

# Adaptation to Climate Change: How does Heterogeneity in Adaptation Costs Affect Climate Coalitions?

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  - Whether to join an agreement
  - How much to emit
- Examples: United Nations Framework Convention on Climate Change (since 1992)
  - 196 parties meet annually
  - Treaties: Kyoto Protocol (adopted in 1997, in force since 2005), Cancún agreements 2010

# To date, discouraging results

- Not surprising for economists
- Structure of agreements:
  - Limiting global warming is crucial for all countries
  - Yet, weak individual country incentives to reduce emissions
  - No global institution to enforce cooperation, leading to lack of policy instruments
- Results of IEA literature are pessimistic:
  - If successful, few countries join
  - If many countries join, unambitious emission reduction

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- Results of IEA literature are pessimistic:
  - If successful, few countries join
  - If many countries join, unambitious emission reduction
- In this paper, how does adaptation affect country incentives to join IEAs?

# What is adaptation?

- Adaptation is any activity with a potential to reduce the damages from climate change
- Examples:
  - Construction of dams, levees or dikes
  - Change crop types used in agriculture
  - Improve storm predictions and their warnings

# Why adaptation matters for climate coalitions

- Two main available options to tackle climate change: emissions abatement & adaptation
- There are strategic interactions between emissions and adaptation
- Public vs private nature
  - Emissions: private decision  $\rightarrow$  public bad  $\rightarrow$  incentives to free ride
  - Adaptation: private decision  $\rightarrow$  private benefits

Yet, environmental agreements often ignore adaptation strategies



# Empirical evidence on adaptation

- Cost of adaptation to climate change
  - World Bank: the cost of adapting to a 2°C warmer world by 2050 is in the range of \$70 billion to \$100 billion each year between 2010 and 2050
- Differences among countries
  - The cost of adaptation differs across countries
  - Large differences between developed and developing countries
  - UN policy: Cancún Adaptation Fund

# Research Question

- How does adaptation affect the incentives to join environmental agreements?

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- How does adaptation affect the incentives to join environmental agreements?
  - 1 How do cross-country differences in adaptation costs affect emissions?
  - 2 How do cross-country differences in adaptation costs change the incentives to join IEAs?
  - 3 How do emission leakages, combined with adaptation, influence the incentives to join IEAs?

# Previous work and our contribution

## Relates to:

- 1 International environmental agreements (e.g., Barrett 1994, 1997, 2001; Kolstad 2007; McGinty 2007)
  - Adaptation and IEA (Marrouch and Chaudhuri 2013; Benchekroun et al 2013)
- 2 Relationship between adaptation and emissions abatement (e.g., Ebert and Welsch 2012; Zehai 2009)

## Our contribution:

- Account for adaptation strategies when deciding whether to join an environmental agreement to restrict emissions
- Key: adaptation cost differs among countries, the role of carbon leakage

# Model assumptions

- 1 Multiple countries
- 2 Each country simultaneously chooses emissions and adaptation strategies to maximize social welfare (payoffs)
  - Emissions:
    - **Private benefit** because by-product of production
    - **Public bad**: global pollution generates damages
  - Adaptation:
    - **Private** benefits and costs

# Model assumptions

- 1 There are multiple countries
- 2 Each country simultaneously chooses emissions and adaptation strategies to maximize social welfare (payoffs)
- 3 Three key features

- 1 Public vs private nature of emissions and adaptation

	Benefit	Cost/Damages
Pollution	Private	Public
Adaptation	Private	Private

- 2 Consider the role of carbon leakage
  - Carbon leakage: a country increases their emissions when another country reduces their emissions
- 3 Adaptation cost differs among countries. Two types: high and low adaptation cost countries

# IEA model

Social Welfare = Benefits - Damages - Costs

Benefits:  $B(e_i) = e_i \left( \alpha - \beta \frac{e_i}{2} \right)$

Damages:  $D(E, a_i) \equiv (\omega - a_i) E^n / \eta$

Costs:  $C(a_i) \equiv \frac{c^j}{2} (a_i)^2$

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■ Private emissions



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- Private emissions
- Public bad: global emissions & carbon leakage

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- Private emissions
- Public bad: global emissions & carbon leakage
- Private adaptation

# New features of our model

- 1 Adaptation: can reduce damages and increase costs
- 2 Carbon leakage
  - 1 No carbon leakage when  $\eta = 1$
  - 2 Carbon leakage when  $\eta > 1$
- 3 Cost heterogeneity in adaptation
  - High cost
  - Low cost

# How do we solve?

Each country maximizes the social welfare simultaneously choosing adaptation and emissions

- 1 For each country
  - Individual emissions,  $e$
  - Adaptation,  $a$
- 2 Global: total emissions,  $E$
- 3 Coalition:
  - Polar cases: everybody joins, nobody joins
  - Coalition formation: how many countries choose to join a coalition

# Polar cases

How does adaptation affect global emissions and adaptation?

- 1 No country joins a coalition: each country maximizes their payoff given others' strategies
- 2 All countries join a coalition: maximize joint payoff

# Polar cases

## Results

- 1 Strategic relationship between emissions and adaptation
  - Strategic complements **without** carbon leakage
  - Strategic complements/substitutes **with** carbon leakage
- 2 With leakage more adaptation with no cooperation

# Coalition formation and stability

How does adaptation affect the incentives to form a coalition?

## 1 Two stage game:

- Stage 1: decide whether to sign emissions agreement
- Stage 2: decide joint emissions & country adaptation

## 2 Coalition stability:

- Find number of countries that satisfies:
  - Internal stability: signatory country wants to stay in coalition
  - External stability: non-signatory country wants to stay out of coalition

# Numerical exercise

Numerical values:

Countries low cost of adap	50
Countries high cost of adap	50
Adaptation cost L	44.5
Adaptation cost H	45
Marginal damage E	0.029
$\alpha$	9
$\beta$	223
$\eta$	1, 2

Results are robust to other numerical values



# Stability of coalitions

No carbon leakage

	Identical cost	Cost differences
No adaptation	max 3 countries	
Adaptation		

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- **Result:** Puzzle of small coalition remains
- The maximum number of countries that can join coalition unchanged

# Stability of coalitions

No carbon leakage

	Identical cost	Cost differences
No adaptation	max 3 countries	
Adaptation	max 3 countries	max 2 countries

- **Result:** Puzzle of small coalition remains and cost heterogeneity discourages coalition formation
  - Cost differences reduce the incentives to join coalition because the net marginal cost of polluting is larger
  - Coalition members emissions are the same, yet incentives to leave the coalition increase due to differences in adaptation costs

# So What? Policy implications

## Cancún adaptation fund

Policies directed at reducing heterogeneity among countries might also affect the success of IEAs

- For example: Cancún adaptation fund
- Aims at reducing cost heterogeneity in adaptation among developed and developing countries

# Stability of coalitions

## Carbon leakage

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# Stability of coalitions

## Carbon leakage

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No adaptation	max 2 countries	
Adaptation	breaks puzzle	

- **Result:** Puzzle of small coalitions breaks with adaptation
  - Adaptation increases incentives to join coalition because the net marginal cost of polluting is lower

# Stability of coalitions

## Carbon leakage

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No adaptation	max 2 countries	
Adaptation	breaks puzzle	<b>breaks puzzle</b>

- **Result:** Cost heterogeneity could encourage coalition formation
  - Adaptation reduces incentives to free ride

# Stability of coalitions

## Carbon leakage

	Identical cost	Cost differences
No adaptation		max 2 countries
Adaptation	breaks puzzle	possibility grand coalition

- **Result:** Cost heterogeneity could encourage coalition formation
  - Grand coalition is a possible equilibrium outcome, even with heterogeneity in the cost of adaptation
  - Result is sensitive to the marginal benefit of emissions; low marginal benefit, grand coalition while large marginal benefit, no incentives to join coalition



# So What? Policy implications

## Cancún adaptation fund

Policies directed at reducing heterogeneity among countries might also affect the failure of IEAs

- **Cancún adaptation fund** aims at reducing cost heterogeneity in adaptation among developed and developing countries
  - As the fund grows, heterogeneity first reduces but might eventually increase

# So What? Policy implications

## Clean Development Mechanism

Policies directed at reducing heterogeneity among countries might also affect the failure of IEAs

- **Clean Development Mechanism** aims at reducing heterogeneity in emissions abatement effort among developed and developing countries

# Conclusion

RQ: How does adaptation affect the incentives to join coalitions?

- 1 Adaptation **without** carbon leakage could discourage joining a coalition
- 2 Adaptation **with** carbon leakage could encourage joining a coalition
- 3 Coalitions:
  - Grand coalition possible
  - Cost differences in adaptation and carbon leakages could encourage coalition formation
- 4 Policies directed at reducing heterogeneity among countries might also affect the success and failure of IEAs