A good opening
The key to make the most of unilateral climate action

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Innovation for climate change mitigation: a study of energy R&D, its uncertain effectiveness and Spillovers

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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 increase emissions

DRIVERS OF NON SIGNATORIES' REACTION

- Damage effect: Free-riding incentive on reduced global damage
- Energy market effect: Reduced international energy prices and increase in energy demand
- Terms-of-trade and production reallocation effect : Expansion of energy-intensive production

  => Positive carbon leakage

- Technology spillovers: Diffusion of cleaner technologies

  => Negative carbon leakage

THIS PAPER

- Evaluate the consequences of incomplete cooperation when 3 effects

    1. Damage
    2. Energy market
    3. Technology

    compete with each other

- Identify the conditions under which either effect prevails

METHODOLOGY

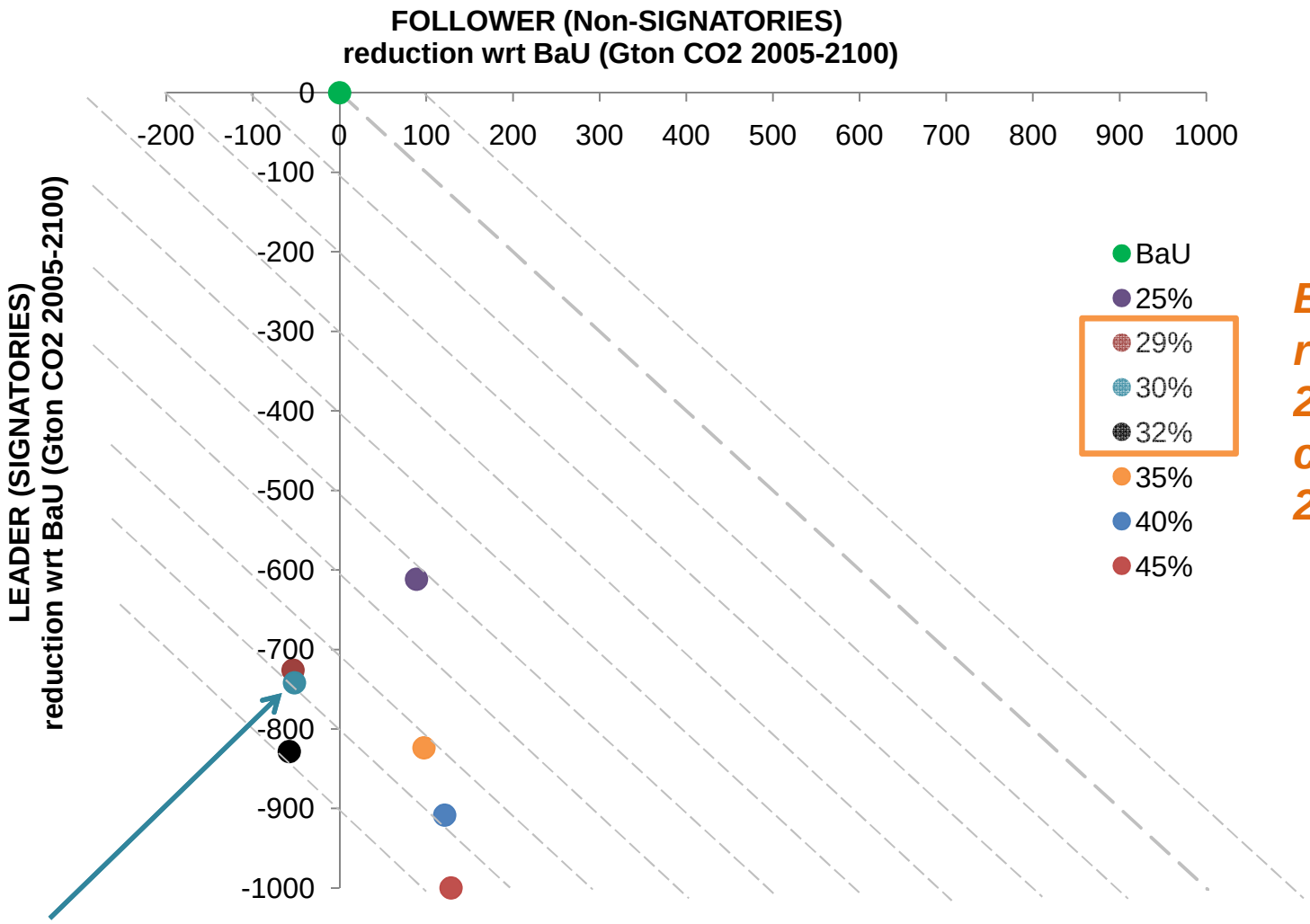
- A stylized, two-regions model solved as a Stackelberg game with a climate leader

Understand the mechanisms that drive non signatories' reaction

- A numerical evaluation using WITCH

Evaluate non signatories' reaction under different assumptions (abatement effort, discounting, coalition composition, parameterization)

MAIN RESULT



Emission reduction in 2050 compared to 2005

Stackelberg solution

A STACKELBERG GAME

e_i fossil-fuel-based technologies

b_i clean technologies

i=1,2

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

$$st$$

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

Region 1: OECD

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

$$st$$

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

Region 2: non-OECD

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

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

THE FOLLOWER'S REACTION FUNCTION

Select the cost minimising combination of technologies, taking as given the leader's effect on clean and dirty technology costs

$$f'_2(e_1) \equiv \frac{\partial e_2}{\partial e_1} \equiv -\frac{\dfrac{\partial^2 c_2(e_1, f_2(e_1))}{\partial e_2 \partial e_1}}{\dfrac{\partial^2 c_2(e_1, f_2(e_1))}{\partial^2 e_2}} = \frac{?}{+}$$

The sign of the reaction function is directly related to the shape of the technology costs

THE LEADER'S OPTIMAL CHOICE

The leader internalises the follower's reaction

$$\frac{\partial C_1(E,B)}{\partial e_1} \equiv \frac{\partial c_b(B)}{\partial e_1} b_1 + c_b(B)\frac{\partial b_1}{\partial e_1} + \frac{\partial c_e(E)}{\partial e_1} e_1 + c_e(E) + \frac{\partial D_1(E)}{\partial e_1}$$

CLEAN TECHNOLOGY

ENERGY MKT

DAMAGE

where

$$E = e_1 + e_2$$

$$e_2 = f_2(e_1) = f(c_b, c_e)$$

She can exploit her position and chose the technology mix that minimises the adverse reaction of the follower

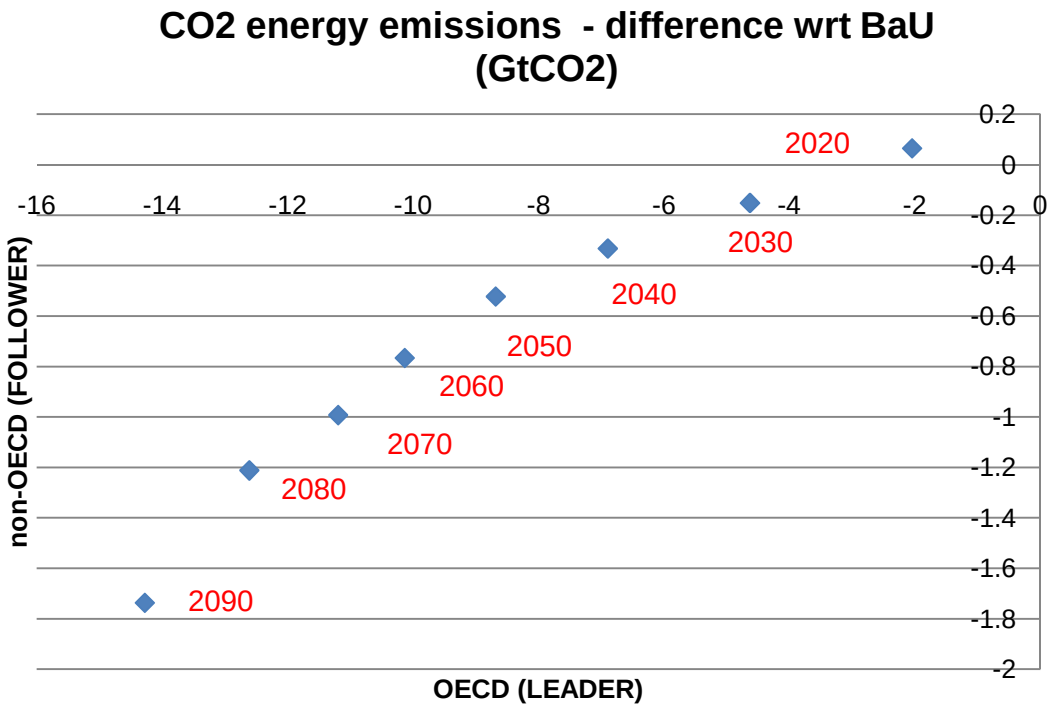
A NUMERICAL EVALUATION: THE WITCH MODEL

1. Reduced form damage function increasing in temperature
2. Endogenous technological dynamics
3. Internationally integrated energy markets

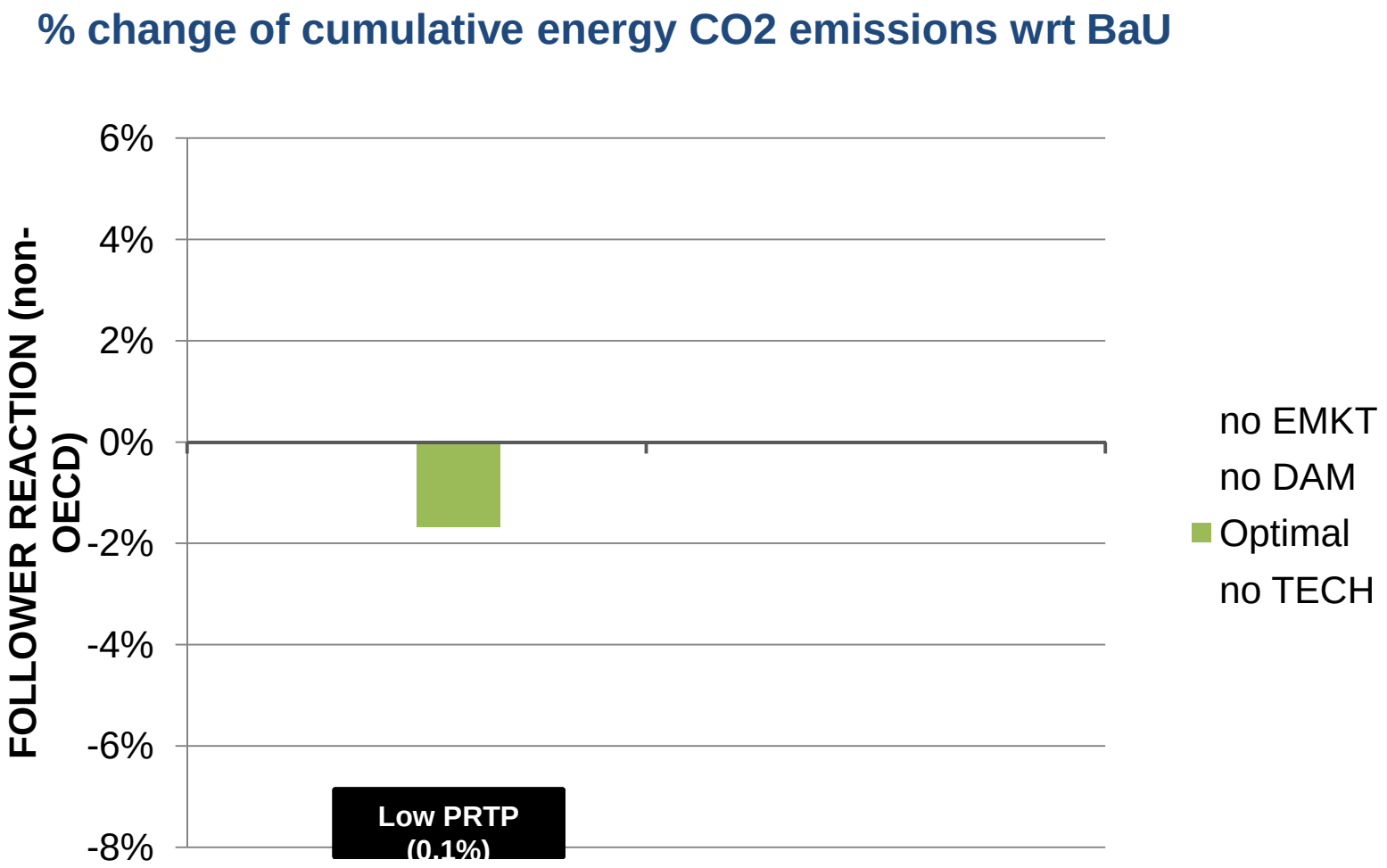
- **OECD countries as climate leader**: CBA to set the optimal abatement path under the following assumptions (relaxed later):
- Low pure rate of time preference (0.1%)
- Climate change damage estimates in the mid range (3.4°C above pre-industrial => 7% GWP loss in 2100)

THE STACKELBERG SOLUTION

- The technology channel dominates the damage and energy market effects
  - *Positively sloped reaction function*



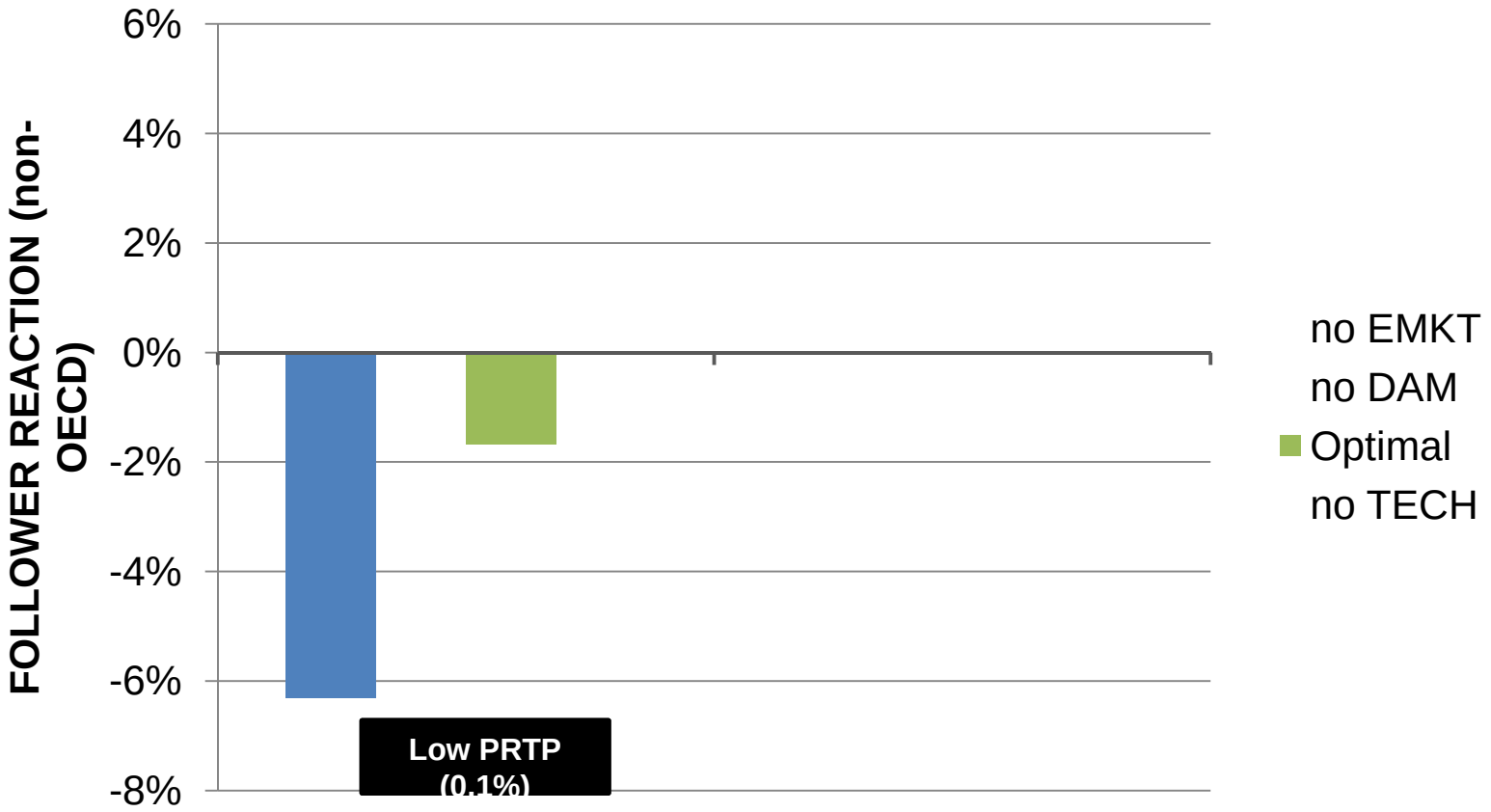
THE STACKELBERG SOLUTION: MAIN DRIVERS



OECD: -34% in 2050 wrt 2005

THE STACKELBERG SOLUTION: MAIN DRIVERS

% change of cumulative energy CO2 emissions wrt BaU



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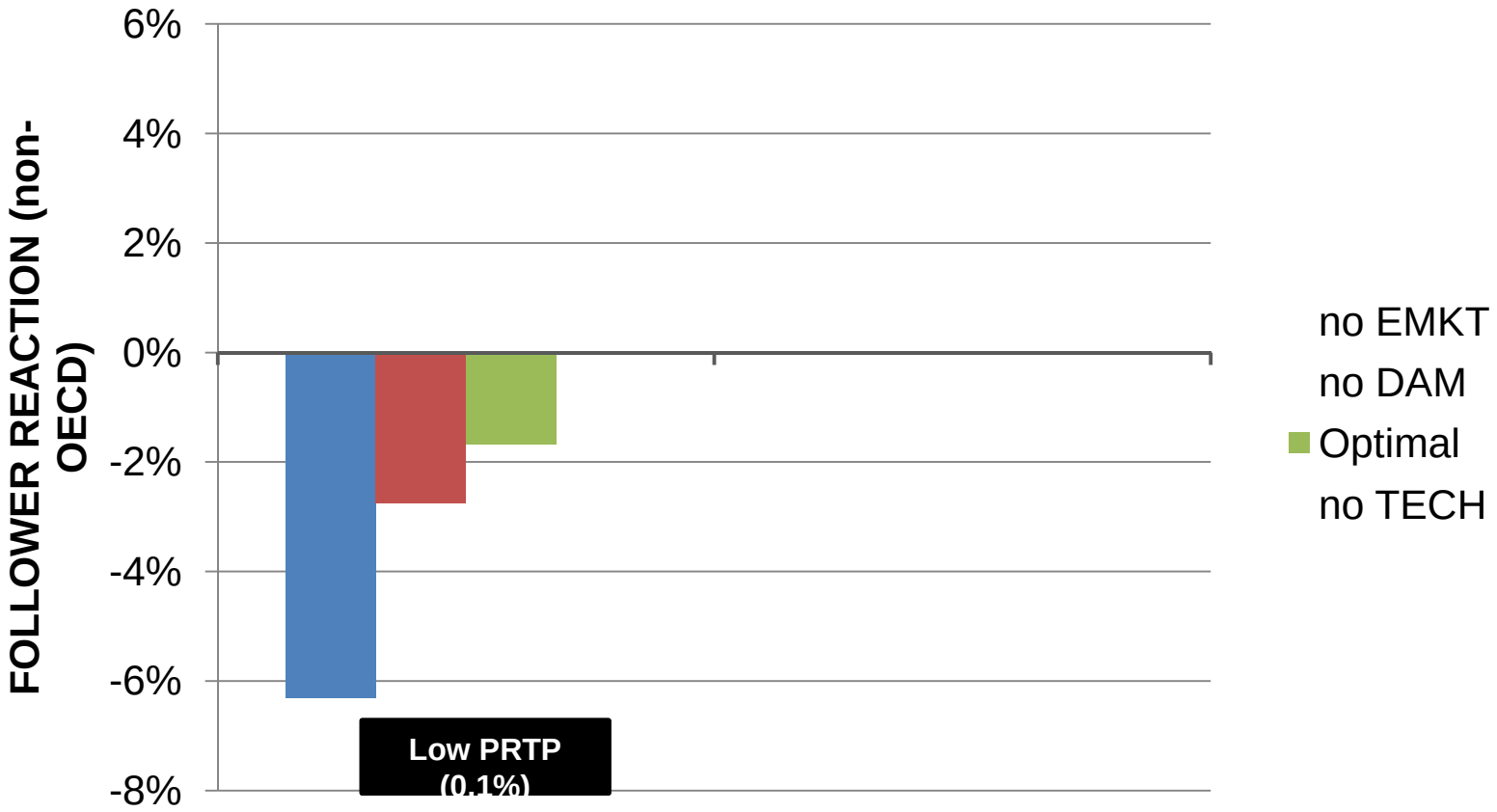

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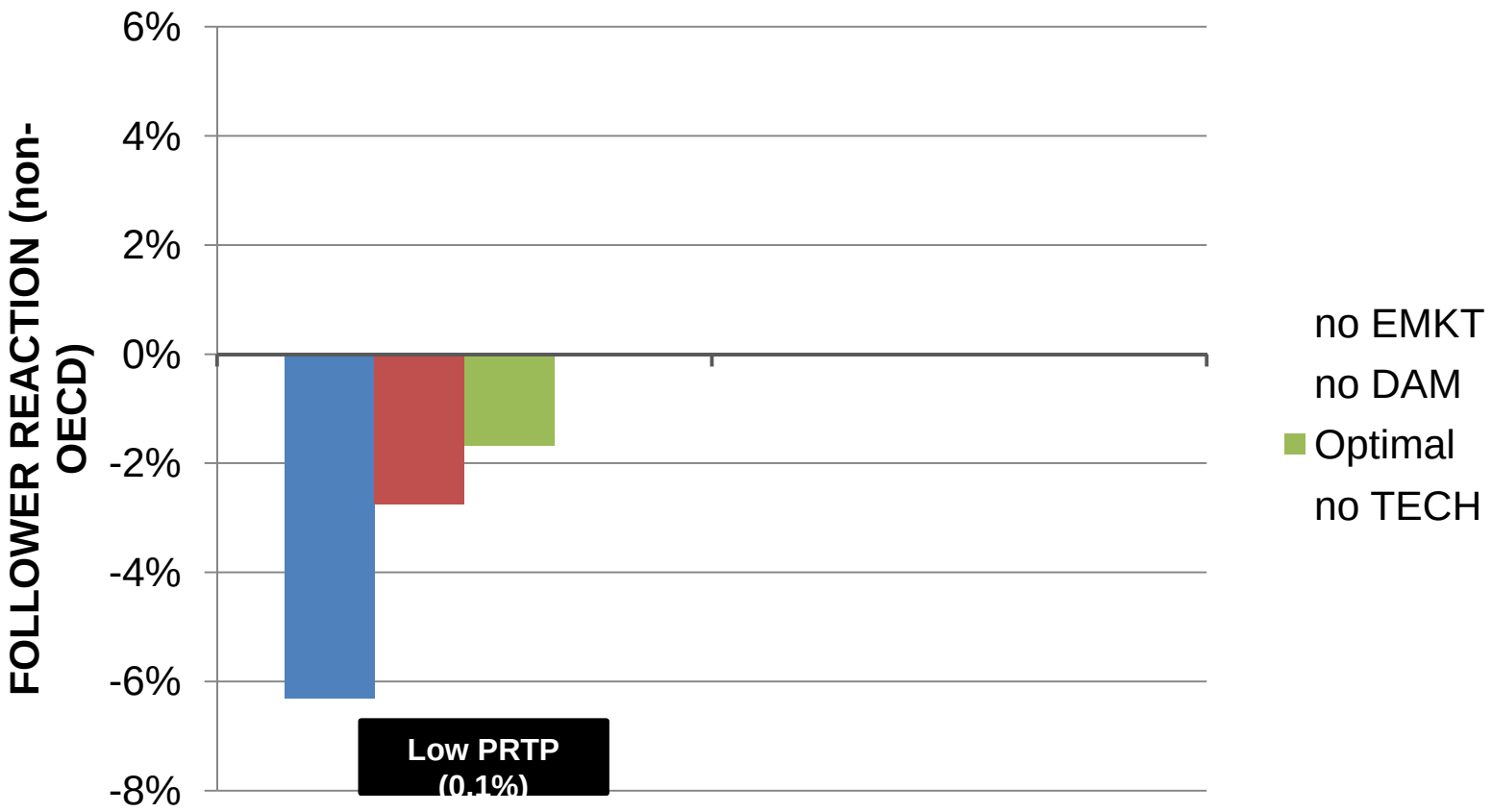

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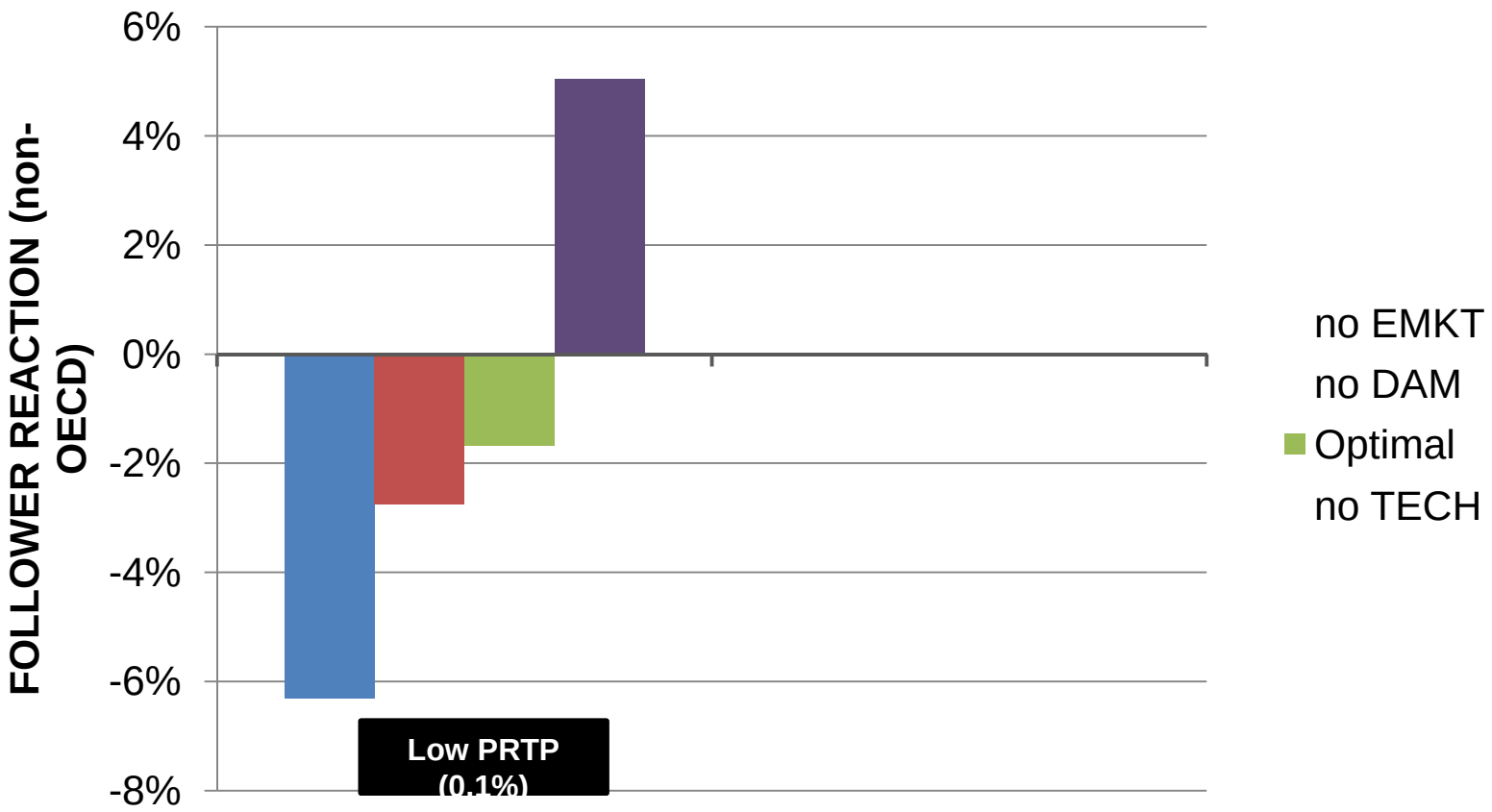

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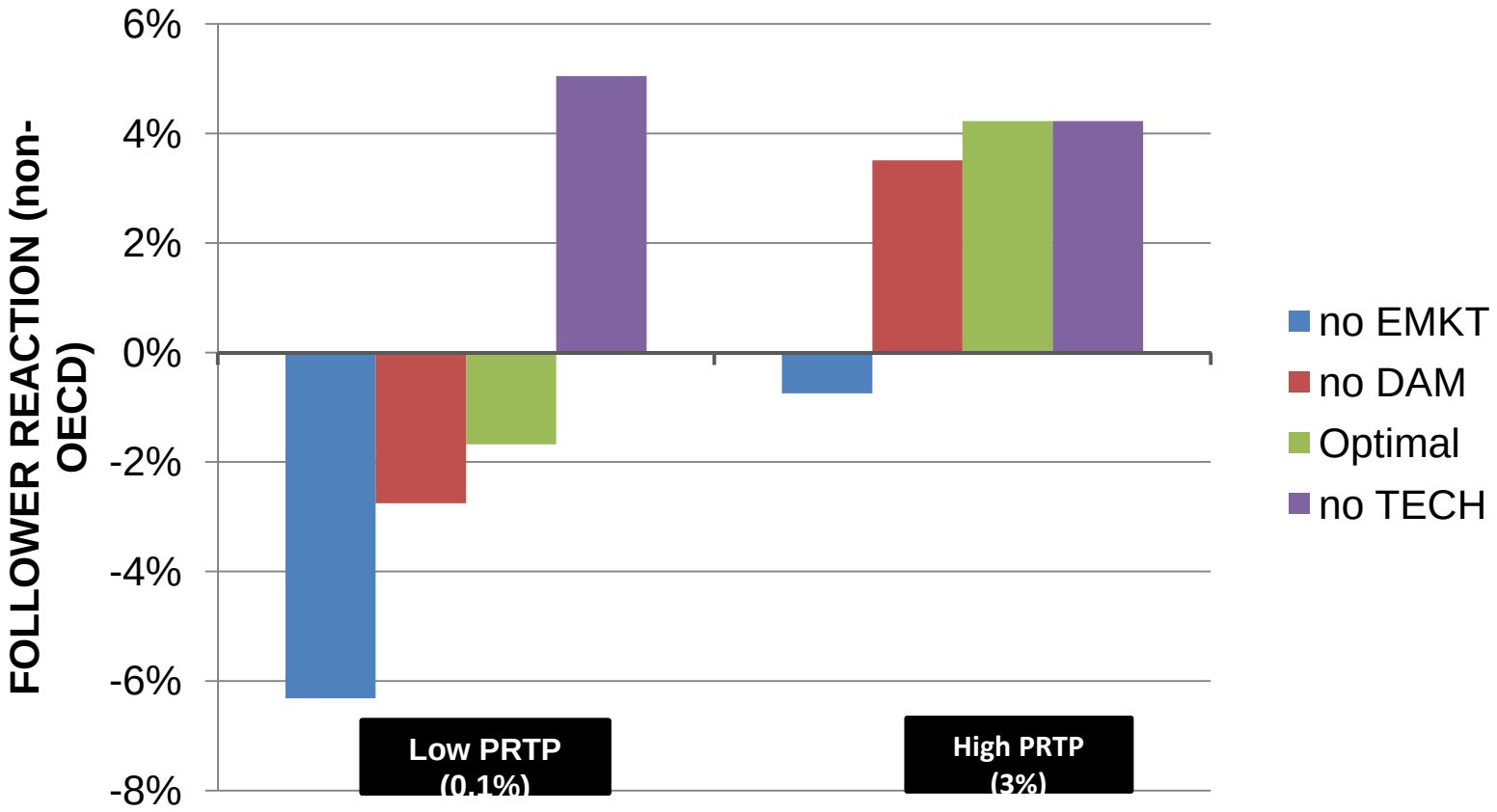

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SENSITIVITY: EFFORT AND COALITION COMPOSITION

The influence of the three factors depends on

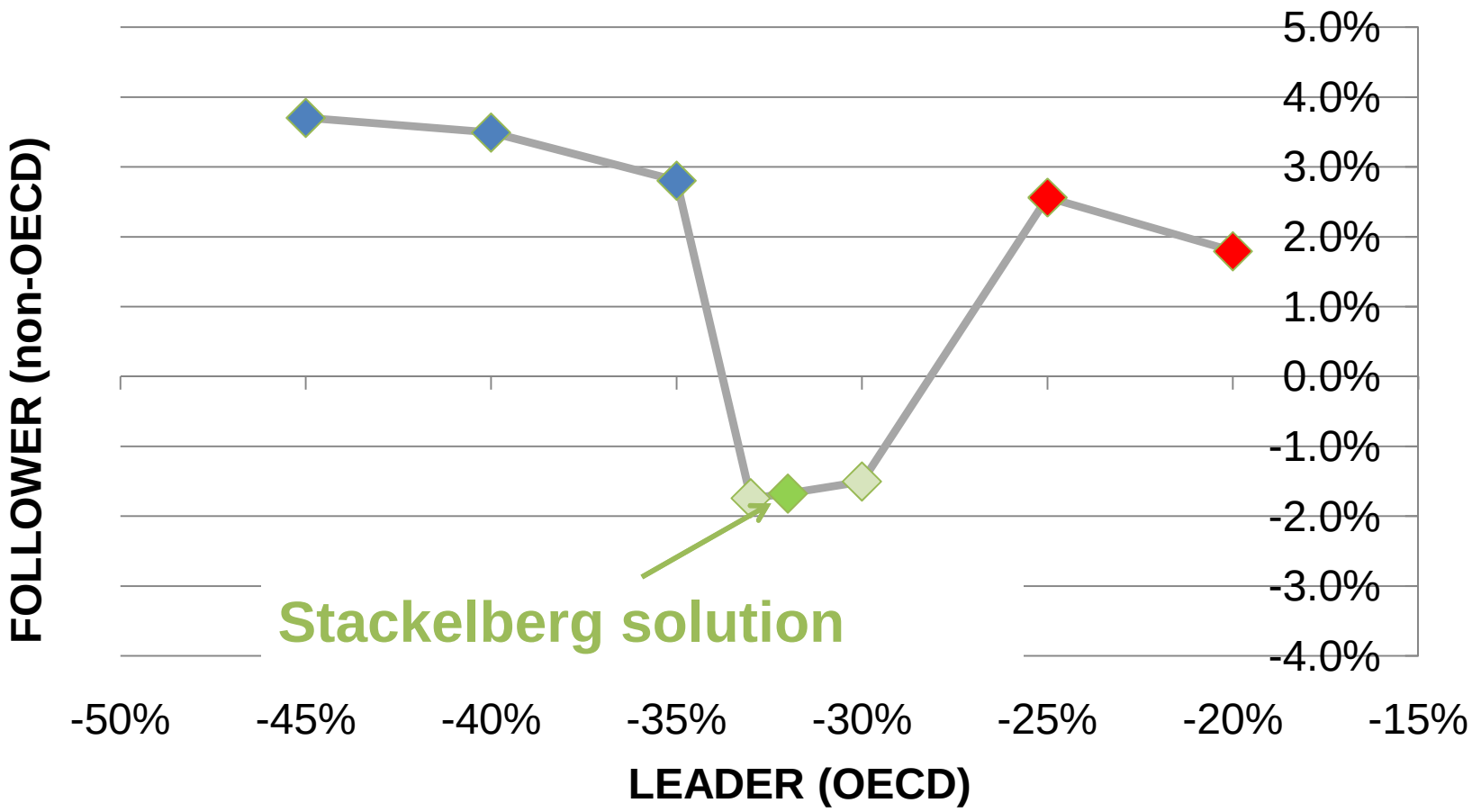
- the emission target
- the coalition composition

We now investigate the effect of:

➢ the stringency of the emission objective

➢ the composition of the coalition

SENSITIVITY: EFFORT



On x-axis: OECD incrementally increases the stringency of 2050 target wrt 2005 emissions

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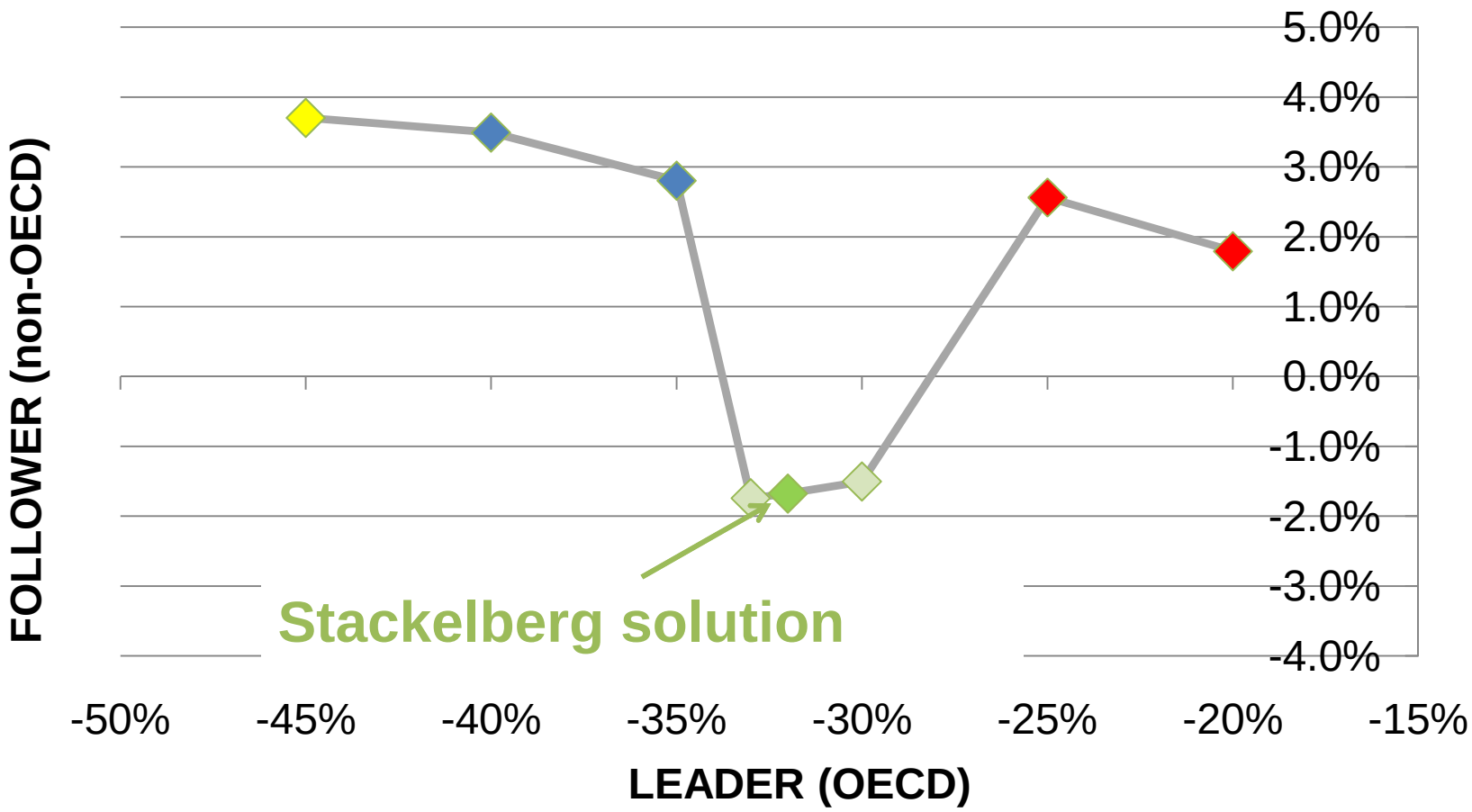

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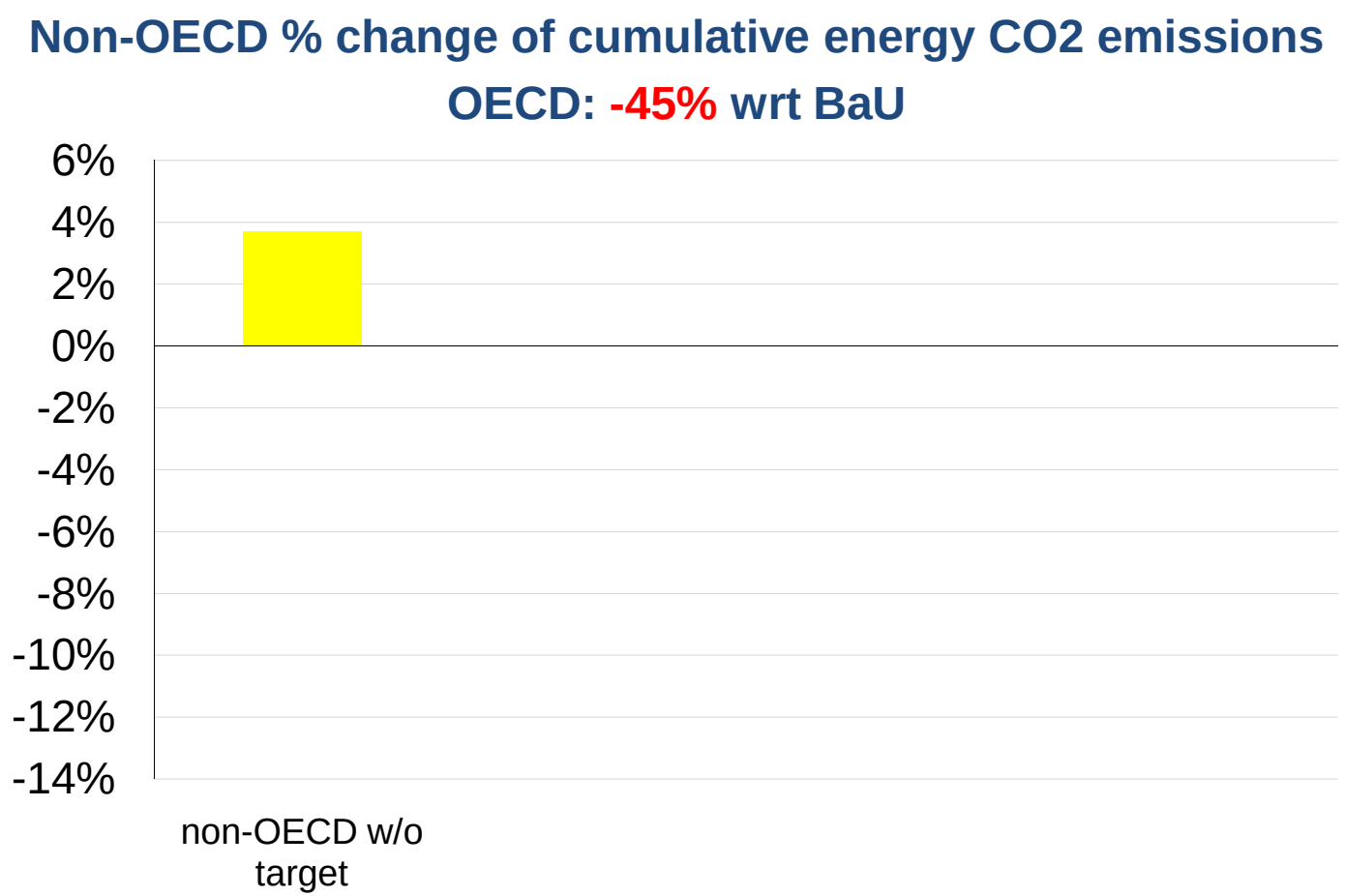
SENSITIVITY: DYNAMIC COALITION



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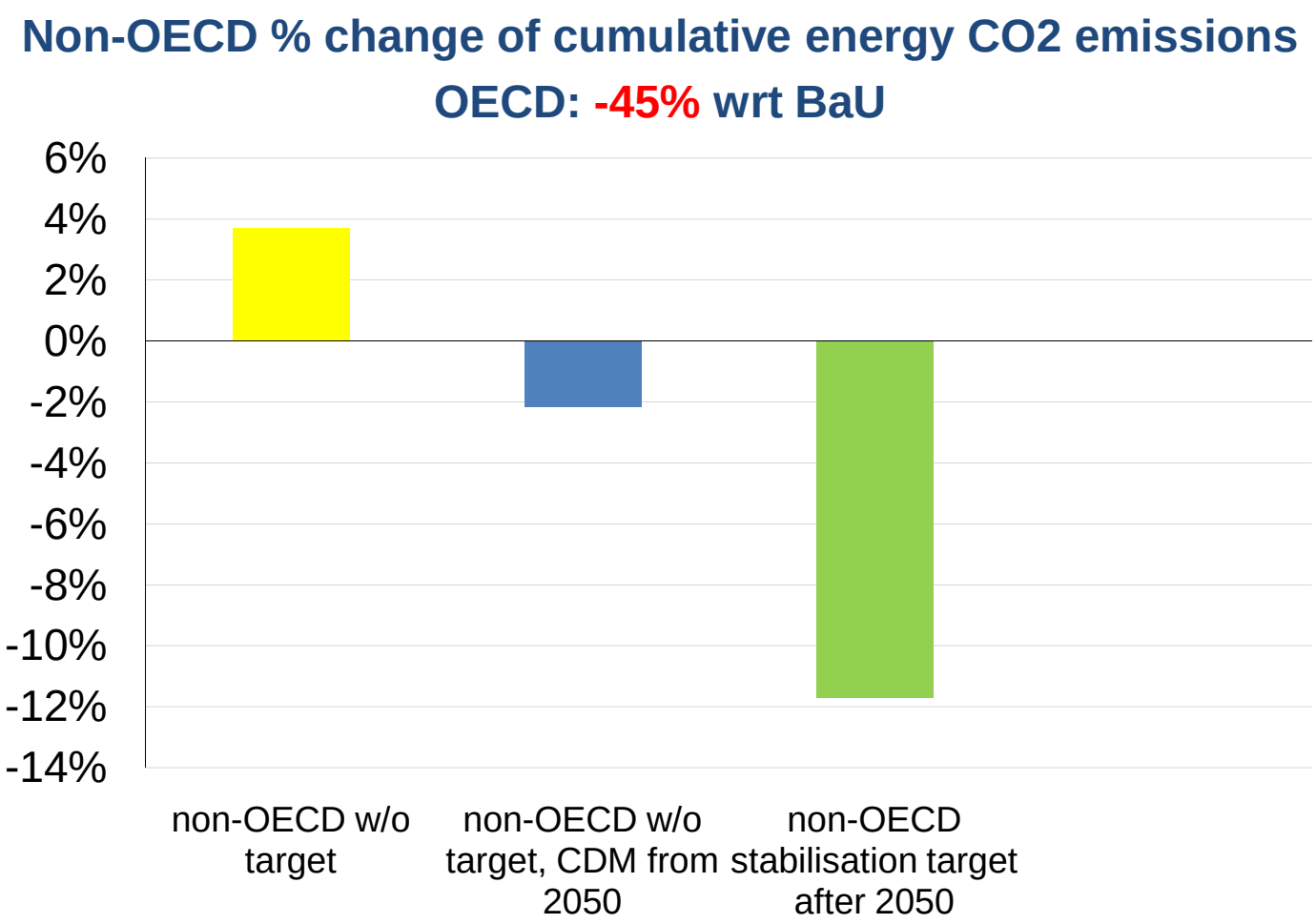
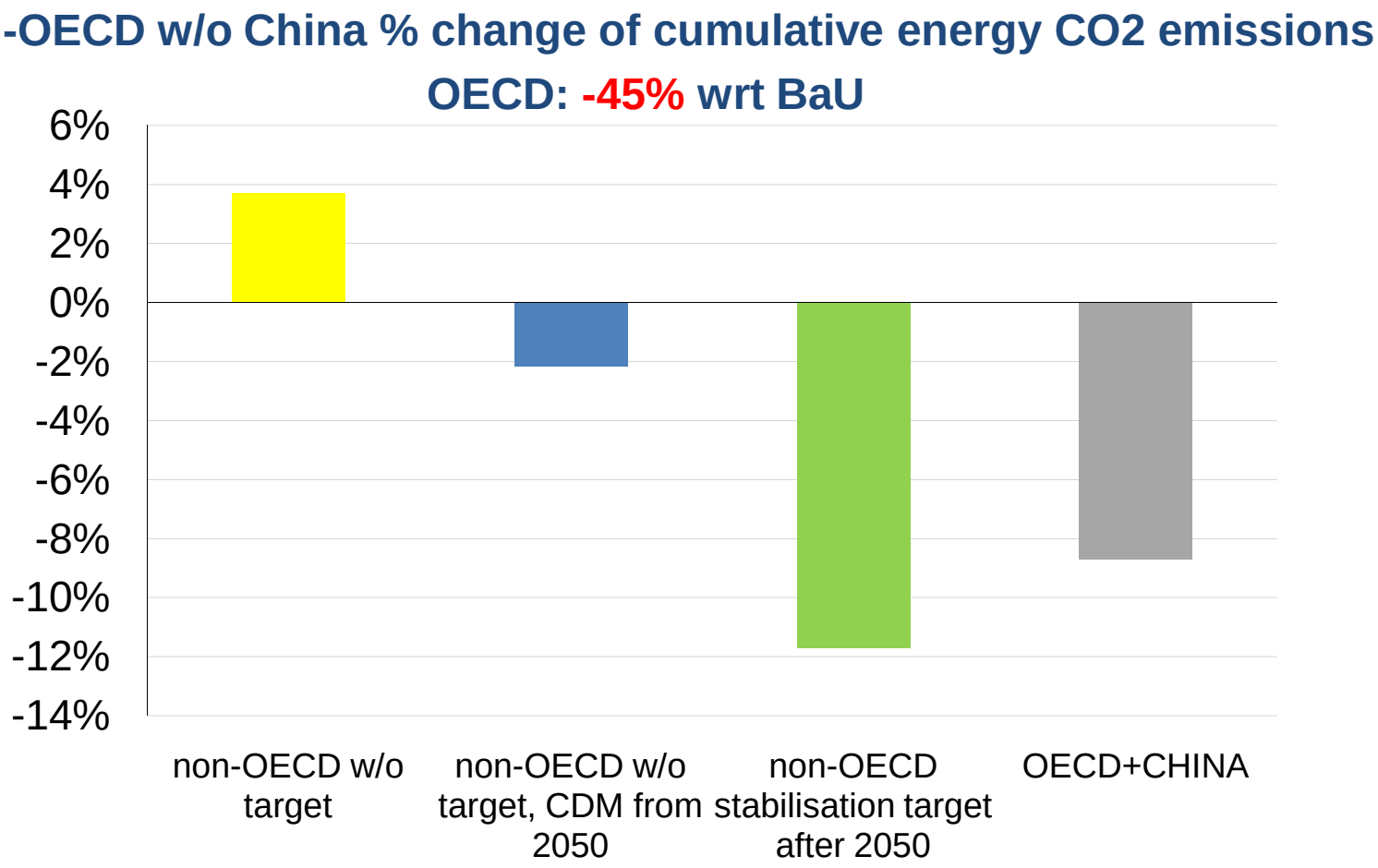
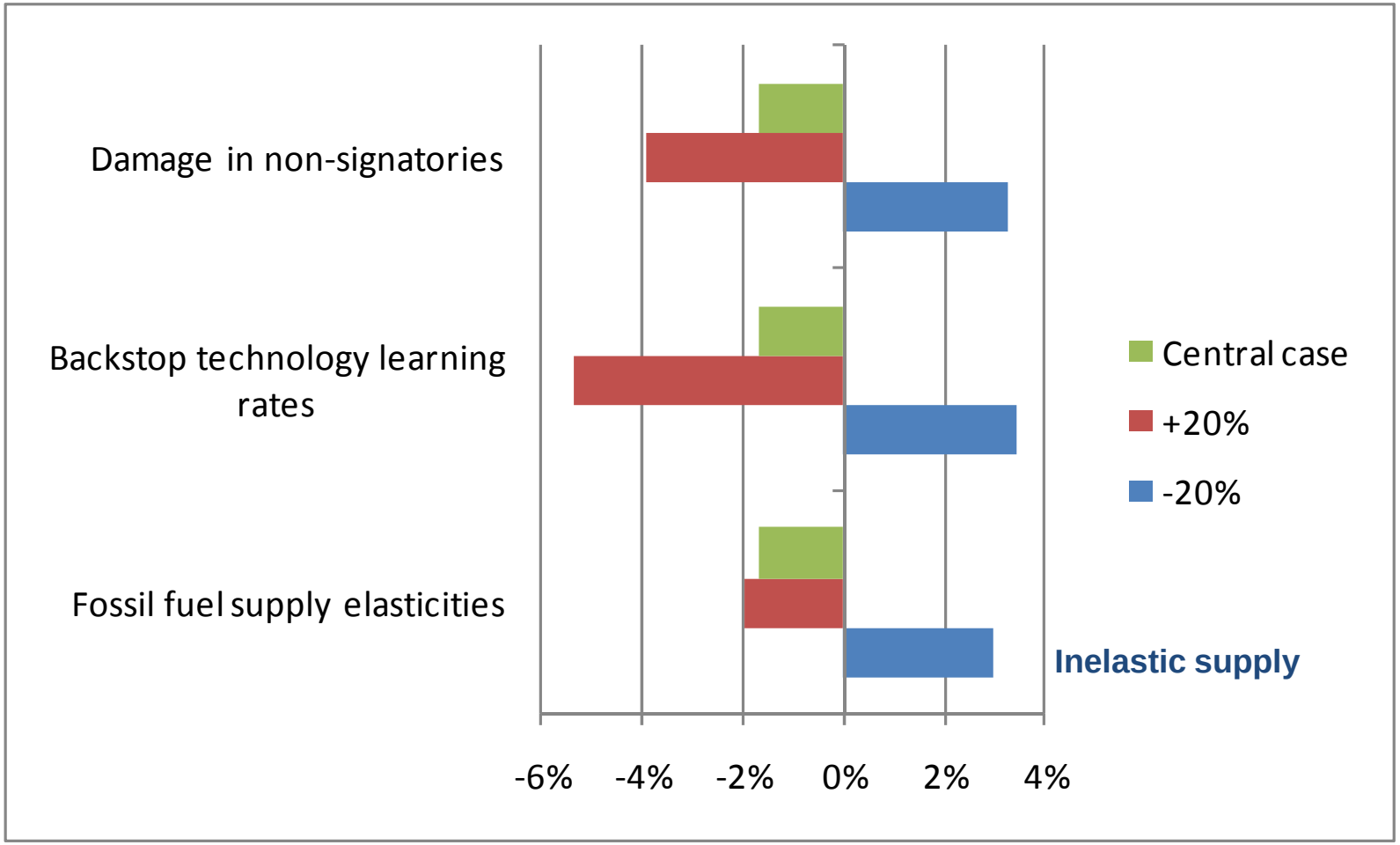


SENSITIVITY: OECD+CHINA



SENSITIVITY TO MODEL PARAMETERISATION

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



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

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