Climate Change, Energy Demand and Market Power in a General Equilibrium Model of the World Economy

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Background and Motivation

- One in a series of studies dealing with economic impacts of climate change
- Previous and ongoing research: sea level, human health, tourism, water, land use
- The CGE approach
- Interpreting impacts as economic shocks (resources, productivity, structural changes, transfers)
How CC may affect energy demand

- Higher average temperatures + secondary effects (extremes, rainfall, wind, etc.)
- Lower energy demand for heating, higher energy demand for cooling
- Secondary effects on energy demand (e.g., transportation)
- Climate change policies
Estimating the relationship between energy demand and temperature

The General Method of Moments is used to estimate parameters for an equation like:

\[
y_{it} = \rho y_{i,t-1} + x'_{it} \beta + c_i + u_{it} \tag{1}
\]

where:
- \( i \) is an index over regions/countries;
- \( t \) is an index over time;
- \( y \) is consumption of a specific energy vector: coal, natural gas, electricity, oil and oil products (index over goods omitted) by three separate sectors: households, industry and services (index over sectors omitted);
- \( x \) is a set of regressors: real GDP, average market price and average yearly temperature;
- \( c \) is a region-specific fixed factor;
- \( u \) is the standard error term.
## Estimated Temperature Elasticities

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<tr>
<th>Energy Vector</th>
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Implementing shocks in the CGE model

- Focus on households
- 2050 baseline (without CC)
- Exogenous shift factors
- Ex-ante and Ex-post variations
<table>
<thead>
<tr>
<th>Regions</th>
<th>% Var. in regional average temperature (2000-2050) °C</th>
<th>Ex-ante % increase in household demand for energy commodities</th>
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<tbody>
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<td></td>
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## Results – Main Economic Aggregates

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<th>Investment</th>
<th>Terms of Trade</th>
<th>Household Utility</th>
<th>CO2</th>
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Introducing Imperfect Competition in Energy Industries

- Why imperfect competition?
- Which imperfect competition?
  - Cournot symmetric oligopoly
  - No entry
  - Baseline profits included in calibration capital income
  - Initial mark-ups estimated from literature
  - Endogenous demand elasticities
Key characteristics of the IC model version, amplifying (+) or dampening (-) the impact of variations in energy demand, in comparison with the PC model version.

<table>
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<th>Key Characteristics</th>
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<td>Exogenous variation of market shares</td>
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<tr>
<td>Endogenous variation of market shares</td>
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<tr>
<td>Lower shares of capital in the price struct.</td>
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Diagram showing the baseline, IC, and PC points with arrows indicating the direction of variation.
<table>
<thead>
<tr>
<th>Product</th>
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<th>EU</th>
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<th>JPN</th>
<th>RoA1</th>
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<th>CHIND</th>
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Table A2 – Results (Perfect Competition) – Prices of primary resources, goods and factors (%)

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### Table A3 – Results (Imperfect Competition) – Industry production volumes (% change)

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<th>EU</th>
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<th>RoAI</th>
<th>EEx</th>
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Table A4 – Results (Imperfect Competition) – Prices of primary resources, goods and factors

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Conclusion

- Climate change will have a direct impact on the demand for energy, since the latter is affected by average temperature levels.
- Results highlight variations in the terms of trade, benefiting energy importing countries and harming energy exporting countries, and falls in prices of energy goods, capital services and natural resources.
- These findings are robust in terms of market structure specification. We repeated the experiment with an alternative model version, where we assumed that energy industries were Cournot oligopolies, with profits in both the baseline and counter-factual equilibria. Although the model simulates changes in market power for the various regional industries, most of the differences in results between the two model versions can be interpreted as consequences of different cost shares for capital in the model calibration.