CHAPTER 12: GLOBAL POLLUTANTS

I. Introduction

A. In turning to global pollutants, the problems inherent in local pollutants are just exacerbated.

B. With local pollutants, we were dealing with problems of externalities within a country or state.

C. We now have to consider externalities crossing national boundaries.

D. In the case of global pollutants, we have even more trouble understanding the consequences of our actions and the potential solutions.

  1. Transfer coefficients are hard to determine.
     a. Especially true for trace gases, i.e., gases that are a minor component in the atmosphere.

  2. In the short term, trends are difficult to determine.

  3. Cannot force other nations to abate their emissions as in the domestic case: free-riding among nations

E. Major issue: ozone depletion and global warming.

  1. Concentration levels of GHGs and ODCs have been increasing

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II. Chlorofluorocarbons and depletion of the Ozone.

A. Ozone in the troposphere (i.e., that portion of the atmosphere nearest to the earth) is a criteria pollutant.

   It causes agricultural damage and respiratory problems for humans, in addition to corroding metals and damaging paints.

B. In the stratosphere, just above the troposphere, ozone is crucial to the quality of life on the earth.

   1. Ozone absorbs ultraviolet wavelengths, shielding people, plants and animals from harmful radiation.

   2. It also absorbs infrared radiation, thus playing an important role in determining the earth's climate.
C. Ozone is being depleted
   1. Since late 1960s, ozone thinning averaged 5% worldwide
   2. Ozone depletion over Antarctica

![Ozone Depletion Over Antarctica](image)

D. Effects of ozone depletion
   1. 1% reduction in ozone leads to 2% increase in harmful UV radiation exposure
   2. UV radiation may cause
      a. skin cancer
      b. suppression of immunological systems
      c. eye cancer in cattle
      d. plant damage

E. CFC's have been implicated in the stratospheric ozone depletion.
Specifically, CFC-11 and CFC-12

Major ozone depleting chemicals

| Table 20-2, Field |

CFC's were invented in the 1930's by DuPont

F. **CFC's are used in**

1. aerosol propellants
2. cushioning foam
3. packaging and insulation foam
4. industrial cleaners (e.g., used in degreasing computer circuit boards).
5. food freezers.
6. industrial sterilization (e.g., used in medical sterilization)
7. air conditioning and refrigeration (Freon is based on CFC's)
8. Dry Cleaning
9. Photocopiers

G. ODC’s concentration level has been increasing.

1. US is the major player in ozone production and consumption
2. In 1978, the U. S. banned the use of some CFC's in aerosol propellants.
   a. This reduced the U. S. contribution to worldwide CFC emissions from about 50% to around 33%.
   b. However, global CFC emissions continue to increase in use.

3. Major emitters of CFC

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H. Costs of controlling nonaerosol application of CFCs in US: the RAND study.

1. Mandatory controls
2. A constant emissions charge.
3. A permit system.

Note: CFC's are a stock pollutant, so that the permits would have to be not on a per/year basis, but rather on a total quantity basis.

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Each method achieved approximately the same goal.

4. Inefficiency of a constant emissions charge:
   a. The charge should rise over time, as the “stock” of allowed CFC concentration rises “depletes”.
   b. Permit price can achieve this.

I. International efforts: the Montreal Protocol
1. Now there are about 140 countries in the Protocol
   a. There were 24 signatory countries initially in 1988

2. The Montreal Protocols called for:
   a. Till 7/1/93: reduce annual consumption and production (ACP) of CFCs to 1986 levels
   b. From 7/1/93 to 7/1/98: ACP cannot exceed 80% of 1986 levels
   c. After 7/1/98: ACP cannot exceed 50% of 1986 levels
   d. Emission transfer between Protocol parties are permitted
   e. Import ban of controlled substances from nonparties starting 1990
   f. Export ban of substances from parties to nonparties starting 1993
   g. Developing countries with consumption < 0.3 kg/capita has 10 years delay in compliance.
   h. Multilateral fund ($240million) to aid developing countries to phaseout old technology and technology transfer.

| Table 20-1, Field |

III. Global Warming

A. One class of global pollutants ("greenhouse gases") absorb infrared radiation as it is reflected from the earth's surface, trapping heat that would otherwise escape into space.

Greenhouse gases include

1. carbon dioxide
2. CFC's
3. Nitrogen Oxides
4. methane
5. tropospheric ozone
B. Concentration of GHGs has been increasing rapidly

1. Since industrial revolution, CO$_2$ +30%; Methane, +100%; Nitrous oxide, +15%.

2. GHG concentration projected to reach double pre-industrial level by about 2060.
C. Contributing countries

### Regional Contributions to Greenhouse Gases

- **Rest**: 36%
- **India**: 4%
- **USA**: 21%
- **Former USSR**: 14%
- **EEC**: 14%
- **China**: 7%
- **Brazil**: 4%

1. Major polluters of industrial-based CO₂.

### Table 4.3, Sandler

2. Methane

### Table 4.4, Sandler

3. Share of developing countries is expected to increase
4. In the U.S.
   a. CO₂ is the major GHG
b. Utilities and transportation are major polluters

U.S. Carbon Dioxide Emissions from Fossil Fuel Combustion: 1995

Source: DOS, 1997

D. The exact implications of an increase in greenhouse gases is not well understood.

1. There are a variety of unknowns in the greenhouse effects. Uncertainty is significant.

2. A doubling of the CO$_2$ level would, in and of itself, lead to an increase in the global air temperature of 1.2° C (2.2° F).

3. There are some not so well understood feedback effects:
   a. Increasing the heat will increase water vapor, which is itself a greenhouse gas, leading to more temperature increases.
   b. Increasing the temperature will decrease the amount of snow and ice, which are effective energy reflectors, again further increasing the heat.
   c. Increased cloud cover may increase or decrease the initial effect.
   d. The heat absorptive capacity of the ocean in unknown, or at least not well modeled.

4. Overall, the EPA estimates that a doubling of CO$_2$ gases would increase the global air temperature by 4° C or 7° F.
As a basis of comparison, it is estimated that the last Ice age coincided with a temperature 7° F less than the current global temperature.

1. It is hard to say.

2. The temperature records for the last century suggest that the surface air temperature has increased by .6° C (or 1° F) in the past century.

3. However, there is uncertainty regarding the reliability to these measurements.

   a. Large portions of the globe were poorly sampled.

   b. A recent study found that part of the problem is due to the location of many weather stations in urban areas.

      i. The heat generated by those cities is potentially substantial.

      ii. Correcting for this problem, the study found "...no statistically significant evidence of an overall increase in annual temperature or change in annual precipitation for the contiguous U. S. , 1895-1987."

4. Computer Models are attempting to capture "...interactions of people and nature that are so staggeringly complex that they can't be duplicated accurately on
computers. "We are mostly twiddling knobs at random," (WSJ 4/10/89) according to the former director of the National Center for Atmospheric Research.

5. This does not mean that the problem does not exist, but just that we may not yet be able to measure the change.

F. The impacts of temperature increases are not well understood either.

1. Widespread impacts (either positive or negative)

2. Different impacts on different parts of the world
   a. The president of the Republic of Maldives has told the U. N. General Assembly that the global warming could completely inundate his island nation.
   b. Some areas/countries would benefit, including the former Soviet Union and Canada, two major sources of CO₂ emissions.

3. For the U. S. the results would be mixed, given the size of the country. Some of the impacts, however, would include:
   a. Agricultural
      i. Shifts in agricultural states.
• Minnesota would benefit to some extent by the shortening of the winter.

• The Great Plains in general, a marginal agricultural region in the U. S., would partially be abandoned in terms of agriculture.

ii. Increased dryness would increase reliance on irrigation, increasing the pressures on groundwater supplies, particularly in the southwest.

iii. Crops would benefit to some extent by the increased CO$_2$ in the atmosphere.

iv. The pests farmers would have to deal with in a given region would change.

v. An EPA study concluded that, while U.S. food supply would continue to be adequate, it would substantially decrease.

b. Forests

Substantial northern migration in trees would occur, endangering wildlife, etc.

c. Sea Levels

i. Global warming would raise sea levels by melting mountain glaciers and causing ice sheets in Greenland, etc., to slip into the sea.

ii. This would inundate wetlands and lowlands, exacerbating coastal flooding and soil erosion problems.

• A 50 cm. rise in the sea level would drown » 1/3 of coastal wetlands.

• A 1 meter rise would eliminate as much as 70% of coastal wetlands.

iii. A 1 meter rise would inundate 7,000 to 8,000 sq miles of dryland, an area the size of Mass.

d. Electricity Demand would substantially increase. New power plant needs would increase by 14 to 23%.

This would increase further the problems of global warming and acid rain.
e. Increased global rainfall, but not necessarily evenly dispersed.
   i. Water distribution systems currently in place may no longer be efficient.
   ii. Some may become inundated.

f. Wildlife habitats would be destroyed in some cases.

g. Warmer oceans and seas would spawn stronger hurricanes and typhoons.

h. Nordhause study

Table 6.3, Kahn

G. What can or has been done?

1. A number of simple minded solutions have been suggested.
   a. A Soviet scientist suggested spreading tons of dust into atmosphere to reflect solar heat.
   b. A Virginia utility suggested that it would plant trees to offset its emissions. But a forest the size of Ethiopia would be required to reduce greenhouse emissions by 10%.

2. A solution to the greenhouse effect will come only with international cooperation and organizations that can survive changes in governments.

3. Earth Summit in Rio de Janeiro, 1992
   a. Virtually all of the countries signed the Framework Convention on Climate Change (FCCC)
   b. Industrialized countries (Annex I nations) are to stabilize emissions at 1990 levels in the year 2000
      i. U.S. did not commit to the stabilization period.
   c. Global Environment Facility (GEF) also has the responsibility to implement these goals.
   d. Joint implementation.
      i. cooperation between two or more countries to decrease the sum total of their emissions
      ii. experience to date has been small projects
iii. essentially a developed country purchases the “right” to continue its current emission through ensuring decreased emission from developing countries

4. Kyoto Protocol: extension of the Summit
   a. Annex I countries to reduce emission to 5% below 1990 levels by 2012

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<td>b. Emission trading is explicitly allowed.</td>
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<td>i. how to allocate the permits?</td>
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<td>c. No specific schedule for developing countries: caused problems in the U.S.</td>
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H. In general it is more difficult to form international cooperation in controlling GHGs than ODCs. Reason:

1. Less scientific uncertainty in the impacts of ozone depletion.

2. Consumption and production of CFCs are concentrated in a smaller group of countries.
   a. the free riding problem is less severe

3. Substitutes for CFCs are available: HFC. This is not true for GHGs.

4. Leadership of the largest polluter: the U.S.