# Chapter 14

## The Economics of Climate Change

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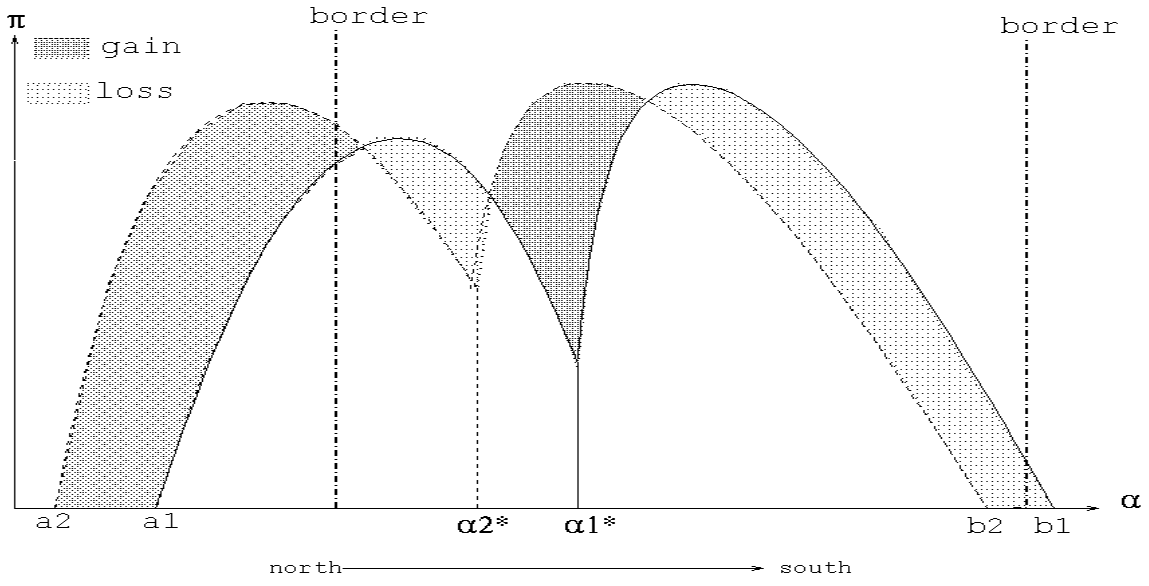
## The Impacts of Climate Change on Agriculture

- Results of economic studies depend on scientific knowledge. Scientific uncertainties => economic impact uncertainties.

- There are several lines of modeling. They differ in:

  -Incorporation of uncertainty
  -Incorporation of variability and spatial heterogeneity.

### *Modeling Approach*




Suppose we have two crops, a warm climate crop and cold climate crop, and we consider the Northern Hemisphere in Figure 1 where we depict profits per acre under the two crops before and after climate change.

Let $\alpha$ measure the distance from the North Pole. Before climate change, the warm crop was grown from b1 to a1* and the cold crop from a1* to a1. After climate change, the warm crop is grown from b2 to a2* and the cold crop from a2* to a2. Obviously, land between b1 to b2 will be deserted and land between a1 to a2 will be settled. There will be both gains and losses in yield and profits, and it is not clear whether the overall effect of climate change will be negative. One has to take into account the other effects:

- **Fertilization effect:** Higher levels of carbon will increase yield.
- **Daylight effect:** Moving north will reduce exposure to the sun and reduce yield.
- **Pest effect:** Warmer climate will lead to northward movement of pest and reduce yield.
- **Water effect:** Climate change may lead to earlier snowmelt and flooding.
- **Protein effect:** Increase in carbon will lead to higher yields but less protein production.
- **Settlement cost effect:** Climate change will require reallocation and settlement cost, from a1 to a2 and from a1* to a2*.

All these effects will have to be taken into account in assessing the impact of climate change. In addition, geography matters. A country that has more land in the north than in the south will likely gain from climate change, while the country that has more land in the south than in the north will lose from climate change. Several models have been developed to assess the impact of climate change, and they are discussed below.

***Hedonic Price Models (Mendelsohn, AER).***

Premise:

- Impacts of climate change will be reflected in asset values.
- Current asset prices can be used to estimate the price sensitivity of land values to changes in climate parameters.
- Various assumptions about changes in climate conditions are used to estimate impacts of climate change on land values.

***Programming Simulations (Adams, McCarl)***

Premise:

- Agronomic estimates of impact on climate change on yields and cost at different locations under various conditions are used to estimate changes in land use choices at various locations.
- Optimal output supplies and input demands are computed using the land-use estimates.

- Equilibrium prices, output levels, and profits for different regions are then derived.

- Assumptions about international trade price supports vary among studies.

***Stochastic Simulations (Segerson-Riley)***

- Consider impacts of estimated changes in means and variability indicators (e.g., impacts of climate change on average temperature and distribution of seasonal and daily temperatures) on yields and profitability at various locations.

***Regional Case Studies (Doering)***

- Interdisciplinary--combine quantitative estimates with expert interviews to assess response to changes.

Lessons:

- Without considerations of variability, overall impacts of climate change are not overwhelming (a 5 to 15 percent increase or decrease in agricultural income and profitability of agriculture).

- Distributional impacts may be much more significant than overall effects.

- Production patterns will shift 100-200 miles northward.

- Impacts in the middle of regions will be smaller than in the periphery.

- The livestock sector is more likely to lose, while crops may gain.

- Water resources will become more valuable.

- Uncertainty about climate change will slow investment in vulnerable regions and enhance value of projects that will dampen the impact of climate change.

- The value of climate monitoring and predicting technologies as well as value of water-saving technology increases.

- Possible increases in seasonal and daily variation in weather may lead to significant income losses.

- Snowmelt will increase flood risks and worsen seasonal supply of water.

- Relocation and adjustment costs may be significant.

- The cost of adjustment depends on speed of change. Gradual changes can be handled easily; brisk changes are a source of concern.

***Limitations of Current Research***

- Under emphasis of research on global agricultural impacts of global climate change. How will climate change affect trade and LDCs?

- The interrelation between climate change and population growths has not been studied. The combined effects are especially worrisome. For example, water problems are a source of concern regardless of climate change.

- Shortages and crises lead to technological and institutional innovations. These cannot be foreseen, and they may lead to overestimation of some costs.

**How Climate Change Impacts Should Be Addressed**

- Major impacts:

  -Rising sea level
  -Desertification

There are understudied issues with many "thorny" problems, e.g., institutional and policy solutions to flooding and related problems.

Response to climate change will include:

- Changes in investment and capital formation policies.

- Investments that reduce negative impact of climate change should be encouraged.

- Investments that enhance negative impacts should be curtailed.

- Emphasis on increased R&D to develop resource-conserving technologies and improved monitoring technologies.

- Emphasis on adaptive management.

- Emphasis on policies aimed to delay climate change.

- No regret policies.

**Policies to Delay and Dampen Climate Change**

Premise:

(a) Individuals and firms respond to incentives.

-Shortages lead to innovation of resource-conserving technologies.
-Shortages lead to adoption of such technologies.
- Shortages lead to institutional innovations.

Examples:

(1) California droughts
-Adoption of modern irrigation technologies
-Introduction of water banks

(2) Energy crisis of 1970 leads to
-Improved fuel efficiency
-Smaller cars

(b) Three types of pollution control incentives:

-Taxes
-Subsidies
-Transferable permits

- Producers overwhelmingly object to taxes.
- Subsidies may be misused.
- Transferable permits are most acceptable politically.

They require:

-Establishing aggregate targets.
-Pollution reduction.
-Verifiable products to be traded.

In the case of climate change, governments may consider incentives, direct control, and educational and voluntary activities to reduce and even sequester emissions of greenhouse gases. But establishing a global policy is different because of two issues:

1) There is conflict between developing and developed countries.
2) Initial allocation of reduction in emissions is a major issue

## The Kyoto Protocol

A framework to reduce global greenhouse gases:

- Signing is voluntary.
- Enters into force when ratified by 55 countries.

- Signatories establish an upper bound on greenhouse gas emissions based on their 1990 emissions

- The U.S. target is –7% of 1990 emissions.
- Japan's target is –6% of 1990 emissions.
- EU target is –8% of 1990 emissions.
- Russian and Ukrainian target is no reduction from 1990 emission level. Since the economies of these countries collapsed, their emissions are smaller than in 1990s. They have "hot air" that they can fill or sell.

- Costa Rica and Argentina and some Atlantic Ocean island countries are the only developing countries to sign the Kyoto Protocol. Many developing countries oppose it for several reasons.

    - Some see it as "new colonialism." They reason that they have not caused the mess and should not be constrained to repair it.

    - They would like to establish clear criteria for emission limits that will be more favorable to lesser-developed countries. For example:

        - Each nation's emissions limits would be proportional to its population.

        - National emission limits are based on a formula that combines 1990 emission base and population size.

Trading in emission rights is allowed, although clarification of the rules of trading continues to be discussed. Some clearer rules were established at the Buenos Aires meeting. Some mechanisms of cooperation to reduce emissions include:

- Joint implementation projects in countries that sign the agreement. Such projects may enable countries to invest in low-cost, emission- reduction activities or provide a foundation for trading.

- Clean Development Mechanisms (CDMs) are emission reduction projects in LDCs that will provide credit to the developed nations that finance them.

- "Banking" is allowed but is limited to next period and restricted.

- Countries may form "bubbles" to combine their targets. The United States and Russia may form a bubble. Obviously, the United States may pay Russia for its "hot air." Russia and the Ukraine may receive tens of billions of dollars for their hot air.

Nations have sovereignty for domestic implementation. Nations are the basic accounting units, and they set appropriate strategies. Since nations are not cost

minimizers, this may not lead to efficiency. Tools that may be used to reduce emissions include:

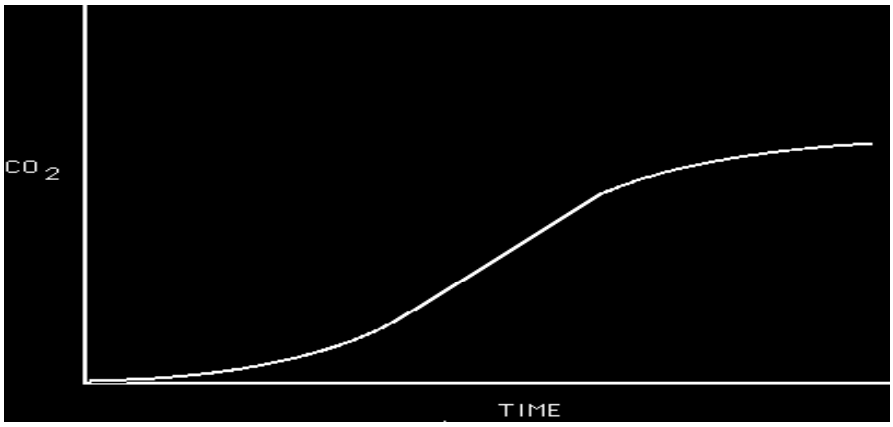
- Carbon tax.
- Internal tradable permits.
- Direct control of the technologies used by utilities.
- Subsidies for desirable activities.
- Sink activities

**The Feasibility and Management of Sink Activities**

Sink activities (that reduce $CO_2$ in atmosphere) are subject to further discussion. They include:

- Activities such as planting forests
- Activities of water resource management (feeding algae).
- Activities of soil management

A key difficulty of implementation is establishing a benchmark (level in 1990). But when it comes to sink activities, measuring reduction is difficult. The amount of $CO_2$ a tree will absorb will change over time.




The tree may be cut—some of the $CO_2$ may return to the atmosphere.

- Accounting of $CO_2$ reduction based on individual activities is difficult. One needs accepted aggregate measures.
- The need for constant monitoring is also costly.
- In cases of soil management, there is five times more $CO_2$ in the soil than in the air (3 to 500 billion tons versus 700 billions tons). $CO_2$ is absorbed in the soil (and plants) by planting grasses. Plowing releases soil $CO_2$ into the atmosphere. Such releases have been a major source of $CO_2$ emissions.

Remedies include:

-Reduction of intensive plowing.
-Transition to no tillage.
-Cover crops.

In addition to risk reducing activities, there are "no regret" activities that improve environmental quality. Problems with such activities include:

- Establishing formulas to translate action in the field to $CO_2$ reductions.
- Establishing simple monitoring procedures.

The complexity of sink activities deters them from being included as part of the Kyoto Protocol calculations. But they provide many avenues to slow global warming.

- Without their inclusion, farmers (at least in the U.S.) will be against Kyoto.

- When farmers recognize green management activities such as $CO_2$ sequestration are legitimate, they will recognize another source of profit and will modify their behavior.

- The extent of modification depends on the price of sequestration. Some suggest it will be \$150/ton of $CO_2$, while others think it will be \$10 to \$20/ton. The high estimates based on reduction of $CO_2$ within existing power technologies. Low estimates are based on marginal cost of alternative sequestration strategies (more to gain in energy production in many regions).

- Even with the low estimate, U.S. farmers may get \$3–5 billion a year for sequestration activities. Since commodity payments will disappear by 2002, and farmers will push for their continuation, a program of "green payments" for sequestration may be introduced.

- This may be a mechanism that will complement (or embody) the trading in $CO_2$ reduction.

Alternative procedure to enact $CO_2$ reduction

- Kyoto is the "trickle down" procedure that will lead to $CO_2$ reduction in atmosphere.

- A "bottom up" approach assures that regulation to reduce $CO_2$ occurs at one country. The success of such regulations will lead to their adoption internationally.

- Once $CO_2$ reductions become valuable, then

  -For-profit institutions to monitor $CO_2$ reduction will be established.

  -Exchange for trading in sequestration rights will be formed.

  -Futures and options markets will evolve.

Some organizations already buy sequestration rights (assuming the Kyoto-type regulations are likely and sequestration will be recognized as an approach to slow climate change). With the bottom-up approach, there will be actual implementation of sequestration before a formal detailed regulatory framework is established. This framework will evolve through exchanges of experiences of sequestration contracts and of sequesters.

**Obstacles to Kyoto Protocol and Carbon Trading**

- Developing countries (LDCs) foresee growth in their own emission and view curtailment of emissions as barriers on growth.
- Developing countries may be more concerned with the present (higher discount rate) than the future and take higher future climate risks.
- LDCs will refuse to cooperate early as part of a bargaining strategy. They want their effort to be subsidized.
- Implementation of trading in carbon sequestration rights is difficult.
- Monitoring of emissions is a major measurement problem. Proxies are needed.
- Proxies are not accurate. Relationships between practices and $CO_2$ emissions or sequestration's in random vary across locations.
- Determination of proxies is linked to other policy problems:

  -Political pressure to support agriculture.
  -Other environmental policy issues (waste management).
  -Transition to "landscape" incentives.

- Technological change and new knowledge may suggest frequent reassessment of proxies and their value.
- What about controlling methane and other substances?
- The United States withdrew from the Kyoto Protocol, and there is a challenge to pursue the Protocol so it evolves without the United States. Eventually, it is important to modify the Protocol so it will be verified by the United States and involve major countries like China and India.

**Conclusions**

- Global change is a threat that needs to be monitored and controlled.
- Contingency responses and worst case scenarios have to be studied.

- New technologies have to be investigated.
- Flexible mechanisms for reduction of global change taxes have to be introduced as part of a larger environmental and resource policy framework.
- The cost of climate change is uncertain, but we can affect these by reasonable choices.