The Economics of the Kyoto Protocol

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Presentation Outline

- The Kyoto Protocol and Economics of Emission Trading
- General Approach to modeling the Kyoto Protocol – Second Generation Model (SGM)
- Necessary Assumptions for SGM
- Reference Case and Calibration
- Compliance and mitigation scenarios
  - No permit trading
  - Joint compliance with Annex I trading
  - The Clean Development Mechanism
- Non-CO_2 Greenhouse Gases
- Land –use Change Emissions
- Summary and Results

The Kyoto Protocol and Economics of emission trading

- Global warming and its negative impacts
- Cost minimization–important issue in curbing emissions
- Past unsuccessful policies
- International policies created by Kyoto
- "The Flexibility Mechanisms"

  Joint Implementation (JI)

  The Clean Development Mechanism (CDM)

  Emission Trading (ET)
- Economic logic of tradable permits

General Approach – SGM

- SGM – a computable general equilibrium economic model that projects economic activity, energy consumption, and carbon emissions for twelve world regions
- Issues addressed by SGM:
  1. Provide estimates of future time paths of environmentally important emissions from economic activity
  2. Provide estimates of the economic cost of actions to reduce GHG emissions

Necessary Assumptions for SGM

Second Generation Model

- Sectors
- Market Clearing
- Carbon Permit Fees
- Modes of Operation
- Data Requirements

Necessary Assumptions for SGM

- Sectors – 9 producing sectors, 12 inputs (land, labor, capital, energy, etc.)
- Market Clearing – markets are said to clear when the model solves for the set of prices for all markets in the modeled economy so that demands and supplies of each market are in equilibrium.
- Carbon Permit Fees – used within each region to provide an economic incentive for economy to substitute away from carbon.

Necessary Assumptions for SGM

- Modes of Operation

  Single-region Operation

  Global Model with Partial Market Clearing

  Global Model with Full Market Clearing

- Data Requirements

  1. Economic and Demographic Data

  2. Energy Balances

  3. Technology Descriptions

Necessary Assumptions for SGM

- Modes of Operation

Single-region Operation

- Each SGM region operates independently
- Produced goods classified as tradable, non-tradable and traded at a fixed quantity
- Fixed world price for certain tradable goods
- Regions import-export tradable goods at a fixed world price s.t. an overall balance of payment constraint.

Tradable goods:

- Compute supply and demand for all producing sectors and primary factors of production

Other goods:

- Compute a set of prices that equates supply and demand and brings all markets to equilibrium

Necessary Assumptions for SGM

- Modes of Operation

Global Model with Partial Market Clearing

- Used when at least one market must clear globally.
- That market is the market for tradable carbon emission permits
- SGM searches for a global permit price that clears this market for permits

Global Model with Full Market Clearing

- There are no markets with a fixed world price
- SGM solves for a set of world prices that clear all world markets

Necessary Assumptions for SGM

- Data Requirements

1. Economic and Demographic Data

Economic – input-output tables, national income accounts

Demographic - population data from the World Bank

2. Energy Balances

Energy balance tables - International Energy Agency or government agency within a region

3. **Technology Descriptions** – annualized cost of providing an energy service (capital cost, equipment lifetime. etc)

Reference Case and Calibration

- Results reported for years 1990 through 2020
- US reference case - calibrated to the AEO'98
- Other global regions - calibrated to regional projections from the WEO'96 or IEO'98
- US population – set according to AEO'98
- Other population – World Population Projections (WB)
- Other calibrations – projections of carbon emissions, GDP, energy consumption and electricity generation for the Annex I regions

Compliance and Mitigation Scenarios

1. No Permit Trading
   - Each region individually meets its emissions limitations.
   - Carbon tax is determined for each region to reduce emissions to be equal to its allocated emissions rights
   - Non-CO2 GHG mitigation cost is calculated as a proportion of fossil fuel carbon mitigation cost
   - Successful compliance will change the regional and world energy systems.
   - Some technology options have significant lead times to their deployment

Compliance and Mitigation Scenarios

Results:

- Costs under No Permit trading case in 2010 are:

  Australia - $ 117/tonne CE

  US - $ 168/tonne CE

  Japan - $ 458/tonne CE

- Energy Sector Adjustments in US:
  - Capture and sequester carbon (afforestation, reforestation)
  - Undertake fuel switching (hydro, nuclear, solar power)
  - Conserve energy increasing the amount of services provided by a fixed energy input, etc.

Compliance and Mitigation Scenarios

2. Annex I Trading

- Regions may only emit more carbon than their allocated emissions rights allow if another Annex I region is willing to sell a same number of its permits - seller region reduce its domestic emissions beyond the required target.

- Important issues:
  - Reference emissions in Annex I nations
  - Trade behavior and market power
  - Trade rules
  - Incomplete markets (“Double Bubble”)

Compliance and Mitigation Scenarios

Results

Examine following four cases (results for the US):

Competitive permit supply	- $ 73/tonne CE
Monopolistic permit supply	- $105/tonne CE
Trade limitations	- $100/tonne CE
Global trading	- $ 26/tonne CE
No trading	**- $168/tonne CE**

Compliance and Mitigation Scenarios

3. The Clean Development Mechanism (CDM)

- Created as a vehicle for non-Annex I nations to continue pursuing economic growth while having access to additional resources to help reduce GHG emissions

- Provides a mechanism in which certified emission reductions can be created on a project by project basis.

Compliance and Mitigation Scenarios

3. The Clean Development Mechanism (CDM)

- Certified emissions can be used by Annex I nations to contribute to compliance with their emissions limitations.

- No rules for creating certified emission reduction credits => can't simulate the impact of the CDM on permit prices and costs of mitigation.

Summary and Results

- Location and national circumstances of emissions mitigation significant for the potential costs or benefits of participation in the Kyoto Protocol
- The range of permit prices for the US $26 under Global trading and $255 under No trading with 70% mitigation
- Same permit price range for other Annex I regions with No Trading values varying from region to region
- Lower end of the range determined by the conditions in the permit supplying regions. Upper end of the range always region specific

Summary and Results

- Potential burden placed on an economy by a particular policy varies significantly depending on methods used to measure mitigation costs.
- Economic costs depend significantly on assumptions about future carbon emissions
- The distribution of costs among countries in a system of global permit trading case sensitive to assumptions on exchange rate and initial permit allocation.
- Any system of global carbon permits trade implies large transfers of wealth from one region to another

Reference

Christopher N. MacCracken, James A. Edmonds, Son H. Kim and Ronald D. Sands “The Economics of the Kyoto Protocol”, The Energy Journal Kyoto Special Issue, 1999, IAEE (International Association for Energy Economics)

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