FONDAZIONE ENI ENRICO MATTEI

A good opening

The key to make the most of unilateral action

Enrica De Cian, FEEM

with Valentina Bosetti

Milan, March 16, 2011

THE DRAWBACKS OF PARTIAL COOPERATION

Partial cooperation on the provision of a global public good can be ineffective

1. Signatories: emission reduction might be too low because they overlook non signatories' damages

2. Non-signatories: their optimal reaction might be to use more energy and increase emissions

=> *Carbon leakage*

DRIVERS OF NON SIGNATORIES' REACTION

- Damage: Free-riding incentive on reduced global damage
- Energy markets: Reduced international energy prices and increase in energy demand
- Terms-of-trade (TOT): Reduced competitiveness and reallocation of energy-intensive industries

  => *Drive carbon leakage*

- Technology spillovers: diffusion of cleaner technologies

  => *Reduce carbon leakage*

THE LITERATURE

- Energy market and TOT effects

  4AR (IPCC 2007) and Burniaux and Oliveira Martins 2000 for a review, Boringher et al. (2010)

- Technology effect

  Numerical analyses: Barreto and Kypreos (2004), Barreto and Klaasen (2002) Gerlagh and Kuik (2007)

  Theoretical works: Golombek and M. Hoel (2004); Van der Werf and C. Di Maria (2008); Hoel and de Zeeuw (2009)

CONTRIBUTION OF THIS PAPER

Evaluates the consequences of incomplete cooperation when

- Damage
- energy market
- technology effect

compete with each other

Identify the conditions under which either effect prevails

MAIN RESULTS

The reaction of non-signatories depends on relative marginal cost of clean and dirty technologies

When OECD countries cooperate, the technology effect prevails and carbon leakage is negative if:

- Their emission reduction is moderate
- Non-signatories anticipate future commitments
- Countries with large incentive to free ride such as China join

METHODOLOGY

1. A stylized, two-region model solved as a Stackelberg game
2. An integrated assessment model - WITCH

- Both models feature the core elements for our analysis (energy markets, damage, technology externalities)

- WITCH allows a quantitative assessment of each competing effect

A STACKELBERG GAME

$$\min_{e_1,b_1} c_1(E,B) = c_b(B)b_1 + c_e(E)e_1 + D_1$$

$$st$$

$$\begin{cases} f(e_1,b_1) = y_1 \geq \bar{y}_1 \\ e_2 = \arg\min c_2(E,B) \end{cases}$$

e_i fossil-fuel-based technologies

b_i clean technologies

LEADER (OECD)

$$\min_{e_2,b_2} c_2(E,B) = c_b(B)b_2 + c_e(E)e_2$$

$$st$$

$$f(e_2,b_2) = y_2 \geq \bar{y}_2$$

FOLLOWER (non-OECD)

$$\frac{\partial c_b(B)}{\partial b_i} < 0 \Rightarrow TECHNOLOGY\ EFFECT$$

$$\frac{\partial c_e(E)}{\partial e_i} > 0 \Rightarrow ENERGY\ MARKET\ EFFECT$$

THE FOLLOWER'S REACTION FUNCTION

Adoption of clean technology:

- LEADER: social cost of carbon and relative cost of the two technologies
- FOLLOWER: shape of technology costs and their relative slopes, in turn affected by leader's choice

A necessary but not sufficient condition for negative leakage: the clean technology cost is steeper than the dirty one

THE WITCH MODEL

Damage

- Increasing in temperature

Technological dynamics

- R&D with international spillovers
  - Incremental – energy efficiency
  - Radical – breakthrough technologies
- LBD and international technology diffusion

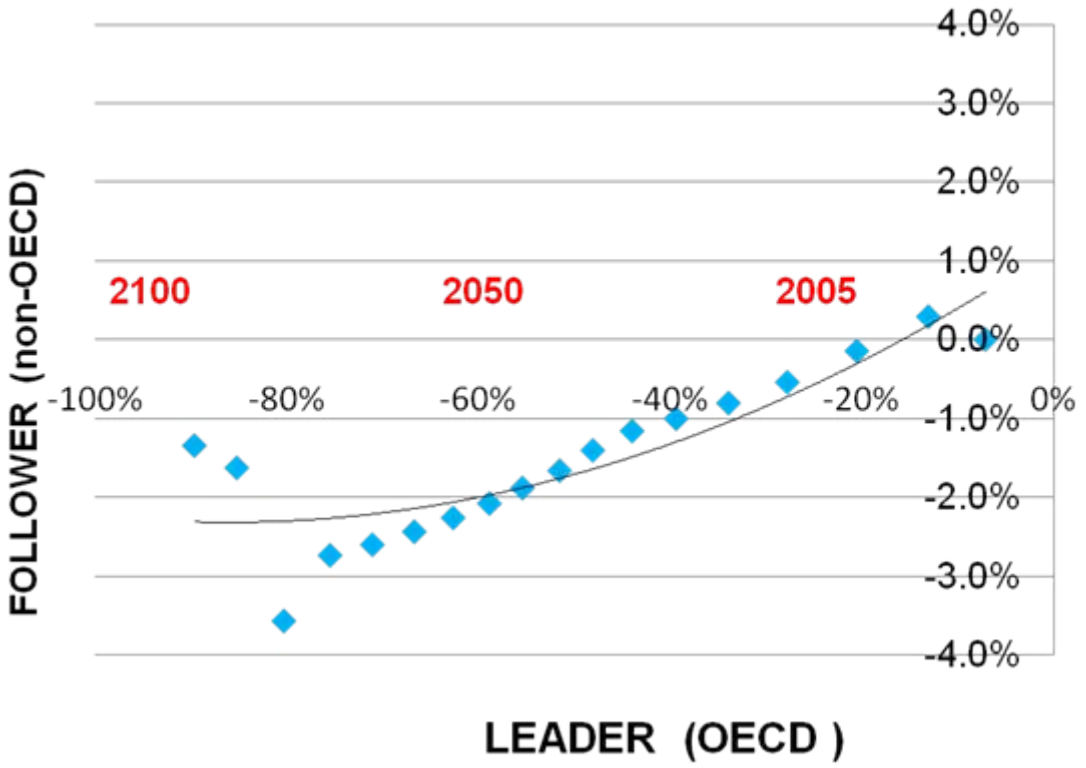
Energy market

- Fossil fuel prices in each region depend on global demand

THE STACKELBERG SOLUTION

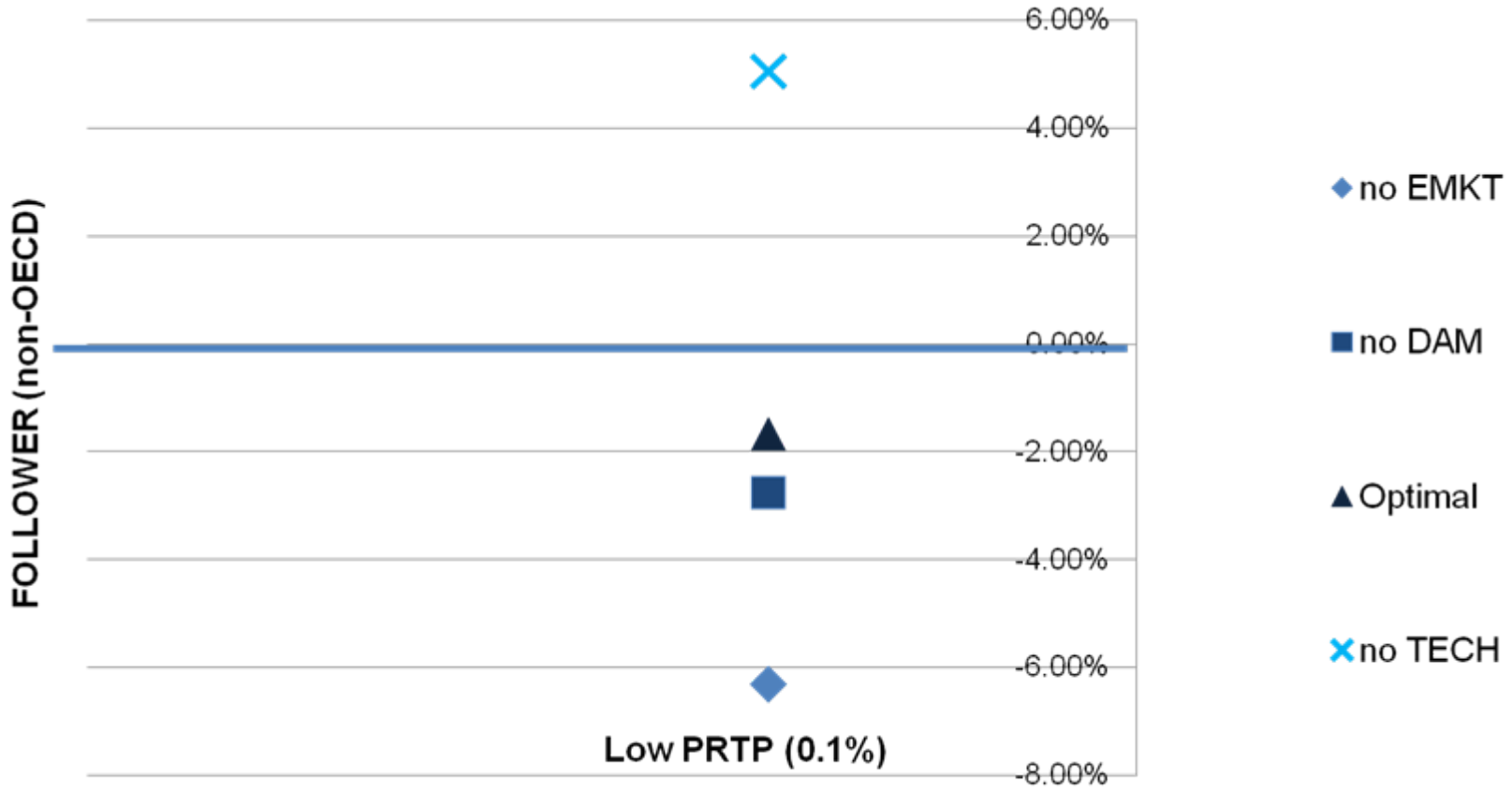
The technology channel dominates the damage and energy market effects => positive reaction function

% change of energy CO2 emissions wrt BaU over time periods



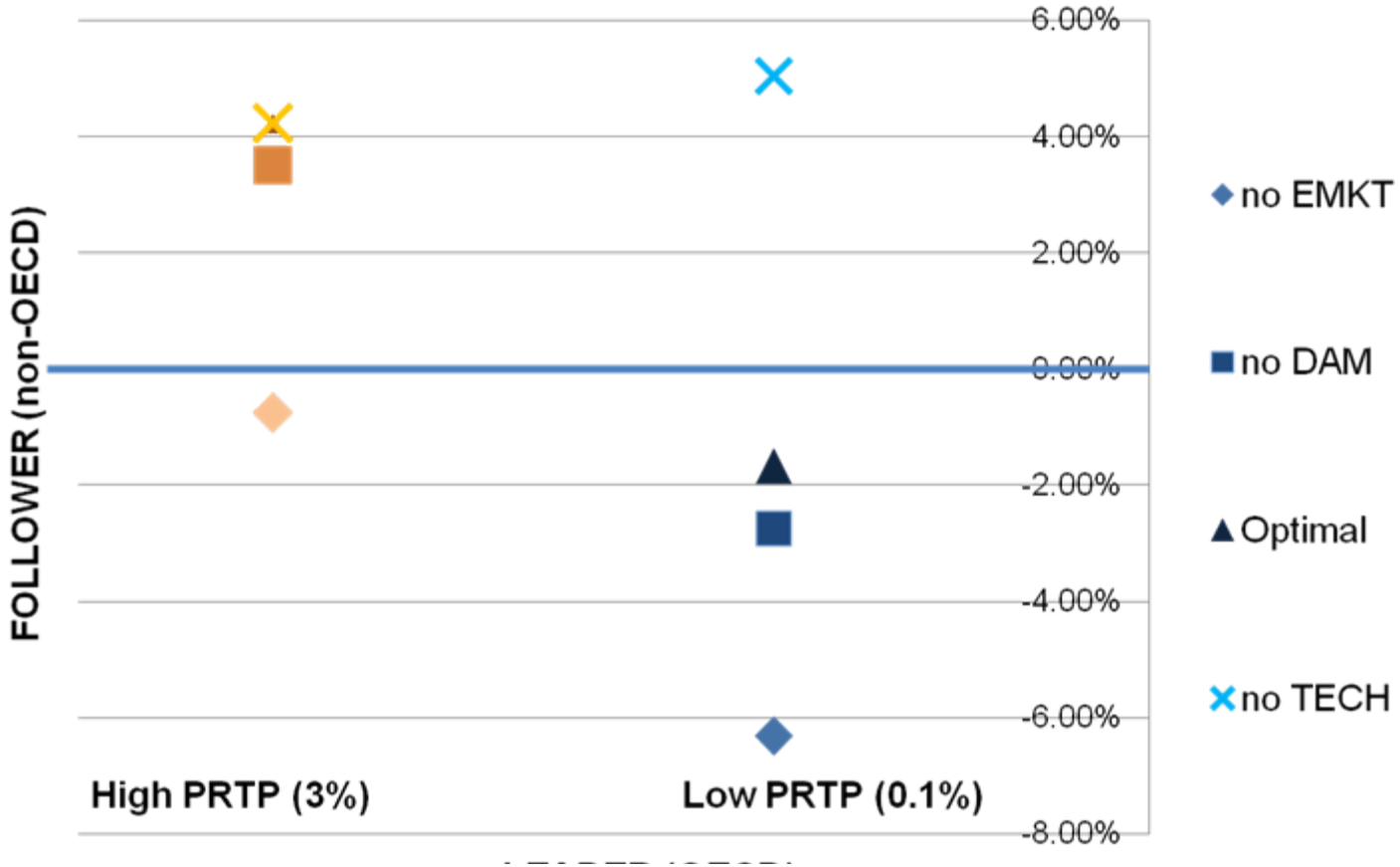
THE STACKELBERG SOLUTION: MAIN DRIVERS

% change of cumulative energy CO2 emissions wrt BaU



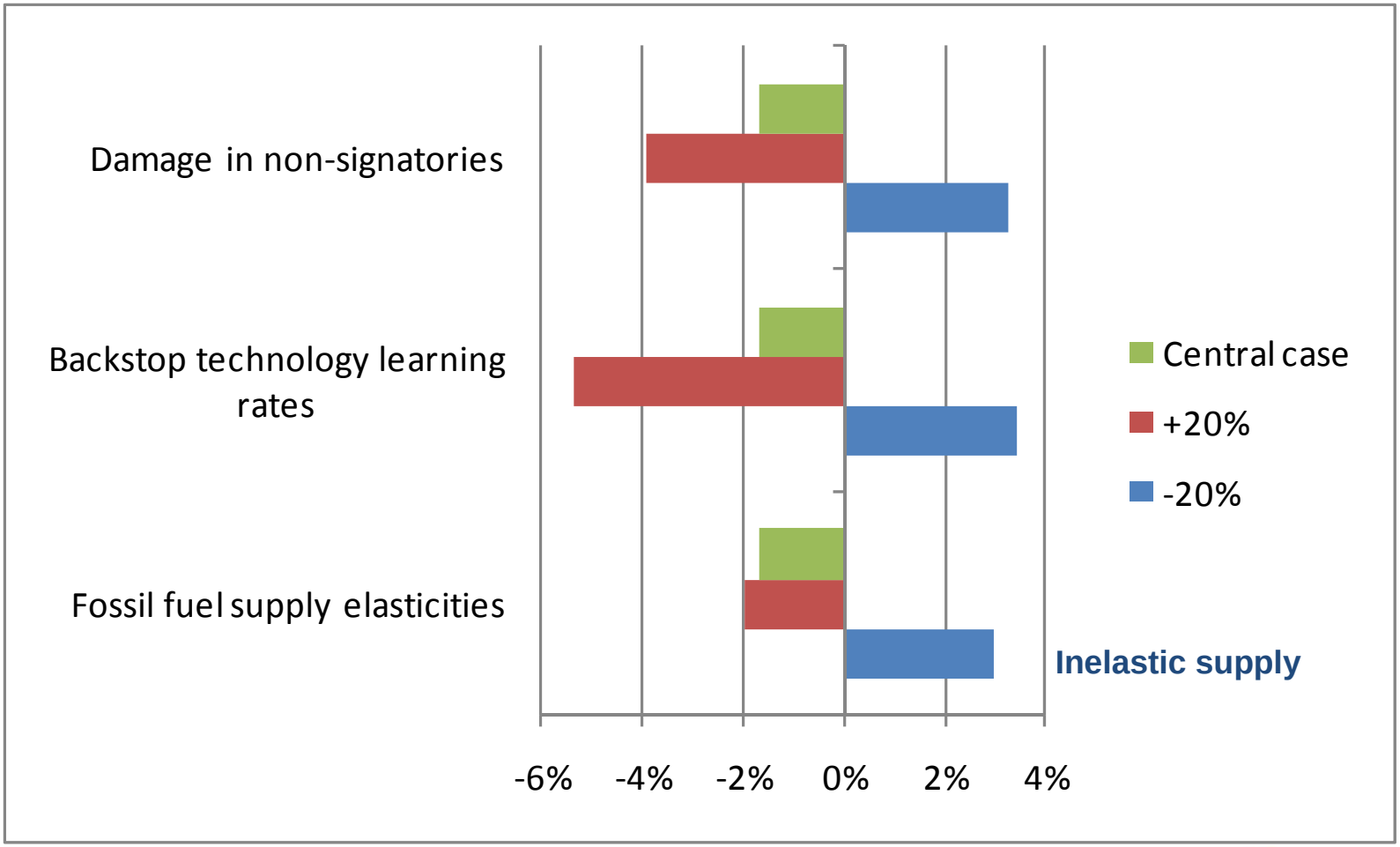
THE STACKELBERG SOLUTION: MAIN DRIVERS

% change of cumulative energy CO2 emissions wrt BaU in non-OECD



SENSITIVIT TO MODEL PARAMETERISATION

% change of cumulative energy CO2 emissions wrt BaU in non-OECD



SENSITIVITY: EFFORT AND COALITION COMPOSITION

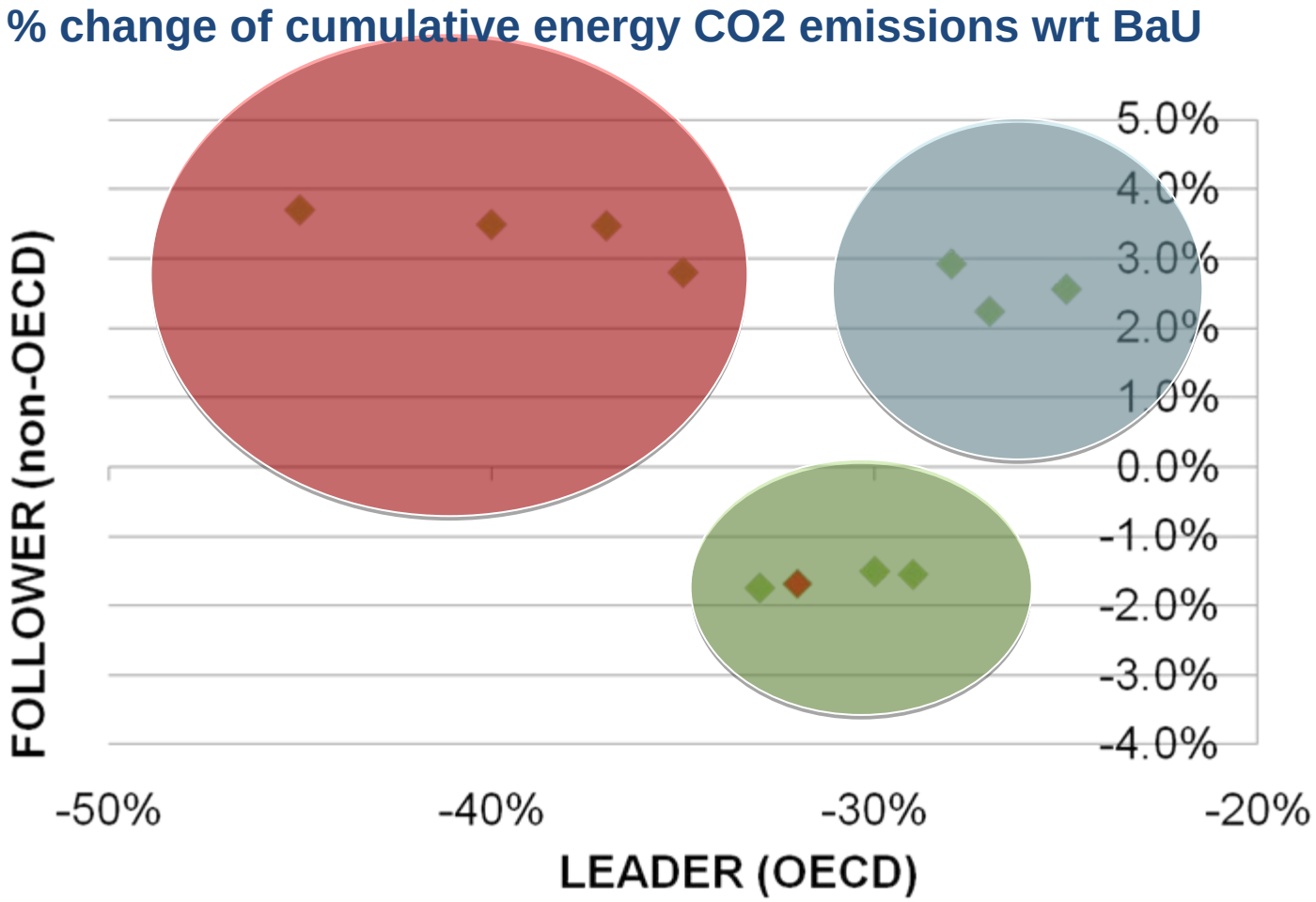
The influence of the three factors depends on

- the effort
- the coalition composition

Vary the stringency of the emission objective

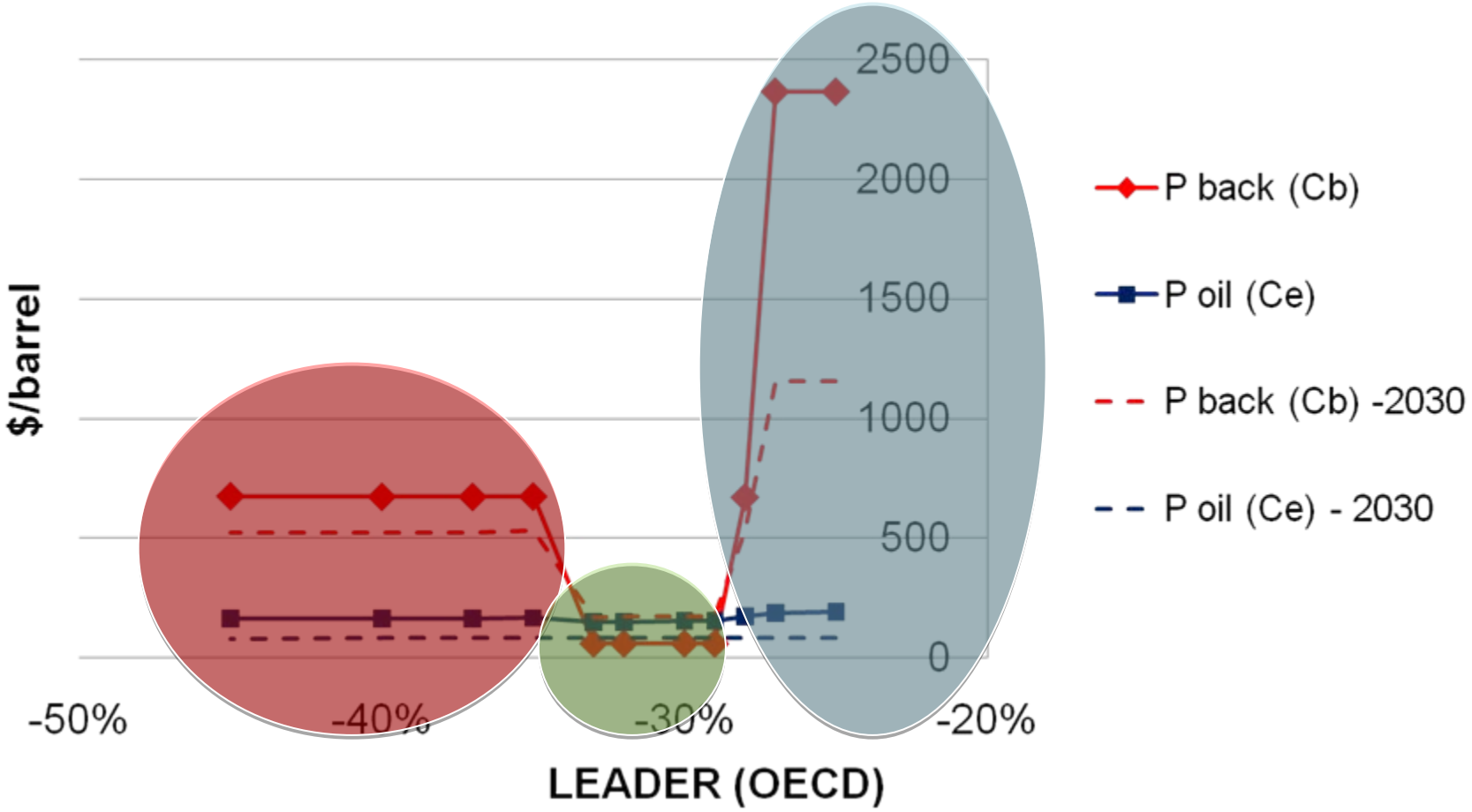
Vary the composition of the coalition

SENSITIVITY: EFFORT



SENSITIVITY: EFFORT

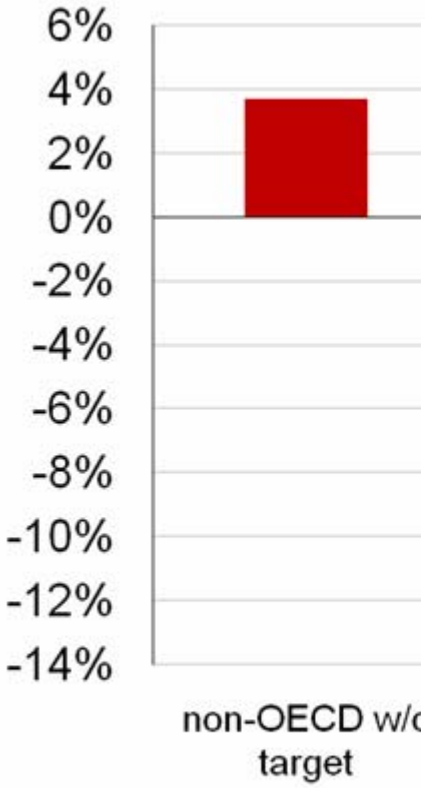
Technology costs of clean (Pback) and dirty (Poil) substitutes



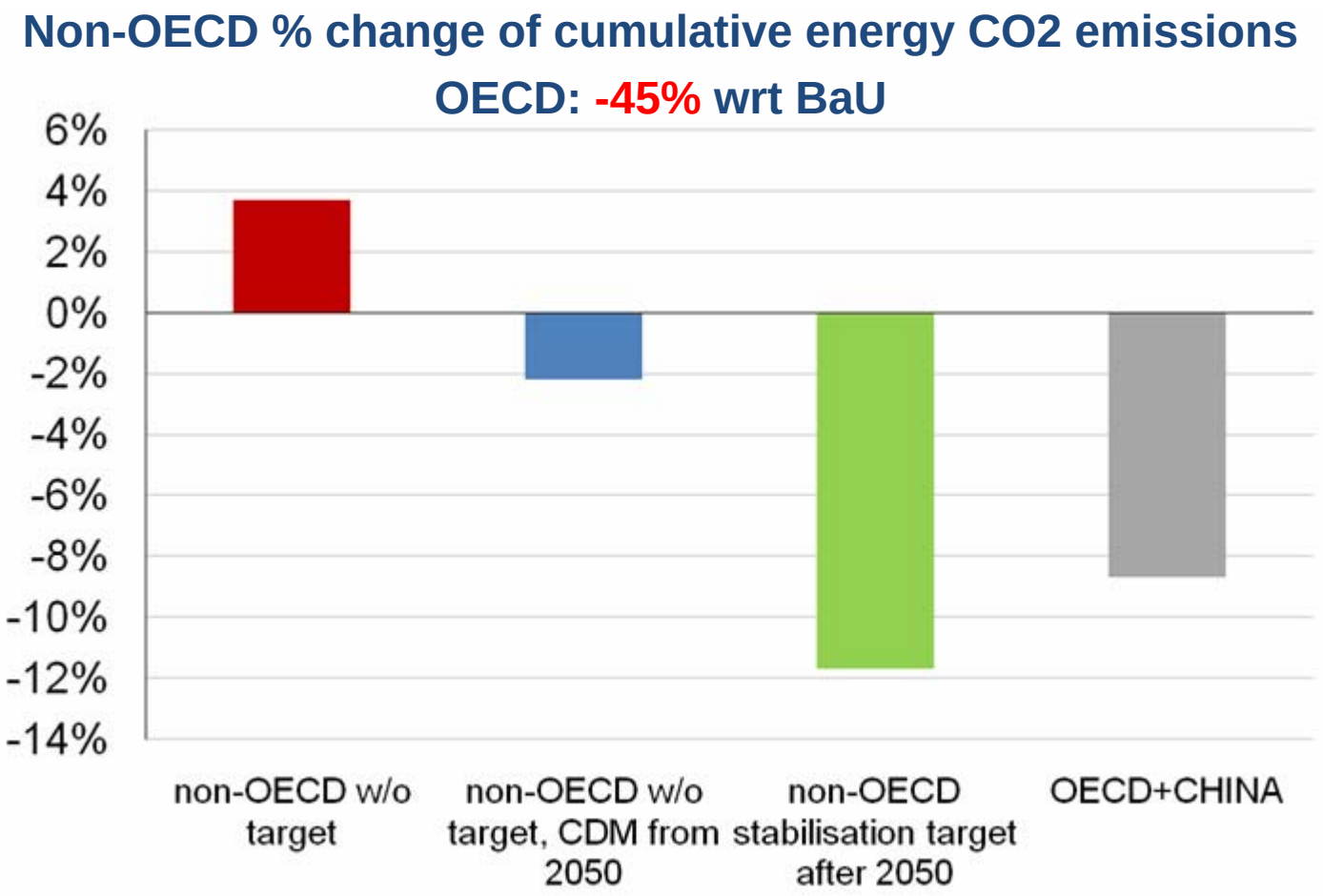
SENSITIVITY: DYNAMIC COALITION

Non-OECD % change of cumulative energy CO2 emissions

OECD: -45% wrt BaU



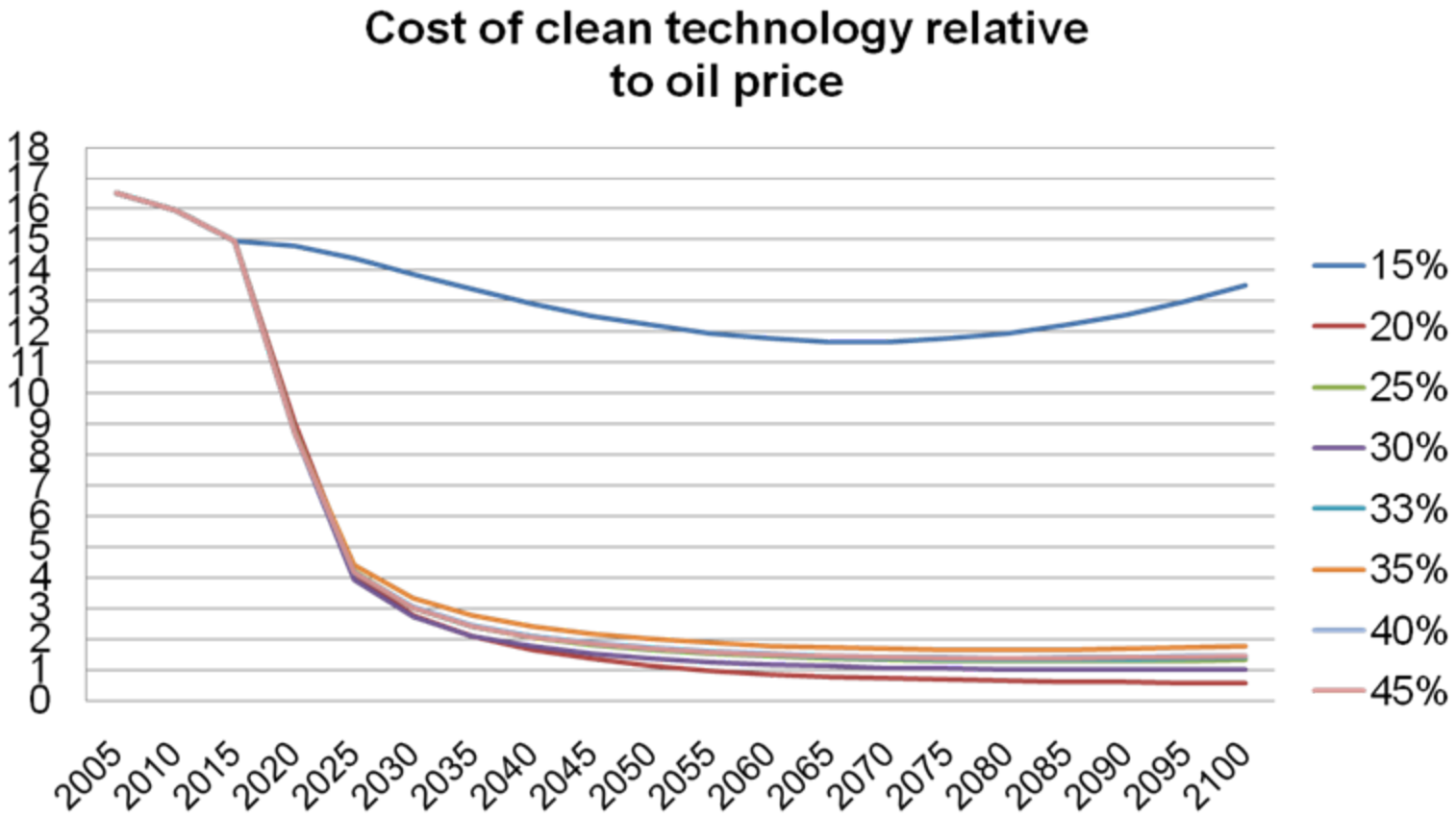
SENSITIVITY: OECD+CHINA



SENSITIVITY: OECD+CHINA

Non-OECD % change of cumulative energy CO2 emissions

OECD: -45% wrt BaU



CONCLUSIONS

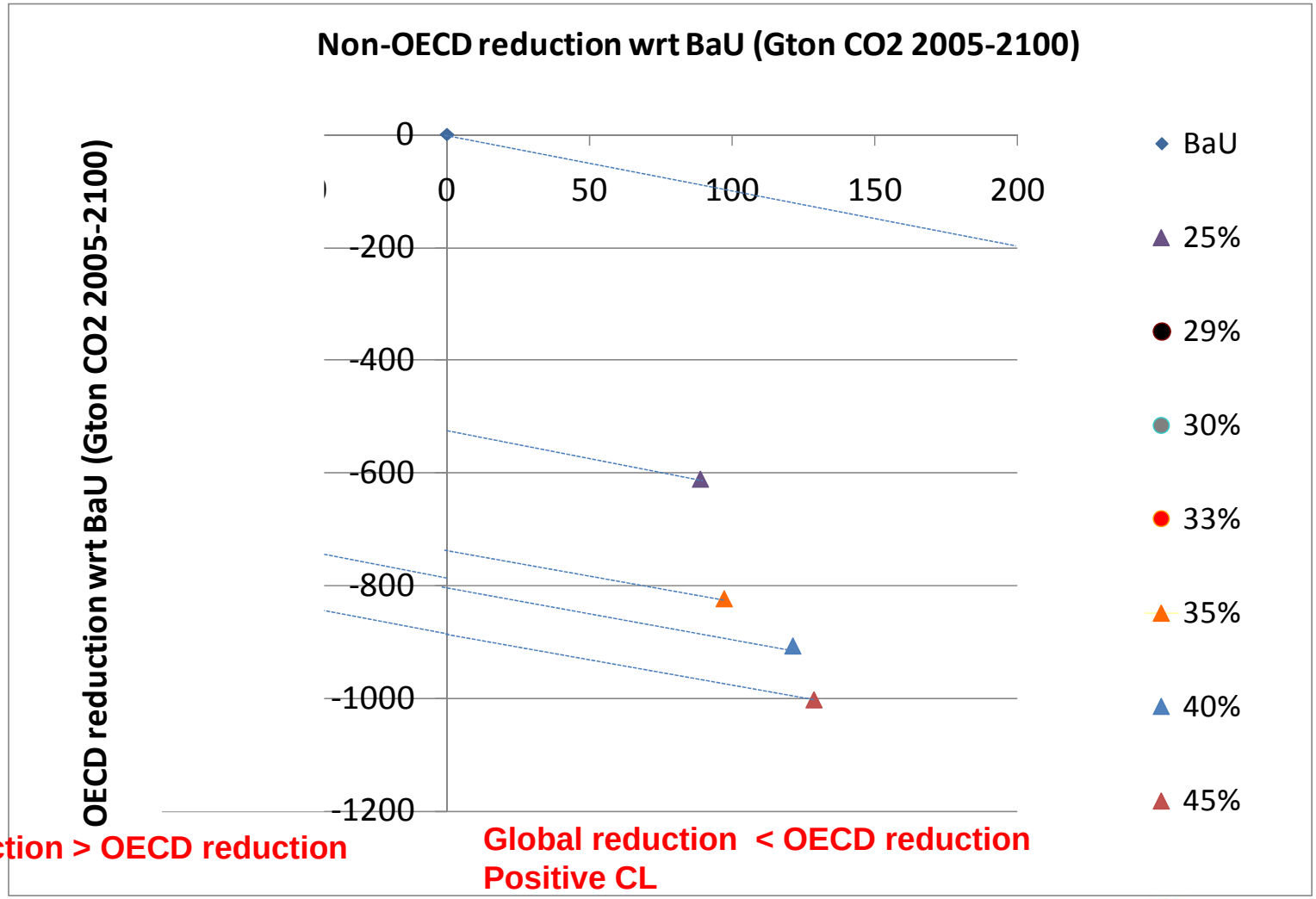
An ensemble of factors drive non signatories' reaction

With partial cooperation, very ambitious abatement might be counterproductive

With partial cooperation, a moderate policy might be better because cleaner technologies become attractive also outside the coalition

Unilateral policies can be more ambitious provided they are temporary (anticipation effect) or they involve countries with large free riding incentives

CONCLUSIONS

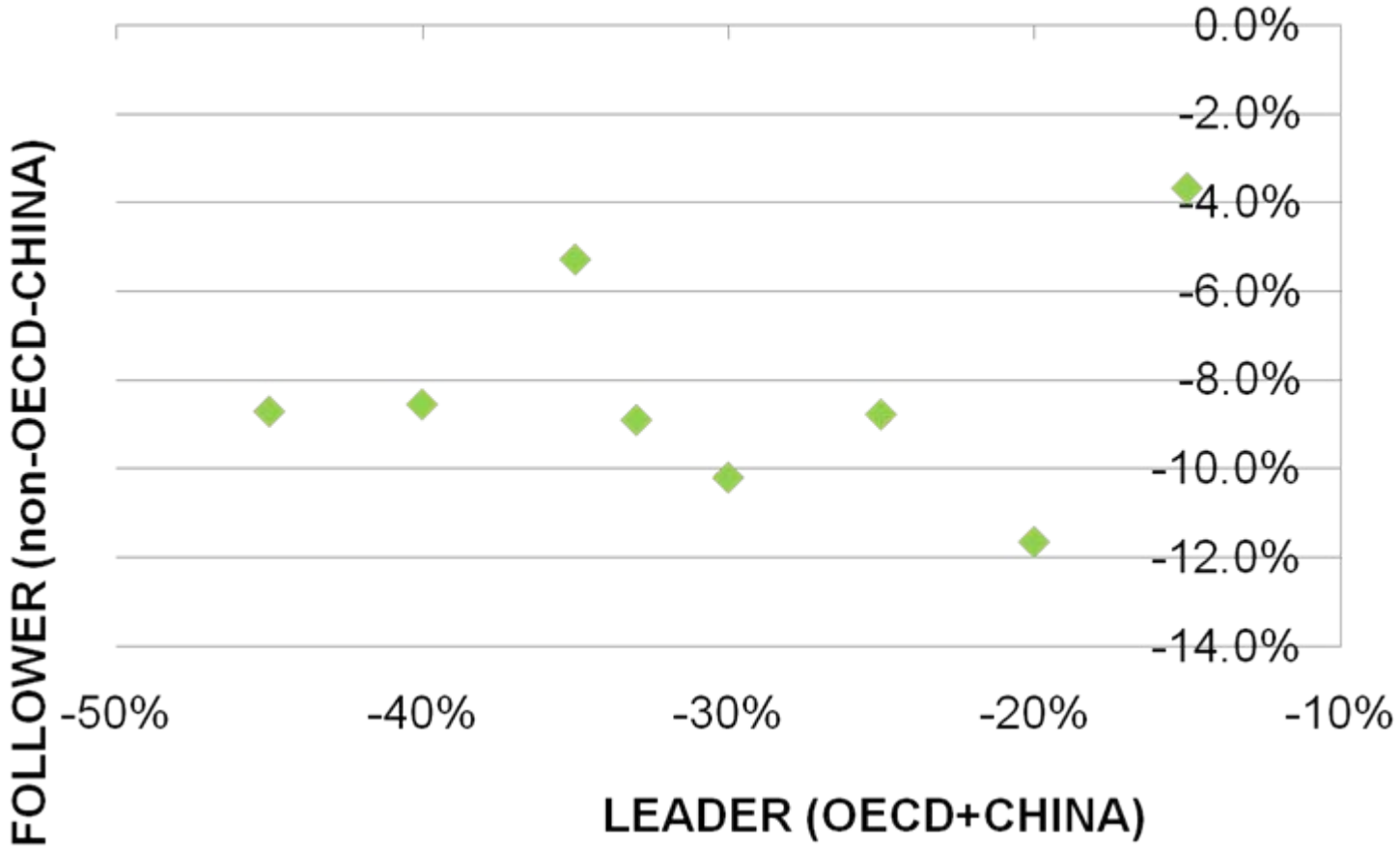


Global reduction > OECD reduction
Negative CL

Global reduction < OECD reduction
Positive CL

Corso Magenta 63, 20123 Milano - Italia - Tel +39 02.520.36934 - Fax +39 02.520.36946 - www.feem.it

SENSITIVITY: COMPOSITION



The Solution Concept

The game is solved as an open loop game

The open loop noncooperative equilibrium is defined as the equilibrium of strategies of all regions

Regions play a dynamic finite game with perfect information

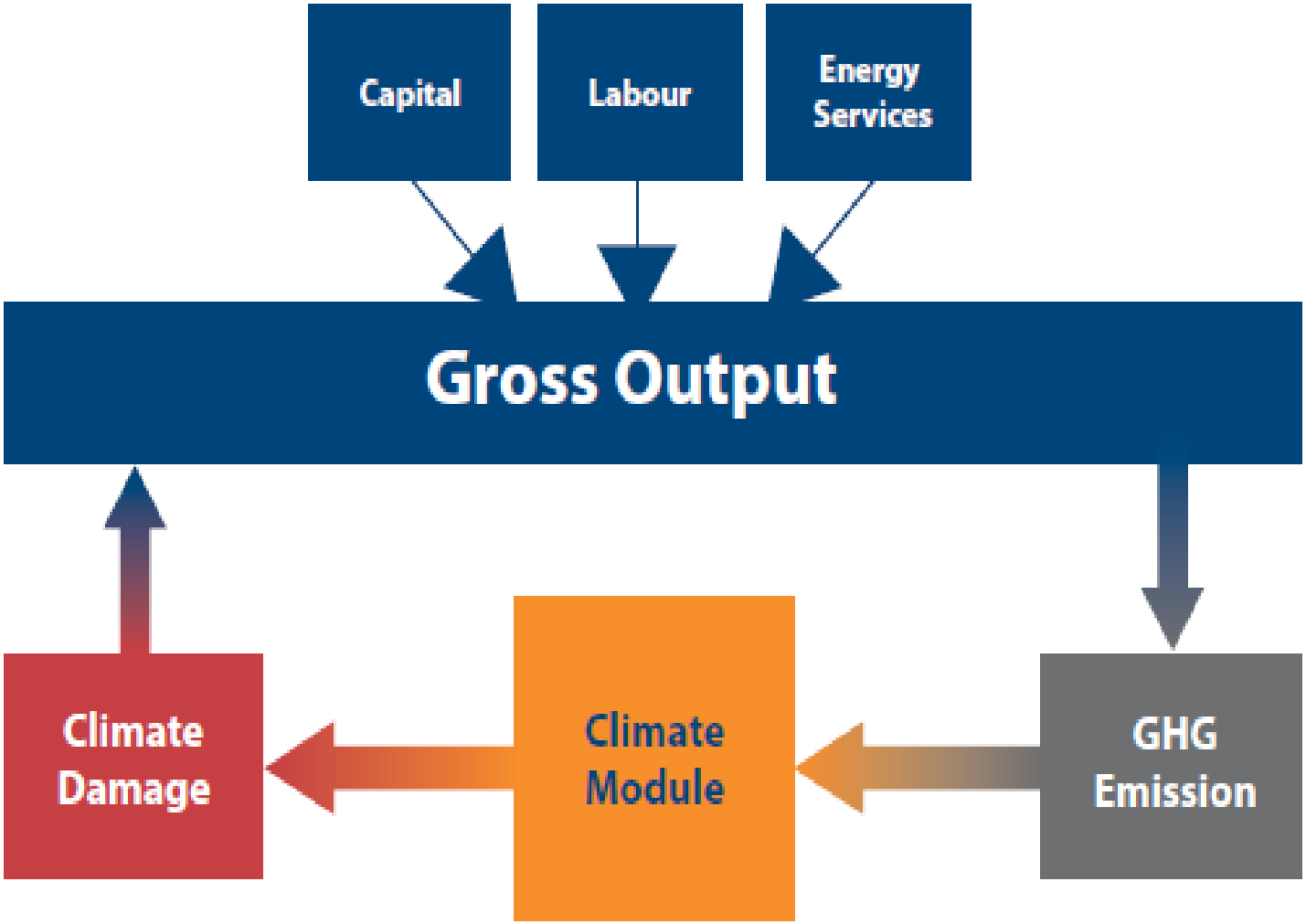
A strategy is a path for all control variables that maximizes the intertemporal regional utility function.

All countries chose their strategy, taking as given other players' strategy.

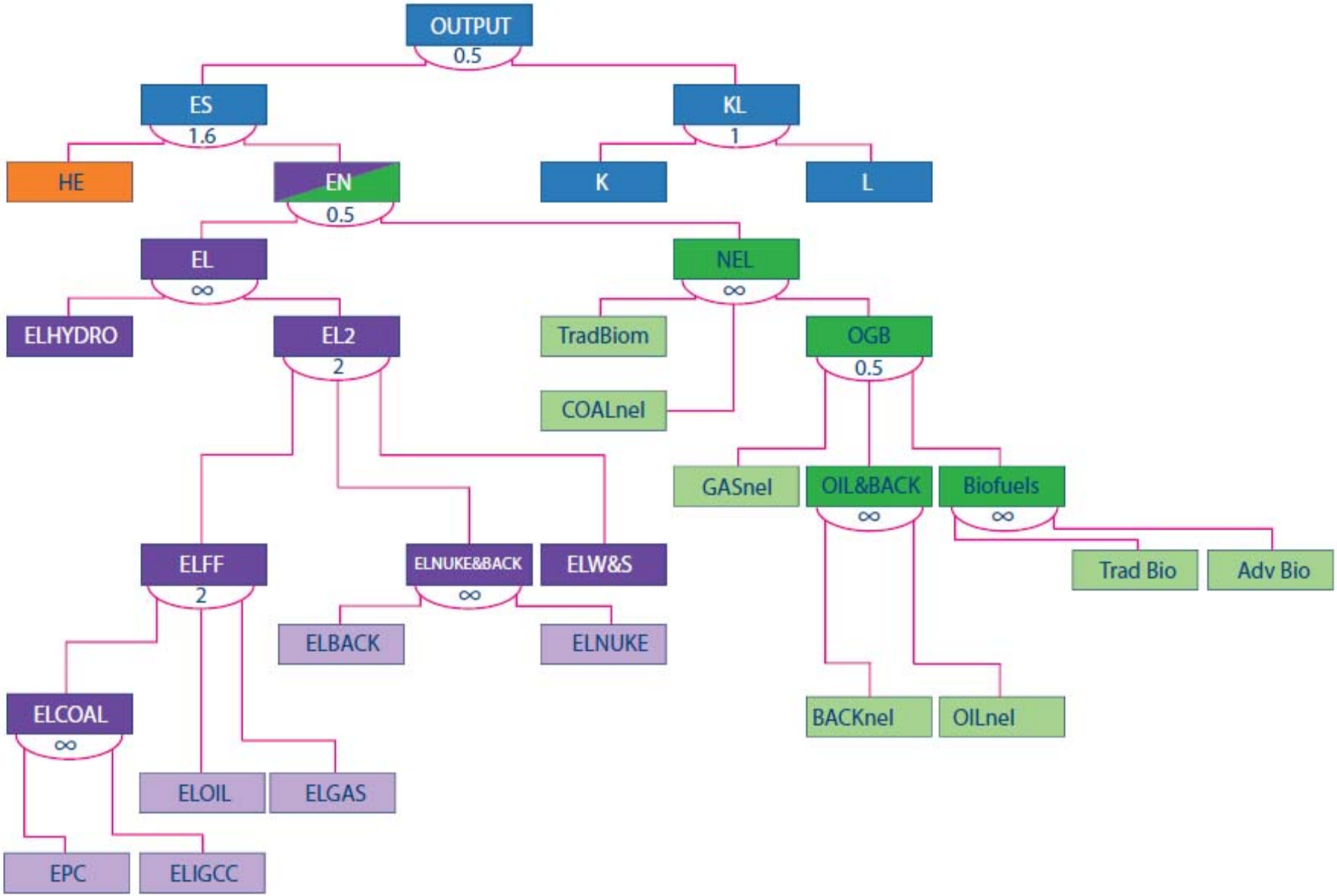
THE INTEGRATED ASSESSMENT MODEL WITCH

- **Economy**: Ramsey-type optimal growth (inter-temporal)
- **Energy**: Energy sector detail (technology portfolio)
- **Climate**: Damage feedback (global variable)
- **Endogenous technical change** – Learning-By-Doing and Learning-By-Researching
- **Strategic**: non cooperative interactions between region with externalities (environmental, price of exhaustible resources, technological spillovers, and trade of emission permits)
- **Dynamic game with perfect information**
- **Open loop game**

THE INTEGRATED ASSESSMENT MODEL WITCH



THE INTEGRATED ASSESSMENT MODEL WITCH



THE INTEGRATED ASSESSMENT MODEL WITCH