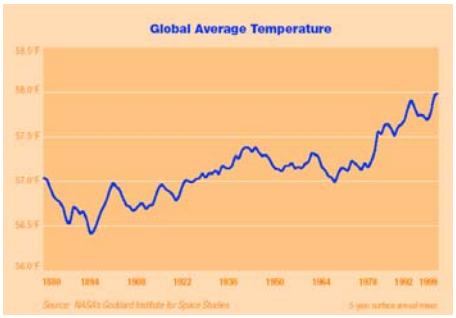
COLUMBIA BUSINESS SCHOOL

Lecture 6

- Decentralized vs. Centralized Optimization
- Context: Pollution Regulation
- Efficiency vs. Equity

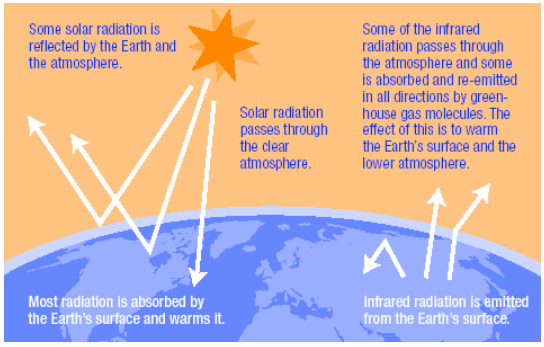
Global Warming

- There has been a 1^0 F average temperature rise over the last century.
- The ten warmest years have occurred since 1983, with seven of them since 1990
- The 20th century was the warmest in the last 1,000 years.
- The 1990's were the warmest decade and 1998 was the single warmest year in the past millennium.

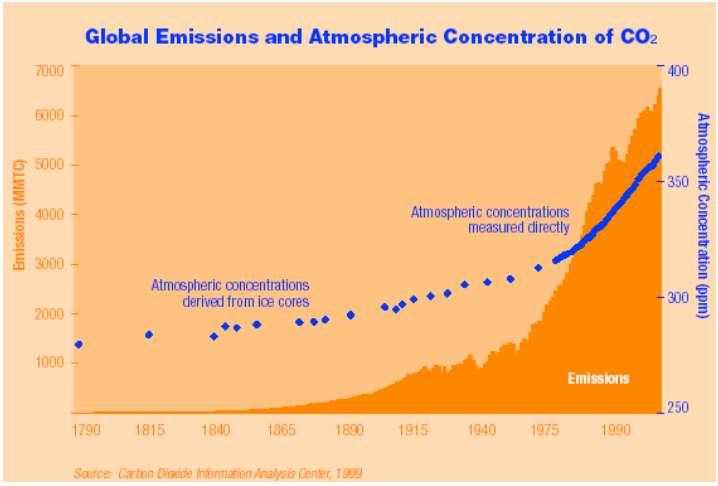


Greenhouse Effect

- Greenhouse gases: e.g. carbon dioxide, methane
- The Intergovernmental Panel on Climate Change (IPCC) concluded that there is a "discernible human influence"
- IPCC projects an average global temperature increase of 2^0-6^0 F by 2100



- A 9^0 F drop in temperature during the last ice age was enough to cause massive ice sheets to extend as far south as New York City



- CO_2 concentrations are now higher than any seen in the last 450,000 years
- Natural CO_2 cycle
  - Decreasing CO_2 emissions appears necessary

Overview

- Corporate perspective
  - Brief discussion
- Policy maker's perspective
  - Use decision models to get insights on advantages, disadvantages of mechanisms to reduce CO_2 emissions
  - Potential implications
    - Efficiency
    - Equity

Regulating Greenhouse Gas Emissions

- 1992 Earth Summit in Rio
  - Annex 1 ("developed") countries to reduce their emissions to 1990 level by the year 2000
  - Institutions to devise implementation policies: Global Environment Facility (GEF), UN Framework Conventions on Climate Change (FCCC), on Biodiversity, on Desertification
- In 1997 in Kyoto, they agreed to cut even further (5.2% below 1990 levels by 2012)
  - US 7%, EU 8%, Canada and Japan 6%, Russia 0%
- US did not ratify Kyoto later on
  - Argued it was too expensive and wrongly excluded developing nations
- 120 countries ratified Kyoto, but represent only 44% of CO_2 emissions

Pollution Patterns: Developed vs. Developing Countries

- Current pollution breakdown:
  - Developed countries: 70%
  - Developing countries: 30%

- Perceptions about pollution differ
  - Developing countries
    - The root of the emission problem = pollution from developed countries
    - Limits on emissions = limits on growth
  - Developed countries
    - Focus on long-term environmental problems originating mostly in developing countries

Viewed as a Large-Scale Optimization Problem

The key issue is how best to reduce greenhouse gases; What activities, industries, countries, regions, etc. should make reductions such that the world-wide economy suffers the least?

Maximize Total World-Wide Utility of Economic Output

Subject to Total CO_2 Emissions $\leq$ X

How do you solve a problem like this?

How can coordination be achieved in general?

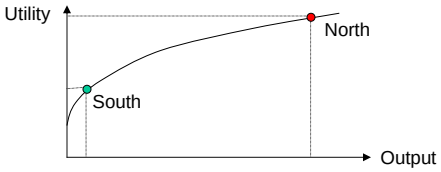
- Centralization
  - Coordinating authority collects all relevant information, solves overall optimization problem and imposes optimal actions on all parties
- Decentralized approach
  - Coordinating authority creates incentives. Individual parties make their decisions independently based on provided incentives
- Pros and Cons

Policy Approaches to Pollution Reduction

- Fixed emission quotas (non-tradable)
- Carbon Tax
  - No limit on emissions.
  - Each unit of emission is taxed at a given rate.
- “Cap-and-Trade”
  - Emissions require permits.
  - Total number of permits = Total desired emission level
  - Permits can be traded among countries

Exercise Context: Simple Model of Pollution Regulation

- Two different country types: North and South
- Different endowment levels (labor, capital, resources, etc.)
  - 35 units for North
  - 5 units for South
- Choice of "clean" and "dirty" technologies
  - "Clean" is more costly
  - "Dirty" pollutes more
- Both types of countries have the same utility for output: $\text{Utility} = \sqrt{1 + \text{Output}}$
  - Increasing in output
  - Decreasing marginal utility (concave)
    - North country values "extra unit" of output *less* than South country



Exercise Outline

- Step 1: Form North and South groups
- Step 2: Study the case of unregulated emissions
- Step 3: Investigate different approaches to pollution reduction
  - Fixed emission quotas
  - Centralized regulation
  - Taxes
  - Cap-and-Trade approach

Step 2: Case of Unregulated Emissions

- Each country maximizes its utility subject to limited endowment. (Unregulated North/South sheets)

Step 3: Cutting Total Emissions Back by 20%

- Approach 1: Give each country a fixed quota of 20% less than the amount they are using up today (20% Prop North/South sheets)
  - Set emission limit for each North country at 80% of its unregulated value: 0.8*11.667=9.333
  - Set emission limit for each South country at 80% of its unregulated value: 0.8*1.667=1.333

- Approach 2: each country has the same emission limit such that the total emissions are reduced by at least 20% (20% Equal North/South sheets)
  - What is the limit?

Questions

- How efficient are the approaches?
- How fair are the outcomes?
- What would be required to determine and implement each approach?

What allocation maximizes total worldwide utility?

Centralized Regulation

- Maximizing total “worldwide” utility, subject to limit on total emissions reflecting a 20% reduction (Centralized Regulation sheet)

Questions

- How efficient is the outcome?
- How fair is the outcome?
- What would be required to determine and implement this centralized regulation mechanism?

Decentralized Approach

- Coordinating authority creates incentives. Individual parties make their decisions independently based on provided incentives

- How?
  - Taxes
  - Cap-and-Trade

Decentralized Approach I: Taxes

- No limits on emissions
- Each unit of emission is taxed at a given rate.
- Each country maximizes its utility net of taxes.

- What should the tax rate be?

Questions

- How efficient are the outcomes?
- How effective is the approach at reducing emissions?
- How fair are the outcomes?
- What would be required to determine and implement such a tax based method?

Decentralized Approach II: Cap and Trade

- Emissions require permits.
- Total number of permits = Total desired emission level
- Permits can be traded among countries.
- Initial allocation of permits proportional to unregulated emission levels.
- Each country maximizes its utility net of permit cost (or in addition to permit revenue)

Questions

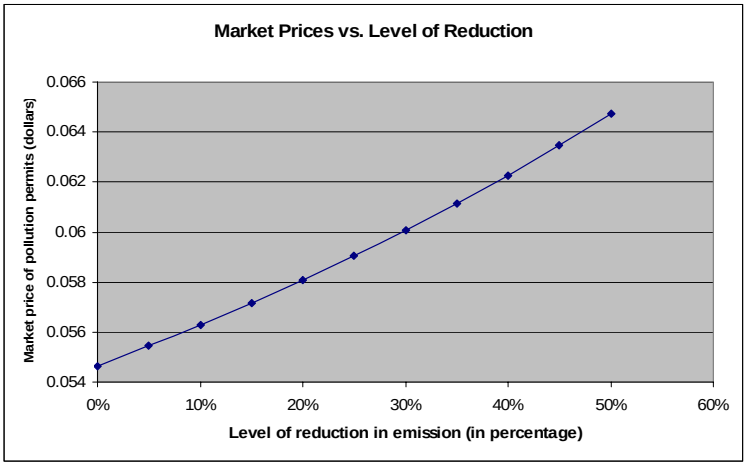
- How efficient is the market mechanism?
- How effective is it at reducing emissions?
- How fair are the outcomes?
- What would be required to implement the mechanism?

Market Prices vs. Shadow Prices

- Market clearing price = Shadow price in the global optimization spreadsheet

- Market clearing price = Tax value that induces 20% reduction in total emissions

Market Prices vs. Level of Reduction



- The more we control pollution the more valuable the permits become

Summary

	Allocation	Taxes	Cap-and-Trade
Achieves targeted emissions level?	Yes	Depends	Yes
Efficiency	Depends	Depends	Yes
Fairness Issues	?	?	?
Implementation Issues	Optimal allocation requires complete information.	Optimal taxes requires complete info or experimentation	No private information required. Needs market mechanism

Other Examples of Market Based Approaches

- Bidding for MBA electives
- Hurdle rates/Internal costs of capital when funding projects
- School vouchers
- Ebay
- Payments to passengers for overbooked flights