQUIRED BY PROTOCOL

The Montreal Protocol will require substantial reduction in CFC usage, since the use of CFCs is growing rapidly. CFC usage would be expected to continue growing at an average rate of 3.3 percent per year in the absence of regulation, for a cumulative increase of 119 percent between 1986 and 2010. U.S. CFC consumption will be reduced, according to the Protocol schedule, by over 11 billion weighted pounds between 1990 and 2010, or the equivalent of more than 18 years of current U.S. production of these compounds.



2. THE PROTOCOL'S IMPACT DEPENDS ON SUBSTITUTE AVAILABILITY

CFC prices will rise in response to regulation-induced shortages.

The degree to which CFC prices will rise in accordance with the Montreal Protocol depends on:

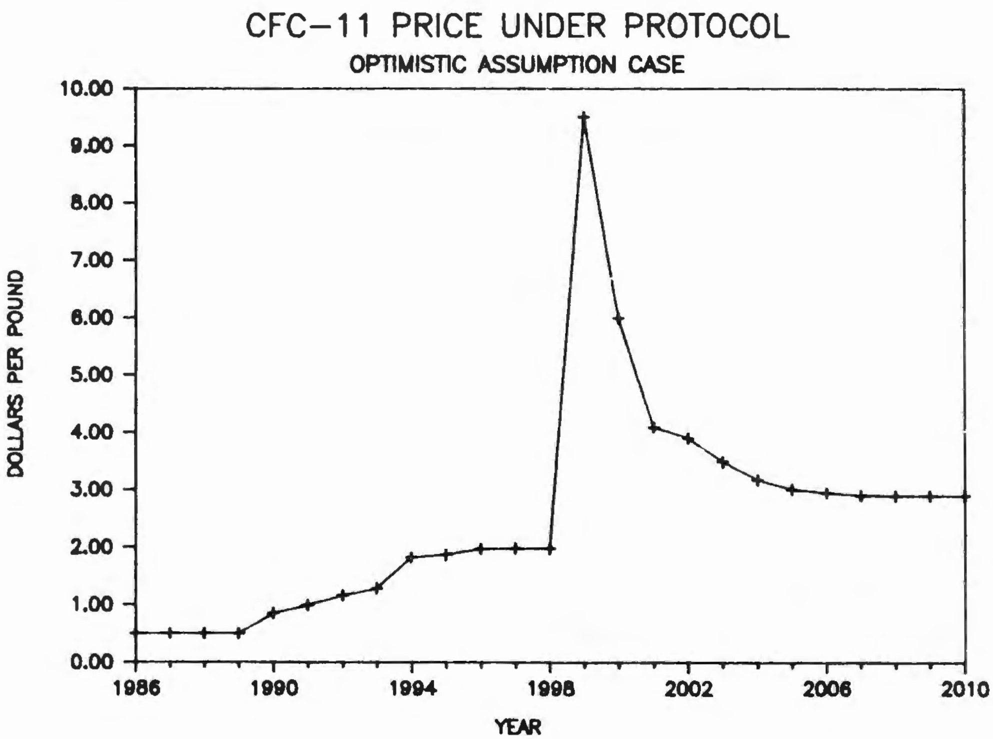
- The timing and magnitude of the regulation-induced shortages;
- The availability and cost of chemical substitutes for CFCs, especially potential new non-ozone-depleting CFCs;
- The availability and cost of control technologies and conservation measures; and
- The extent to which price increases will induce industry and consumers to reduce their demand for products containing CFCs and switch to non-CFC products. For example, CFC home insulation foam product prices will rise as CFC prices rise. As a consequence, consumers will purchase less CFC insulation foam and may switch to other non-CFC insulation products.

We have studied each of these four factors extensively with the assistance of industry experts.

3. EVEN IF SUBSTITUTES ARE AVAILABLE, THE PROTOCOL'S IMPACT WILL BE LARGE

A. CFC Prices Will Rise Significantly

Assuming CFC substitutes are commercially available by 1994 (these assumptions might be optimistic, as discussed below), CFC-11 prices would double from $0.50 to about $1.00 under a freeze, increase to almost $2.00 (a fourfold increase) when the 20 percent phasedown becomes effective, and rise rapidly ("spike") in 1999 when the 50 percent reduction becomes effective.



Under a weighted pounds production quota, the price behavior of CFC-11 is essentially identical to the behavior of CFC-12 and CFC-113. The price profile of other CFCs is given in the Appendix.

The large increases in CFC prices resulting from the freeze in 1990 and the 20 percent reduction in 1994 will have severe ramifications on CFC-using industries.

Those end-user industries without a short-term CFC substitute will have to invest in CFC conservation measures or absorb the total price increase and the accompanying reduction in demand for their end-use products. At these high CFC prices, some firms may become bankrupt if there is competition from non-CFC products in their end uses.

In the longer term, as CFC substitutes become available, the end-use industries that survive will become effectively shielded from further price increases. However, at the expected price level of the substitutes (three to five times higher), demand for those end-use products will be less.

The price spike in 1999 is caused by the inability of CFC substitutes and conservation measures to satisfy the 50 percent rollback target. Hence, prices are bid up by relatively price-insensitive users until quantity is reduced to meet the Protocol-required reductions.

The issue of how much CFC prices will rise in response to regulation has been extensively studied by EPA as well as by PHB; our price projections differ from EPA's projections.

- EPA has previously estimated that very large percentage reductions in CFC usage will be forthcoming with very small increases in CFC prices—for example, a 30 percent reduction in CFC usage with a price rise of only 7 cents per pound (EPA Preliminary Analysis of April 13, 1987).
- Our CFC price projections are substantially higher than EPA's April 13 estimates, primarily because our analyses and work with industry experts indicate that EPA's Preliminary Anaylsis substantially overestimated the low-cost CFC-reducing measures that will be quickly adopted.

3. EVEN IF SUBSTITUTES ARE AVAILABLE, THE PROTOCOL'S IMPACT WILL BE LARGE (Continued)

If CFC prices rise by a small amount, as EPA projects, then the impact on the CFC industries will be less than we estimate. However, if CFC prices increase significantly, as we expect, then the economic impact will be substantial and potentially severe.

- Sound regulatory policy would recognize the risk that CFC prices might rise significantly and, therefore, would seek to prevent any costly and avoidable economic disruptions that those significantly higher prices might precipitate.

B. The Substantial Price Spike in 1999 Would Cause Major Market Disruptions

A sudden increase in price might result in bankruptcy for marginal firms—those that depend on CFCs and have relatively price-sensitive applications. In effect, those firms that cannot sustain the losses associated with the spike will be driven out of business.

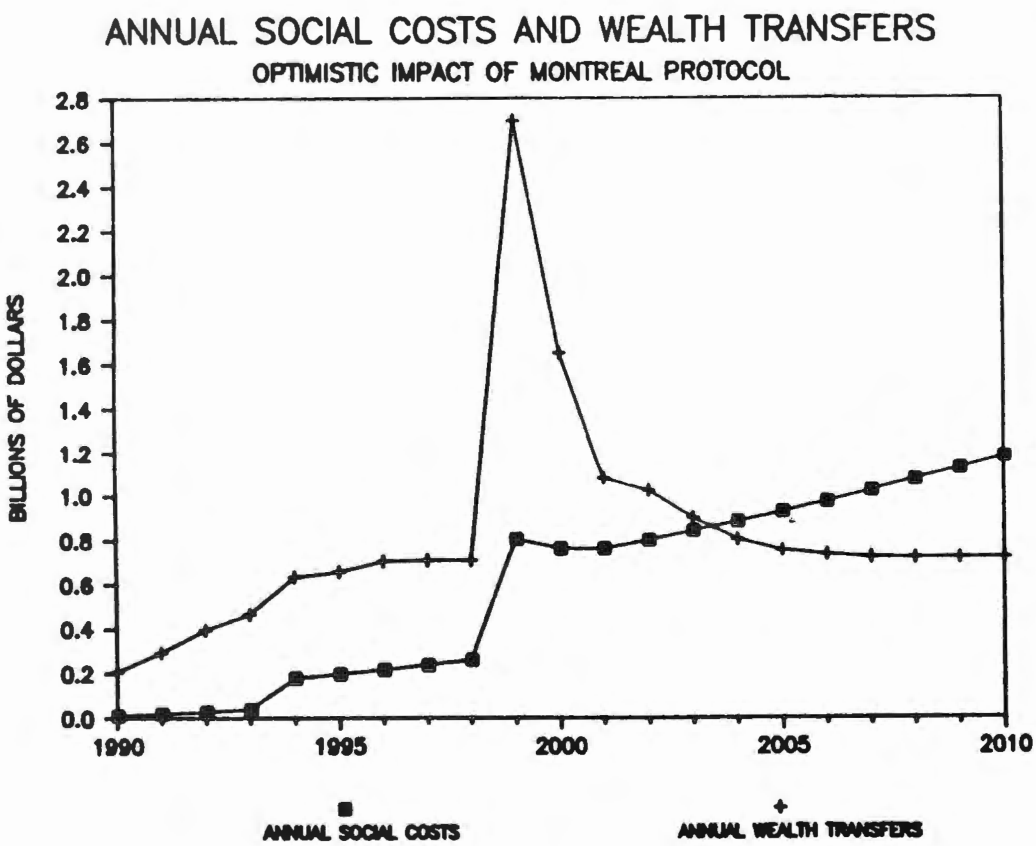
These bankruptcies will yield job losses, premature capital obsolescence, and, correspondingly, a loss in U.S. productivity and competitiveness. These significant economic impacts are not reflected in the social-cost calculation, although social costs are also very large.

The rapid increase in price could dissipate the societal consensus for CFC restriction. For example, if auto air conditioners on many cars were inoperative, then consumer dissatisfaction could undermine the basis for regulation.

After 1999, CFC-substitute use increases to the point where the price rise is moderated.

C. The Social Costs and Wealth Transfers Caused by the Protocol Are Substantial

The annual costs to society of implementing the Montreal Protocol, even given optimistic assumptions concerning CFC substitute availability, are substantial. The present value of social costs from 1990 to 2010 is $5.5 billion; the present value of wealth transfers is $9 billion. The Montreal Protocol will reduce cumulative U.S. CFC consumption by 11 billion weighted pounds between 1990 and 2010, or the equivalent of 18 years of current U.S. production of these compounds.



Examples of the effects of CFC restrictions are:

- Commercial and home refrigeration manufacturers will spend more than three times current amounts for CFC refrigerant in the mid-1990s.
- Car manufacturers will make large capital and retooling expenditures in the 1990s to allow the use of CFC substitutes in mobile air conditioners.
- Food processors will abandon liquid food freezing as CFC price rises make these frozen foods noncompetitive with lower-quality frozen products and fresh produce shipped from warmer climates.
- Medical equipment suppliers will make large capital investments in order to recycle the CFCs used in sterilant gas.
- Consumers will pay higher prices for CFC home insulation products and will reduce their demand for these products.
- Manufacturers employing CFC-113 for metal degreasing will install more conservation equipment where possible (e.g., covered openings, thermostats, refrigerated freeboard), install hot vapor recycle in new systems, and revert to methyl chloroform or emulsion cleaning in some cases.
- Furniture manufactures will employ higher density foam or switch to alternate cushioning material.
- Foam-packaging manufacturers will switch to CFC-22 or hydrocarbons as a blowing agent.
- Manufacturers or builders using spray or pour-in-place insulation will switch to non-CFC-using materials, or they will pay substantially higher prices for products blown with potential new CFC substitutes, if and when substitutes are available.
- Commercial air conditioning manufacturers will make large retooling expenditures in the middle to late 1990s in order to switch to potential new refrigerants, if viable refrigerants are available.

4. IF SUBSTITUTES ARE NOT AVAILABLE, ADDITIONAL DISRUPTIONS WOULD OCCUR

The previous CFC price projections (see page V-9) assumed that the potential new substitutes for CFC-11 and CFC-12 would be available in 1994 at a price of $1.50 per pound and $3.00 per pound, respectively. Since potential CFC substitutes are not certain to be available at that time or at that price, our CFC price forecast is optimistic.

Our analysis indicates that a 1994 substitute availability and the CFC-substitute price assumption might be optimistic for the following reasons:

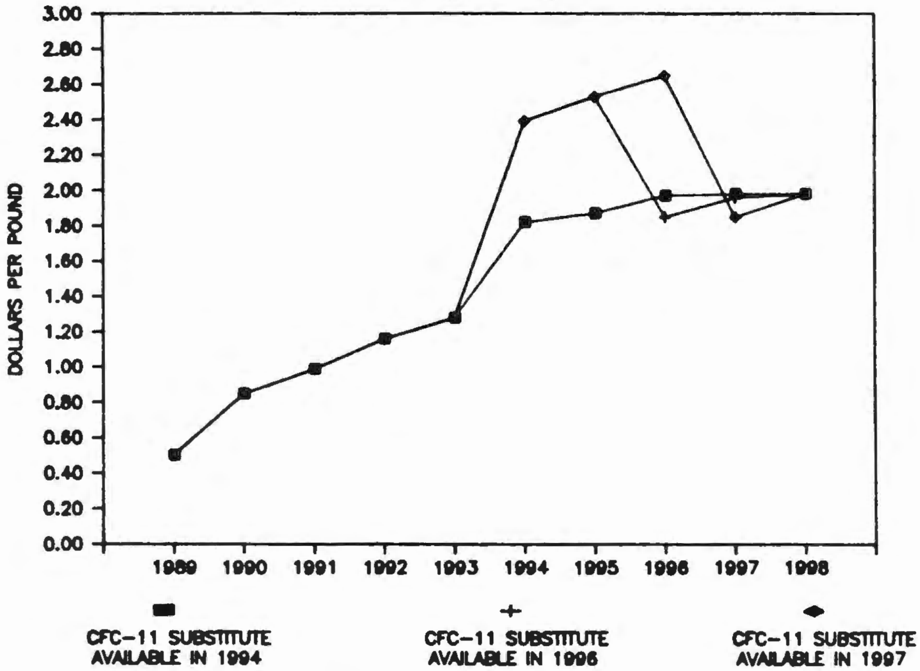
- CFC substitutes have not been tested in most applications, and testing requires time;
- CFC substitutes might pose toxicological concerns or may require costly workplace exposure controls or emission controls;
- Producers might experience difficulties in developing commercial production facilities for the CFC substitutes; and
- Applications testing may show that the most promising candidates (CFC-123, CFC-134a, CFC-141b) are not viable substitutes for some or all uses.

If the most promising substitutes are not viable, then at a minimum, several additional years would be needed to develop other viable substitutes.

CFC prices might also be higher in the short term if the price sensitivity of CFC end users is less than we have estimated.

If a viable substitute for CFC-11 does not become available until 1996 or 1997, then prices will rise more rapidly during the 1994-1997 period. These price rises will cause additional economic disruptions in the form of job losses, bankruptcy, and so forth.

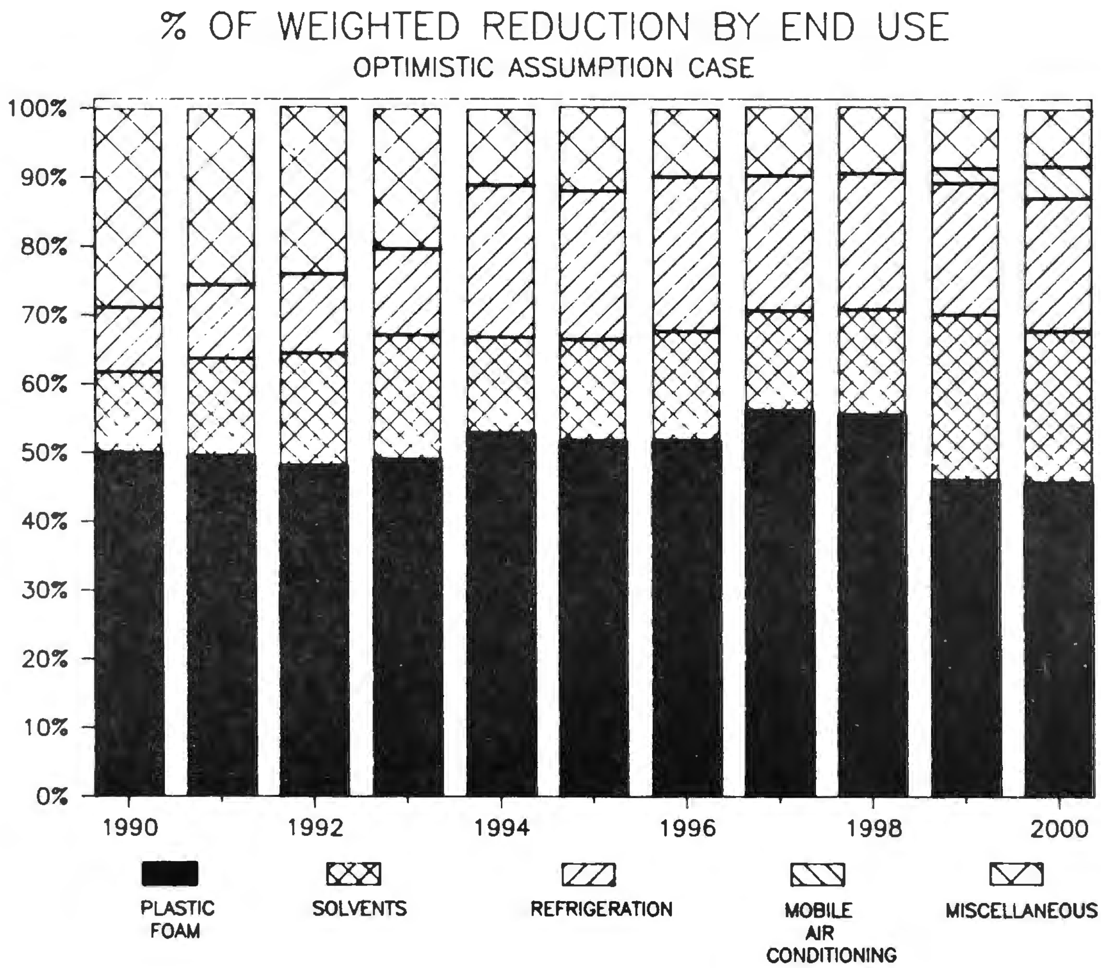
PRICE OF CFC-11 IF SUBSTITUTE NOT AVAILABLE
UNTIL 1996 OR 1997



Under a weighted pounds production quota, the price behavior of CFC-11 is essentially identical to the behavior of CFC-12 and CFC-113.

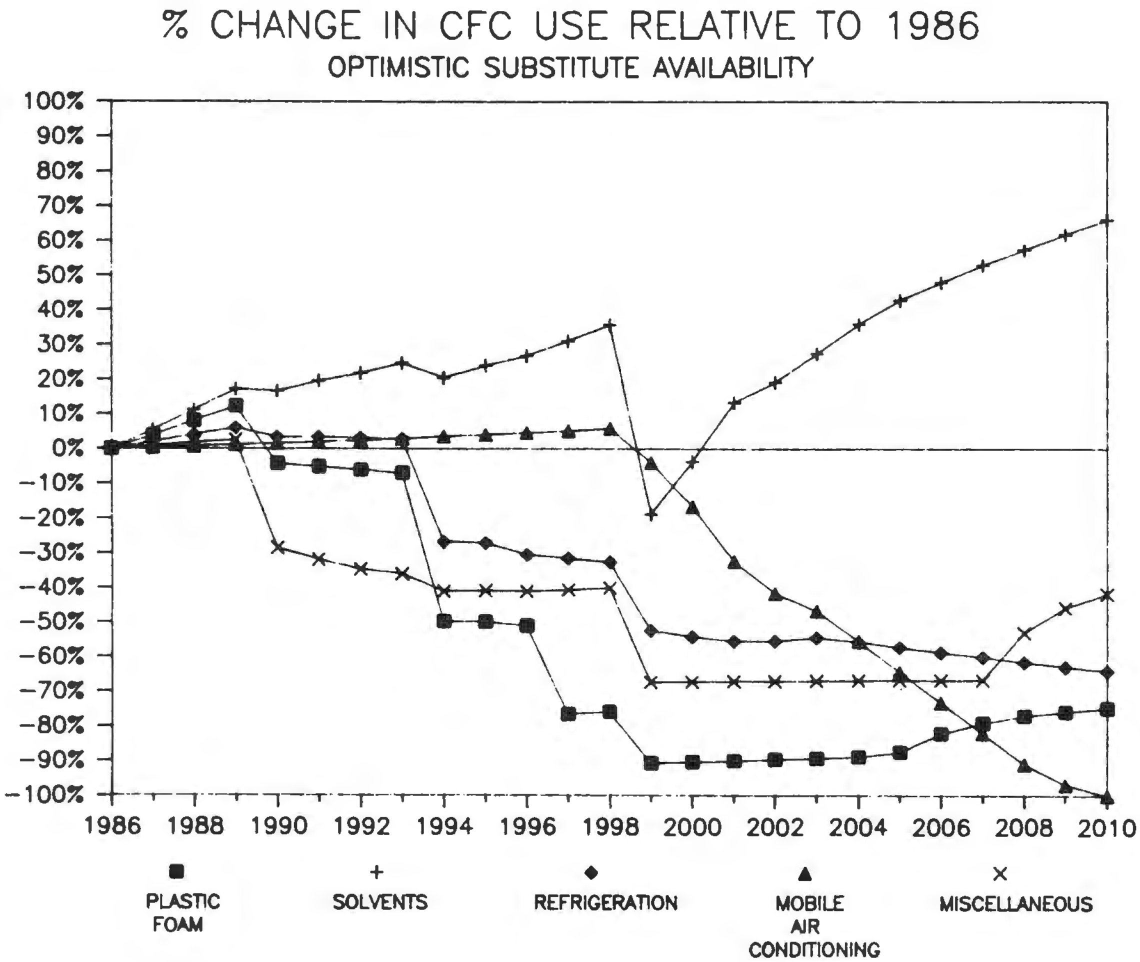
5. UNDER THE PROTOCOL, CFC REDUCTIONS ARE NOT EQUALLY DISTRIBUTED

The plastic foam industry and miscellaneous uses (e.g., sterilants, liquid food freezing) account for most of the reduction in the early years. The foam and refrigeration industries account for most of the reductions in later years.



5. UNDER THE PROTOCOL, CFC REDUCTIONS ARE NOT EQUALLY DISTRIBUTED (Continued)

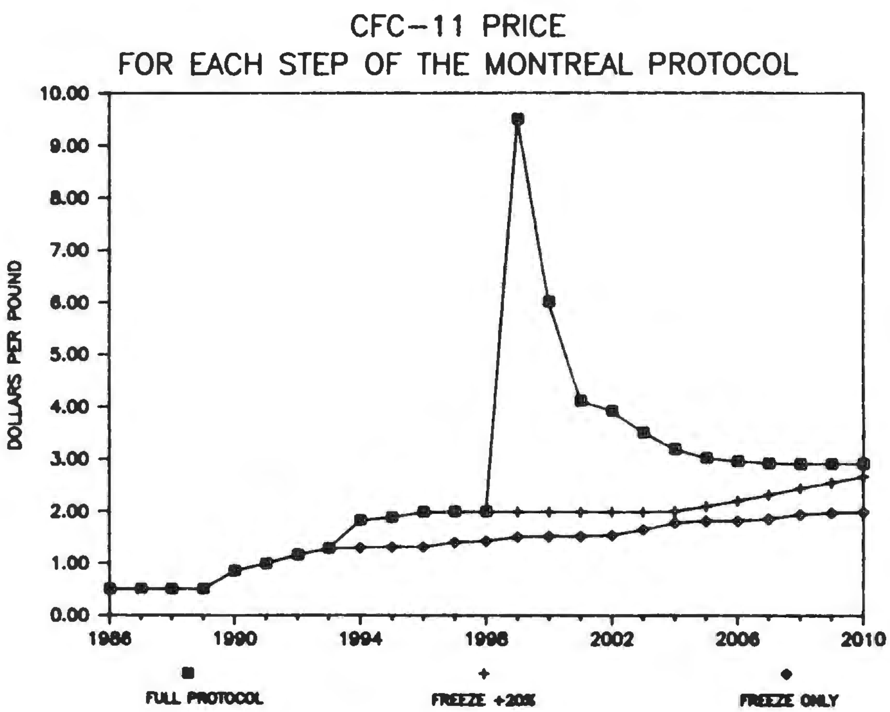
Solvent, mobile air conditioning (until 1999), and refrigeration (until 1994) applications increase use of CFCs relative to 1986 levels (although their use is less than it would have been in the absence of regulation), while other applications decrease CFC use.



6. EACH STEP OF THE PROTOCOL CAUSES SUBSTANTIAL ECONOMIC IMPACTS

A. The Price Rise Induced by Each Step Is Significant

The CFC price rise is substantial in each Protocol step. Only the 50 percent reduction step causes the price spike.

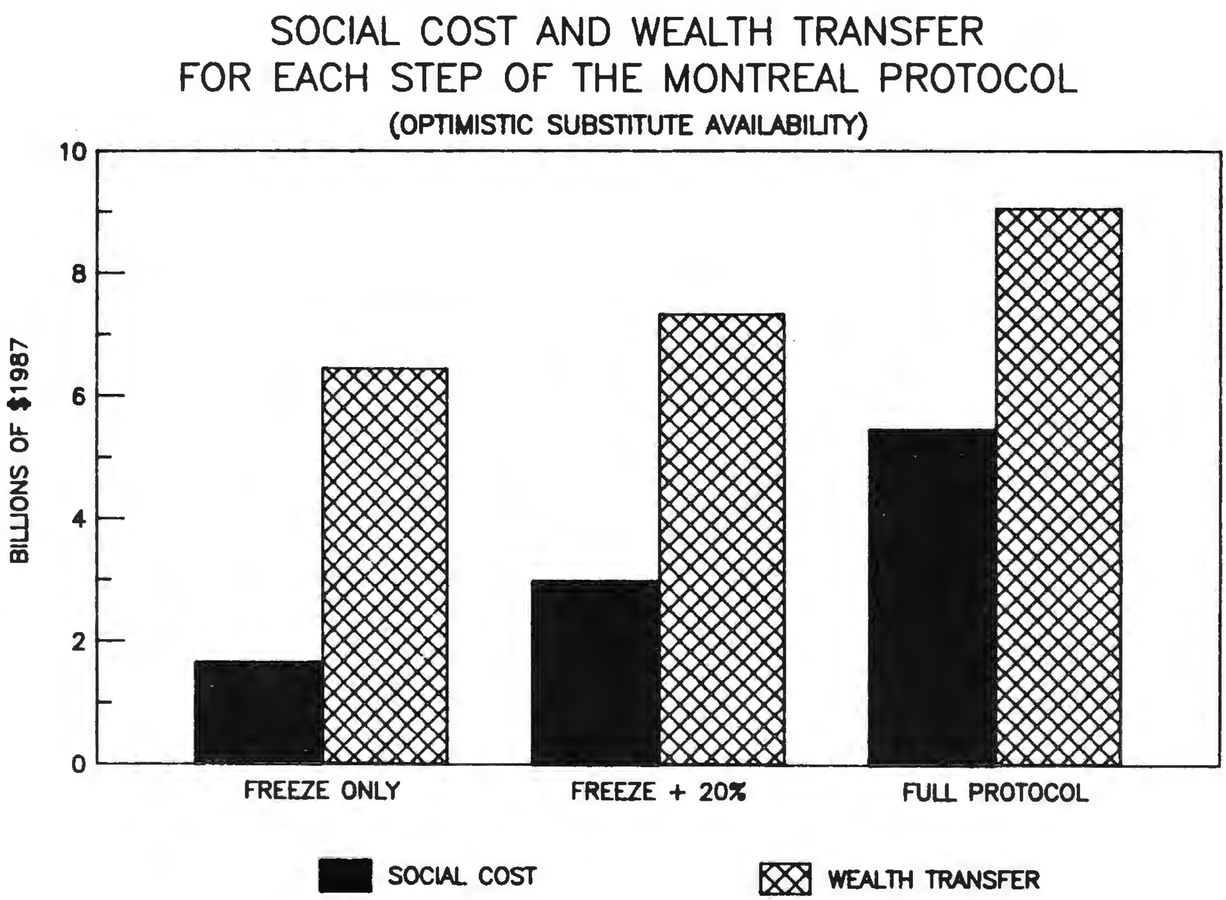


The price behavior of CFC-11 is used to illustrate the impact of each step. The price behavior of CFC-12 and CFC-113 is essentially identical.

6. EACH STEP OF THE PROTOCOL CAUSES SUBSTANTIAL ECONOMIC IMPACTS (Continued)

B. The Social Costs and Wealth Transfers of Each Step are Also Substantial

Social costs and wealth transfers would be less, although still high, if only the freeze or the freeze-plus-20-percent-reduction steps of the protocol were implemented.



6. EACH STEP OF THE PROTOCOL CAUSES SUBSTANTIAL ECONOMIC IMPACTS (Continued)

C. The Freeze and Freeze-Plus-20-Percent-Reduction Steps Both Spur Substitute Development

The CFC price rise induced by the freeze and freeze-plus-20-percent-reduction requirement will spur development of commercial quantities of potential new CFC substitutes.

Our analysis indicates that even without the 50 percent reduction step, CFC prices still would rise to the levels necessary to support introduction of CFC-123 and CFC-141b—potential substitutes for CFC-11—and CFC-134a—a potential substitute for CFC-12.

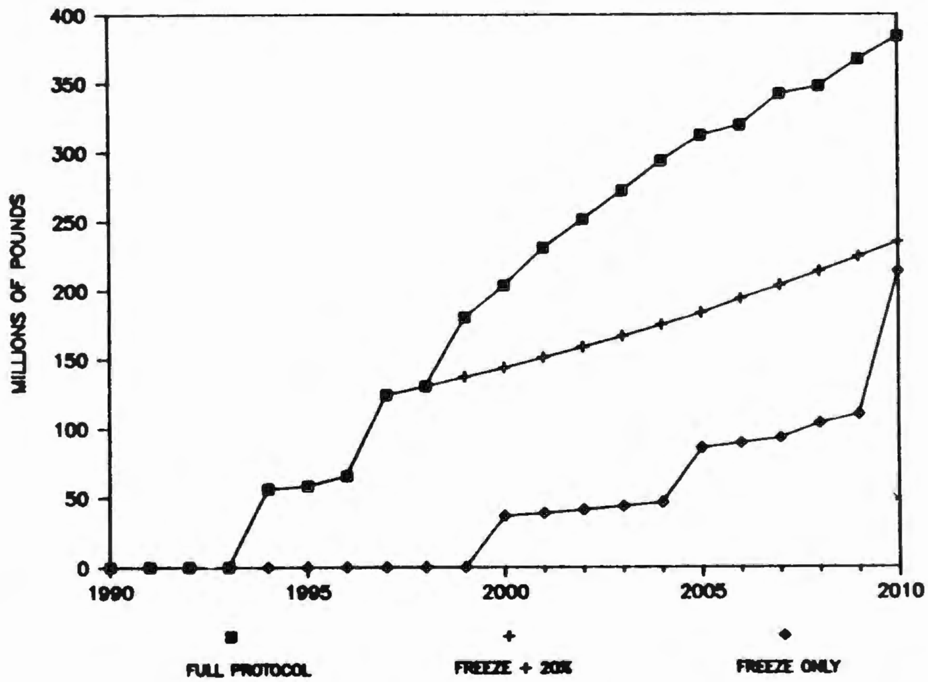
- The time at which each potential substitute becomes competitive depends on the rate at which CFC prices rise, on each substitute's production economics, and on the price sensitivity of each user group.

Higher CFC prices would:

- Provide sufficient incentives for conservation technologies to be applied by industry and
- Reduce CFCs in some applications (e.g., fiber board might be used in building insulation instead of CFC insulating rigid foam, in spite of the reduced insulation efficiency).

The use of potential new substitute CFCs, which may include CFC-123, CFC-134a, and CFC-141b, is expected to grow substantially under the full Protocol and under the freeze-plus-20-percent-reduction step alone.

ANNUAL USE OF POTENTIAL NEW CFC SUBSTITUTES FOR EACH STEP OF THE MONTREAL PROTOCOL*



*Includes projected use of three potential CFC substitutes: CFC-123, CFC-134a, and CFC-141b. Does not include the use of chemicals that are commercially available currently and that may be suitable chemical substitutes in some applications.

7. UNILATERAL ACTION WOULD IMPOSE SUBSTANTIAL COSTS

Pending legislation calls for a 95 percent reduction in CFC use by 1993. The costs of this legislation would be extraordinary compared to the cost of the Protocol and extend beyond our ability to reliably forecast CFC-related impacts.

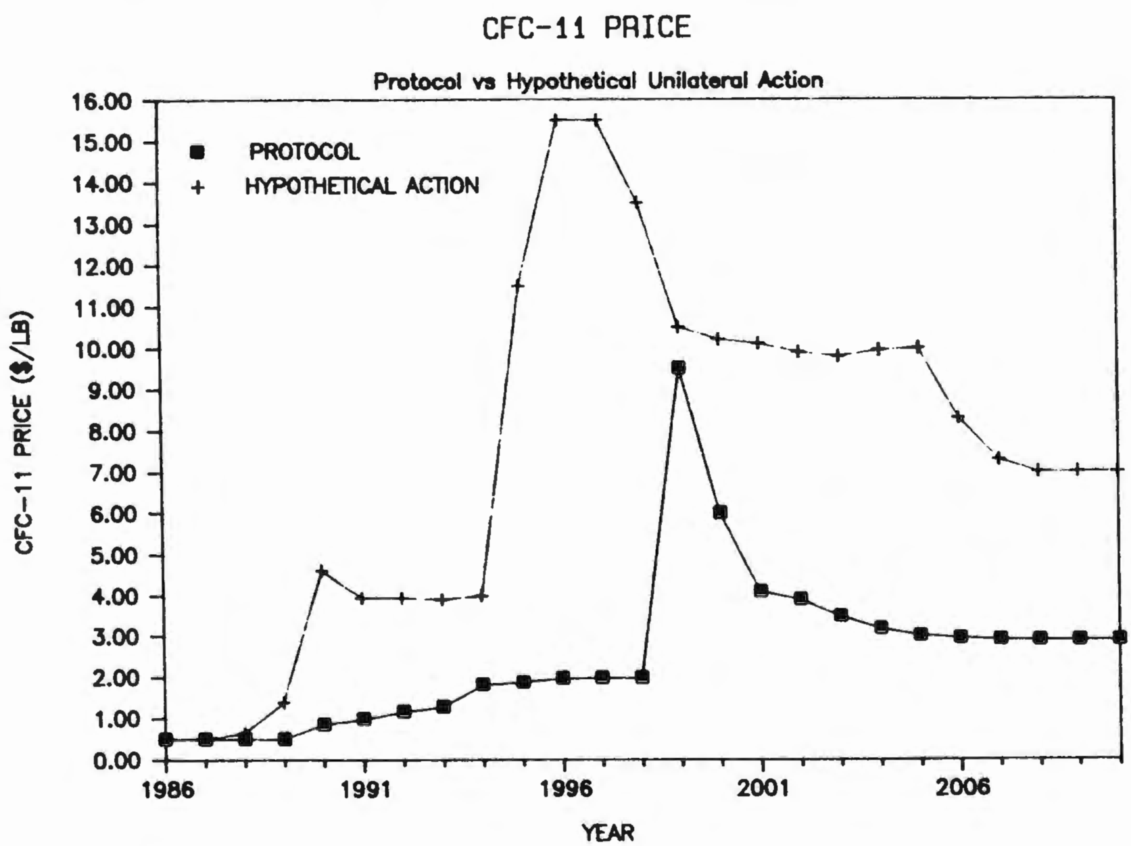
If enacted, pending legislation would be vastly more costly but would not be much more effective in reducing global emissions relative to the Protocol. For example, a 95 percent reduction by 1993, while beyond our model's ability to reliably predict impact, we believe would cost the U.S. economy at least $20 billion—about four times the cost of the Protocol. Recent scientific analysis indicates such a requirement would have a negligible effect on ozone depletion compared to the significant effect of the Protocol.

As an alternative to the pending legislation, we examined a hypothetical unilateral action that required:

- A 30 percent reduction in 1990,
- A 50 percent reduction in 1995, and
- Increasing reductions to 70 percent by 2005.

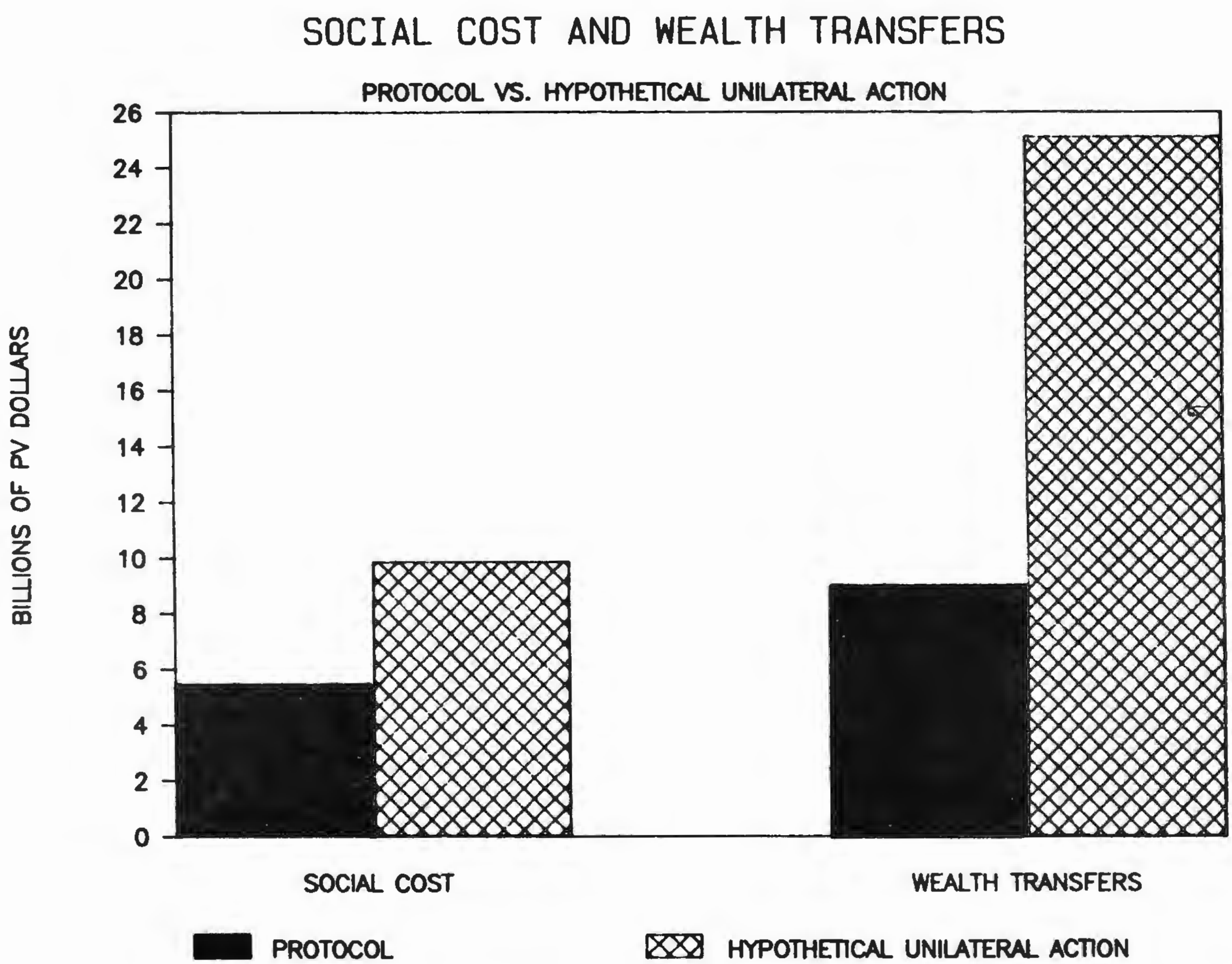
As the following exhibits show, this hypothetical action almost doubles the economic costs of regulation from $5.5 billion to almost $10 billion, while only reducing worldwide emissions by 7.3 percent.

Unilaterial action will result in substantially higher prices than the Protocol. Assuming CFC substitutes are available by 1994, CFC prices would rise to almost $16.00 by 1996 and would remain above $7.00 throughout the analysis period. Relative to the Montreal Protocol, under the assumed hypothetical unilateral action scenario, U.S. and world emissions would be reduced by 24.6 percent and 7.3 percent, respectively.



7. UNILATERAL ACTION WOULD IMPOSE SUBSTANTIAL COSTS (Continued)

The cost to society of this hypothetical unilateral action is almost double the cost of the Montreal Protocol ($9.9 billion versus $5.5 billion). The wealth transfers almost triple from $9 billion to $25 billion.



8. IMPACT ON INTERNATIONAL TRADE

The impact of the Montreal Protocol will depend heavily on implementation. Under Article 3, beginning in 1993, CFC exports to Non-Parties are excluded from the consumption calculation (i.e., the exporting nation is charged with consumption). Article 4 provides for four types of controls on trade with Non-Parties:

- A ban on CFC imports one year after entry into force.
- A ban on CFC exports by Developing Countries beginning 1 January 1993.
- A ban on import of CFC-containing products within four years after entry into force, but only if listed in an annex that has yet to be created.
- A ban on imports of products produced with CFCs within six years after entry into force, but only if listed in an annex that has yet to be created.

Implementing the Protocol trade provisions presents a number of difficult issues; however, implementation procedures have yet to be defined.

- Since the important controls on CFC-containing and CFC-produced products will not be addressed until after the Protocol takes effect, some adverse trade impacts are possible but difficult to ascertain at this time.

However, if unilateral CFC restrictions beyond the Protocol are implemented, important adverse trade impacts are likely.

Examples of potential adverse impacts include the following:

- Unilateral action would cause higher domestic CFC prices, leading to higher prices for final products using CFCs thus putting U.S. firms involved in international trade at a competitive disadvantage.
- The impact of the CFC price rise would vary according to the amount of CFC used in the end product, as well as the price of the end product.
- Unilateral action could cost U.S. industry foreign customers, as these customers switch to lower-cost foreign suppliers.
- Unilateral action would place U.S. industry at a competitive disadvantage since end users would face higher input prices as well as the costs of retooling their production lines in advance of foreign industries.
- Unilateral restrictions beyond the protocol would further damage the U.S. industry's international competitiveness. U.S. end users have already made significant reductions in their CFC usage as a result of previously mandated cutbacks. Under the Protocol alone, industry will need to reduce its CFC usage in applications far beyond those required of other signatories.
- Additional U.S. legislative action beyond the Protocol could precipitate capital flight as end-use industries shift production facilities offshore to postpone adjustment. This could mean the loss of jobs in the United States.
- If U.S. industry were rushed into developing substitute products, it would face the possibility of greater servicing requirements and costs. This is because some CFC substitutes will place greater strains on equipment, which could in turn make U.S. products less competitive in nations that have the option of purchasing systems with CFCs or their chemical substitutes.
- Unilateral action could restrict the availabilty of CFCs to trade-sensitive industry segments (e.g., electronics and air conditioning).

  Lost export sales would seriously injure domestic industry. For example, the commercial refrigeration sector exported approximately $145 million in 1986. With growing international demand for commercial refrigeration products, limiting industry's access to CFCs could result in either significant losses in foreign sales or a shift to overseas production.

9. COMPARISON OF PRODUCTION QUOTA WITH AUCTION-PERMIT SYSTEM

The analysis in this study is based on the assumption that CFC restrictions would be implemented using a production-quota type of regulation. An auction-permit system is another regulatory approach under consideration by EPA.

An auction-permit system would differ from a production quota in that the rights to purchase and use CFCs would be acquired through a government-sponsored auction. The proceeds of the auction would be retained by the government. Hence, wealth would be transferred from end users to the government.

Both a production quota and an auction-permit system are considered economically efficient by economists. Many drawbacks of the auction-permit system relative to a production quota stem from uncertainty with respect to how the government would operate such a system.

The principal concerns and problems with an auction-permit system are:

- Prices might be more volatile than under a production quota. In a production quota, producers can adjust market prices to reflect changes in demand and supply of CFCs. Periodic auctions do not have this flexibility; hence, buyers may bid prices up higher than expected under a production quota to assure supply.
- Prices would rise higher than under a production quota if speculators rather than just users or producers were allowed to purchase permits.
- Prices would also be higher if the government sold permits to the highest bidders at the prices offered in the bids, rather than at the price that would be just sufficient to sell the number of permits to be auctioned. This type of auction would also increase the cost of regulation.
- The timing or duration of the permit could cause a variety of problems. If permit duration were too short, prices could rise higher than they might otherwise so users could obtain a secure supply. If duration were too long, incentives for switching to CFC substitutes may be reduced.
- The act of auctioning permits might induce bidding strategies that result in a less efficient allocation than the production quota. This effect would increase the total cost of regulation. Such a situation could occur if some users underestimate the likely permit prices and do not acquire sufficient quantities of CFCs in the auction.
- Small businesses who are less capable of obtaining information on the operation of the auction-permit system may not participate in an auction as effectively as their larger business competitors.
- With up to 10,000 major CFC buyers and as many as 375,000 users, the administration of an auction-permit system could be cumbersome and costly. Management and enforcement of this type of system would require many more EPA staff than under a production-quota regulation.

In summary, relative to a production quota, an auction-permit system could result in increased market uncertainty, higher CFC prices, and higher-cost regulation. Further analysis of an auction-permit system would require more specific information on how such a system would operate.

SUMMARY OF FINDINGS

1. The Montreal Protocol will require substantial reductions in CFC usage since demand for CFCs is growing rapidly. In the absence of restrictions, CFC use would grow by 48 percent from 1986 to 1999 and by 119 percent by 1986 to 2010.
2. The severity of the Protocol's economic impact is highly dependent on the timing and commercial availability of non-ozone-depleting chemical substitutes for CFCs.
3. Even under optimistic assumptions concerning the availability of potential CFC substitutes (i.e., substitutes are commercially available in 1994), the economic impact of the Protocol will be very large:
   A. CFC prices will rise significantly for user industries and consumers; for example, CFC-11 will rise from $0.50 in 1986 to almost $2.00 in 1994.
   B. In 1999, when the 50 percent reduction is required, a substantial price rise (i.e., price "spike") is expected. The price spike, which is caused by the inability of substitutes, process controls, and conservation measures to satisfy the 50 percent target level, would cause major market disruptions.
   C. Social cost to the U.S. economy will be $5.5 billion between 1990 and 2010. Over $9 billion (present value) of wealth will be transferred away from consumers and user industries between 1990 and 2010.
      —U.S. CFC consumption will be reduced by over 11 billion weighted pounds between 1990 and 2010 or the equivalent of more than 18 years of current U.S. production of these compounds.
4. If substitutes are not commercially available for widespread use by 1994 (when the 20 percent reduction is required), an economically disruptive price "spike" would likewise occur and continue until substitutes are commercially available.
5. CFC reductions induced by the Protocol will not be equally distributed among user industries. Some of the least price-sensitive users (e.g., electronic solvents, mobile air conditioning) can increase their CFC use, relative to 1986 levels, at the expense of more price-sensitive users (e.g., plastic foam users) or users that have available substitutes.
6. Substantial economic costs would be incurred if just the freeze or only the freeze and the 20 percent reduction were implemented.
   A. The price rise induced by the Protocol reduction scenario, the freeze only, and the freeze with 20 percent reduction would all induce significant price rises; however, only the 50 percent reduction step of the Protocol causes the price spike.
   B. The social costs and wealth transfers of each step are also substantial. Social costs are about $2 billion for the freeze alternative and $3 billion for the freeze with 20 percent reduction alternative.
   C. The Protocol, the freeze-only, and the freeze-with-20-percent-reduction alternative would all spur development and high usage of CFC substitutes in response to much higher CFC prices. Since the 20 percent reduction will provide sufficient price incentives to use CFC substitutes, the costs associated with the additional 30 percent reduction in the Protocol should be considered as part of the Protocol's ongoing scientific, technological, and economic evaluation process.
7. Proposed legislation unilaterally reducing CFC usage more than required by the Protocol would substantially increase the economic cost of CFC restrictions.
   - Pending legislation calls for a 95 percent reduction by 1993. The cost of this legislation would be extraoridinary and extends beyond our ability to reliably forecast CFC prices.
   - As an alternative, we examined a hypothetical unilateral action that required a 30 percent CFC reduction in 1990, increasing to 50 percent in 1995 and 70 percent by 2005. This hypothetical action to further restrict U.S. CFC usage could increase costs from $5.5 billion in the Protocol to almost $10 billion, while only reducing worldwide emissions by another 7.3 percent.
8. The impate of the Montreal Protocol on international trade will depend heavily on implementation. However, if U.S. unilateral reductions beyond the Protocol are required, then potentially severe trade impacts could occur, especially if the availability of CFCs to trade-sensitive segments is curtailed.
9. The method of implementing the Protocol in the U.S. could affect costs. Relative to a production quota, an auction-permit system could result in increased market uncertainty, higher CFC prices, and a higher-cost regulation.