Multi-model analyzes
of climate policy options
and their impact on
China and India
in terms of costs and energy system development

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Background

• Efforts to limit temperature increase to max 2°C above pre-
industrial levels (Copenhagen Accord and Cancún Agreements).
• Need to cut global GHG emissions 35-55% by 2050 compared 1990
(to meet 2°C-target with probability of at least 50%).
• Emissions from developing countries alone will soon exceed global
emission trajectory for reaching ambitious targets.
• Expected growth of Indian and Chinese economy implies important
role in shaping the dynamics of the future global energy system and
related CO₂-emissions.
• Mitigation efforts of India and China increasingly important.
Why this collaborative project?

- Traditionally, assessment of climate policy impacts in India or China has
  - either been carried out in national model or global models.
- Large differences in
  - assumptions on e.g. economic growth, energy prices and technology development
  - effort sharing approaches
- Global analyses often made in industrialized countries.
- National analyses often lack international perspective.
- Difficult to compare different studies.

In this project:

A more consistent perspective by harmonizing and soft-linking different kinds of models.
- Global models - international linkages and feedbacks
- National models - national impacts of climate policy
- Energy system models - technological details
- CGE models - macro-economic feedbacks, changes in demand and trade.
Collaborating partners

- Chalmers University of Technology, Sweden
- Netherlands Environmental Assessment Agency, The Netherlands
- Kiel Institute for the World Economy, Germany
- Indian Institute of Management - Ahmedabad, India
- Institute of Economic Growth, India
- Tshinghua University, China
- Beijing Institute of Technology, China

Aim

- Analyze global climate agreements, and their impact on China and India, focusing on
  - impact on energy systems; and
  - gains and costs
- Understand the
  - major driving forces in different models.
  - drivers behind the partly diverging model results.
Methodological approach

- A multi-model based approach
- Addressing model similarities/dissimilarities
- Harmonizing assumptions (partly)
- Application of climate regimes
  - common but differentiated convergence (CDC)
- Sensitivity analysis
  - Economic growth
  - Timing of emission reductions
  - Delayed effort-sharing

Models

- Six models differing in
  - Geographic scale:
    - Global
    - China
    - India
  - Scope:
    - economy wide models (CGE models)
    - energy system models (Markal type)
- A seventh model
  - Determines global emission pathway's for the 2°C target
  - National emission allowances based on effort-sharing approach
The FAIR model

- Used to construct long-term greenhouse gas emission pathways consistent with the 2°C target
- Analyze emission reductions and abatement costs for different effort-sharing approaches.
- Uses a least-cost approach involving regional Marginal Abatement Cost (MAC) curves.
- Allow offsetting mechanisms such as emission trading and the Clean Development Mechanism (CDM).

Energy-system models - details

- TIMER
  - Dynamic, global, 26 world regions, energy and industry related emissions of all Kyoto gases, substitution processes of various technologies based on long-term prices and fuel preferences.
- China MARKAL and MARKAL-India
  - Dynamic, linear, cost-minimizing models, energy related CO₂ emissions.
Computable general equilibrium (CGE) models - details

- **DART**
  - **Global**, 13 regions,
  - Divided into private households, government sector, capital, labor, land and natural resources.

- **CEEPA**
  - **China**, single country, based on input-output data of the National Bureau of Statistics PR China.
  - Consumers divided into households, enterprises and government.

- **IEG-CGE**
  - **India**, single country, based on a social accounting matrix.
  - Consumers divided into households, based on socioeconomic characteristics, enterprises and government.

Soft-linking of models

- **Common baseline scenario**
- **FAIR** calculates the emissions pathway and regional emission allowances
- **DART** determines the carbon tax based on the global CO\(_2\) pathway and the regional emission allowances from FAIR
- The **national CGE** models use the emission allowance from FAIR and the carbon tax from DART to determine changes to the energy system and total climate policy cost
- **TIMER** and the **national MARKAL** models use the emission allowances and carbon tax from FAIR to determine changes to energy system and total climate policy cost.
Common-but-differentiated convergence (CDC) allocation (effort sharing) scheme

- Similar to contraction and convergence (C&C) regime but developing countries start reduce CO₂ only after reaching a certain threshold of per capita emissions.
- Important parameters
  - the threshold that requires countries to enter the regime
  - the long-term per capita emissions convergence level

- All countries that made a reduction pledge under Cancún Agreements are assumed to meet their targets in 2020.
- After 2020, developed countries follow the convergence trajectories.
- China and India start in 2025 and 2030, respectively.
- China and India take 30 years to converge.
- All countries converge to a level of 1.7 tCO₂/capita in their respective convergence year.

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Global GHG emission pathways

![Graph of Global GHG emission pathways](image-url)
Results: Emissions China

Results: Emissions India
Results: Changes in fuel mix India I

Results: Changes in fuel mix India II
Decomposition of abatement

Decomposition analysis can help to better visualize the differences in how abatement is taking place in the models. Here, results are analyzed using the Kaya identity:

\[ E_{\text{CO}_2} = \text{GDP} \times \text{EI} \times \text{CI} \]

Abatement in models: China

El = annual average energy intensity (i.e., unit primary energy per unit GDP)
Cl = annual average CO₂ intensity (i.e., unit CO₂ emissions per unit primary energy).
Abatement in models: India

EI = annual average energy intensity (i.e., unit primary energy per unit GDP)
CI = annual average \( \text{CO}_2 \) intensity (i.e., unit CO\(_2\) emissions per unit primary energy).

Gains/Costs of climate policy: China

In the policy scenario, international fossil fuel price declines. China import fossil fuels and thus profit from this. This effect is only captured in DART.
Gains/Costs of climate policy: India

- Indian per capita emissions are low. India can sell more credits on the carbon market than China.
- Indian economy is smaller than the Chinese and net export of credits has a larger impact on India.
- The world (as a whole) consumes less fossil fuels in the policy scenario. International fossil fuel price declines. India import fossil fuels and profit from this. This effect is only captured in DART.

Main insights I

- Economic and energy implications of climate policies for China and India vary per model.
  - Models with similar structure (CGE vs. Energy system) lead to comparable results.
  - Models with national focus tend to show more negative economic implications of climate policies than global models.
- Decreased energy intensity is most important in the CGE models
- Decreased carbon intensity is most important in the energy models.
- Thus, different models are required to address the different important aspects
Main insights II

• To reach the 2 degrees target significant reductions are required - also in China and India – implying huge changes in their energy systems
• CCS is a central abatement technology, as is renewable energy.
• Climate policy costs (direct costs or as welfare change) vary per model.
  – In general, India benefits from allowance trading the entire period until 2050 while China becomes a buyer during the period.
  – Both India and China benefit from declining international fossil fuel prices.