THE ROLE OF PROACTIVE ADAPTATION IN INTERNATIONAL MITIGATION COALITIONS

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Introduction: climate change

- Climate change creates an environmental threat
- Increased GHG emissions are changing the climate making it hotter and more variable
- Economics can be used as a tool to analyse this problem and its possible solutions

Introduction: policy options

- Policy options include adaptation and mitigation
- Adaptation is a private good where the damages of climate change are reduced
- Mitigation is a public good where emissions are reduced limiting climate change
- Cooperation is needed to ensure global optimal level of mitigation leading to the issue of International Climate Agreements (ICAs)

Introduction: purpose

- Adaptation has been ignored in ICA literature, where it is assumed that adaptation will be applied optimally w.r.t. the expected climate change
- How can adaptation affect mitigation coalition formation and stability
- Level effect
- Strategic effect

Previous studies

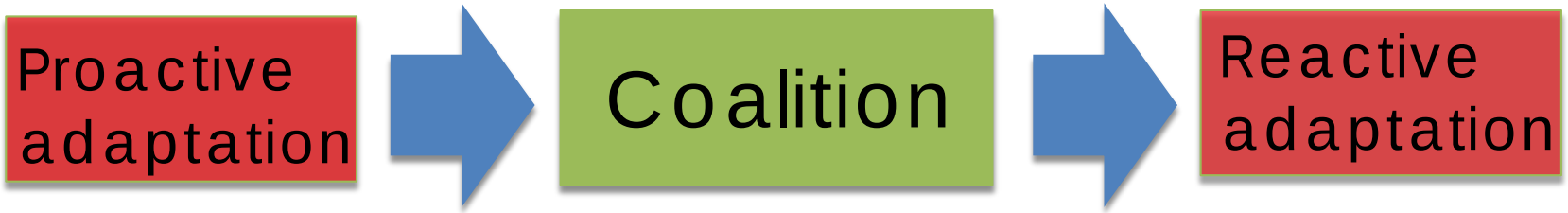
- Barrett (2008) defines adaptation in an ICA as taking place after the coalition is in place and hence ineffective in signaling other members. No credible threat.
- Zehaie (2009) assumes adaptation takes place before mitigation cooperation and has a strategic role, by increasing the other regions mitigation.
- Zehaie looks at only 2 regions and not at coalition formation and stability (enforced cooperation).

Proactive vs reactive adaptation

- Adaptation is often divided into 2 categories: proactive and reactive.
- Proactive adaptation takes place before climate change is felt and often involves large scale infrastructure e.g. seawalls
- Reactive adaptation takes place in reaction to climate change and often involves small scale adjustments, e.g. crop changes

Proactive vs reactive adaptation

- We distinguish between these 2 forms assuming they take place before and after coalition formation:



Methodology

- In this paper we apply a three stage cartel game of coalition formation and an applied game theoretical model: AD-STACO

The game

- 3- stage one shot coalition formation game
- First stage: set proactive adaptation level
- Second stage: decide whether or not to join a unique coalition
- Third stage: transboundary pollution game: set mitigation levels. Singletons optimise regional benefits, coalition members maximise coalition benefits

The game

- Heterogeneous regions $i \in N$
- Atleast 3 regions $|N| \geq 3$
- One unique coalition $S \subseteq N$
- Adaptation is given by p

- Mitigation is given by $q = \sum_i q_i$

The game

- Value function for singletons (payoffs):

$$V_i(S) = d_i \cdot \bar{e} - d_i \cdot (\bar{e} - q) \cdot (1 - p_i) - \frac{1}{2} \cdot m_i \cdot q_i^2 - \frac{1}{2} \cdot a_i \cdot p_i^2$$

- Value of coalition: $V_S(S) = \sum_{i \in S} V_i(S)$

- Value function for coalition members (applying optimal sharing rule):

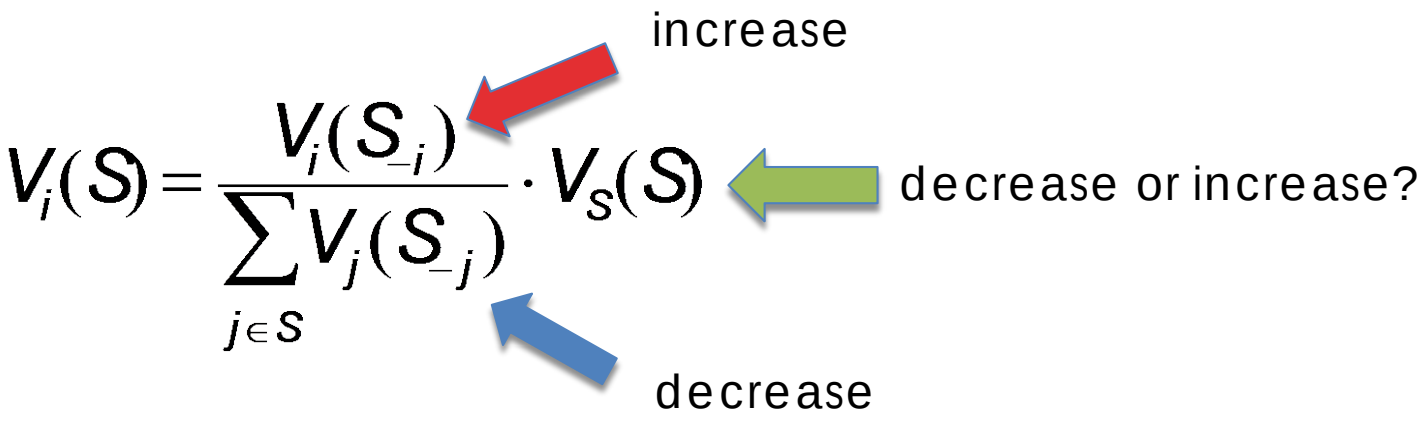
$$V_i(S) = \frac{V_i(S_{-i})}{\sum_{j \in S} V_j(S_{-j})} \cdot V_S(S)$$

The game

- No supranational authority so coalition needs to be self enforcing, hence stable
- We use d'Aspremont (1983) definition of stability: internal stability and external stability
- Calculate optimal levels of mitigation and adaptation for each coalition and check for stability
- Generally the optimal level of adaptation depends on the level of damages only
- But by over-adapting, a region could use adaptation strategically to influence other regions

Adaptation strategies

- Due to constant marginal benefits of mitigation adaptation has no strategic effect as a singleton
- Adaptation of coalition members has an effect through the sharing rule:



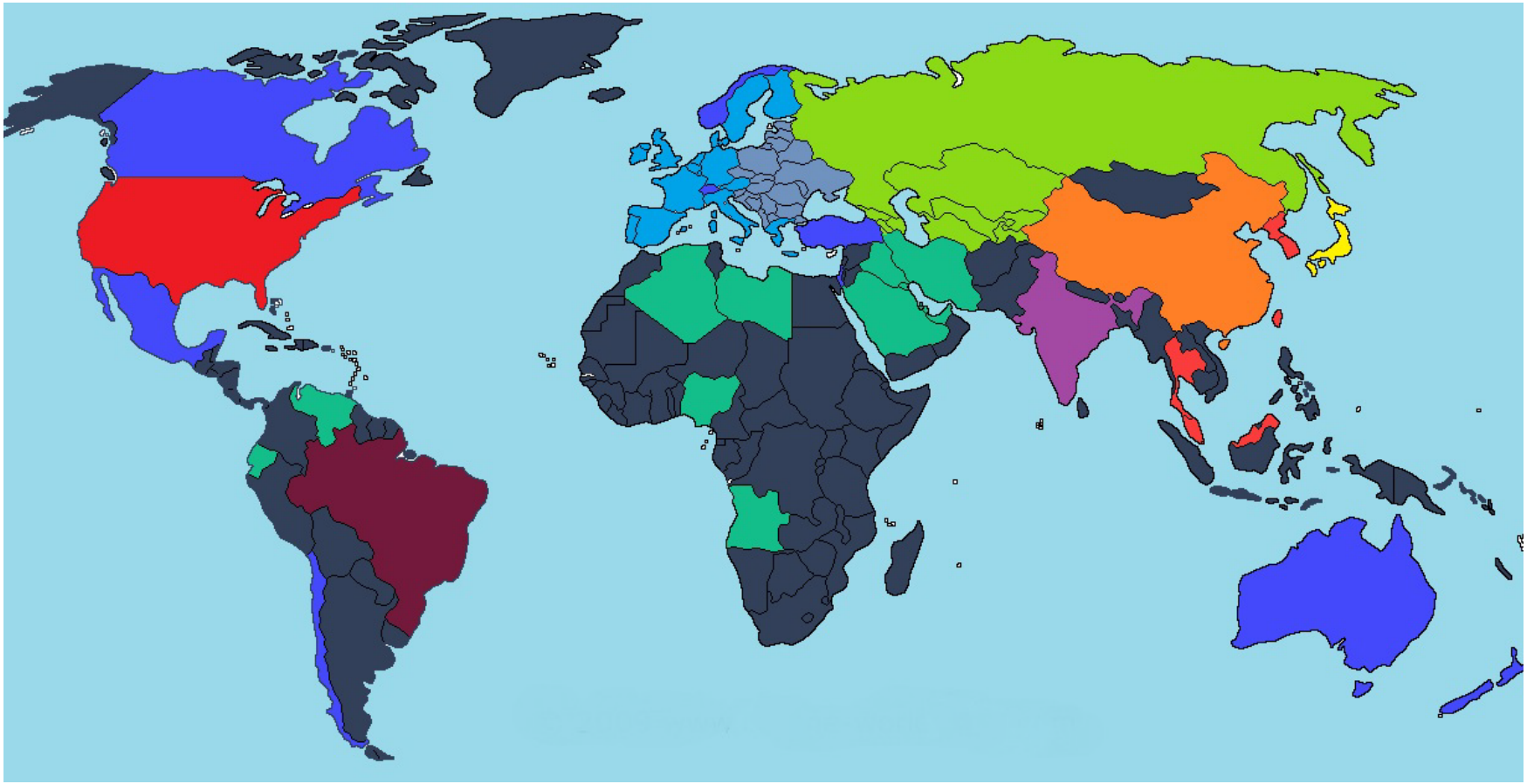
The model: AD-STACO

- Theoretical model shows difference between optimal singleton and coalition member adaptation but does not give much insight
- Combines Integrated Assessment modelling and game theory and replicates the game presented before
- Based on the STACO model (Finus et al.) but includes adaptation

The model: AD-STACO

- 12 regions with unique climate change damages, economic growth, mitigation and adaptation cost functions (etc.)
- All possible coalitions between the regions are checked for stability (4084)
- Stability includes external and internal stability
- Calibrated based on EPPA model(2010), Tol (2009), Nordhaus(2008) and de Bruin (2011)

AD-STACO regions



USA
Japan
EU15
Other OECD
China
Brazil
Former Soviet Union
Rest of the world
India
Eastern European regions
Energy exporting regions
Dynamic Asian economies

Results

- We look at 2 levels of adaptation: GC adaptation and AS adaptation
- We look at the cases of no transfers and optimal transfers (optimal sharing rule)
- GC is lower rational level
- AS is upper rational level
- Grand Coalition
- Stable coalitions
- Best performing stable coalition
- Strategic adaptation

GC payoffs (NPV in Bln $ over 100 years)

Region	GC adap No transfers	AS adap No transfers	GC adap Transfers	AS adap Transfers
USA	**7021**	6996	**6067**	6052
JPN	**8495**	8449	**7230**	7212
EU15	**7985**	7946	**6591**	6571
OOECD	**865**	863	**932**	929
EET	183	**185**	**357**	356
FSU	**1622**	1619	**1718**	1713
EEX	470	**472**	**714**	712
CHN	-753	**-724**	**1268**	1268
IND	754	**757**	**1035**	1033
DAE	413	**415**	**621**	620
BRA	**439**	438	**402**	400
ROW	**1635**	1632	**1723**	1717
Global	**29130**	29048	**28657**	28583

GC payoffs

- In the case of no transfers, CHN is better off with no coalition
- In the case of no transfers EET, EEX, CHN, IND and DAE prefer AS adaptation as these regions have relatively low marginal mitigation costs
- In the case of optimal transfers all regions prefer GC adaptation

Incentives to leave GC

(NPV of divergence benefits)

Region	GC adap No transfers	AS adap No transfers	GC adap Transfers	AS adap Transfers
USA	-22	**-26**	933	**919**
JPN	**-161**	-151	1105	**1086**
EU15	**-377**	-374	1017	**1001**
OOECD	212	**209**	144	**142**
EET	230	**226**	55	**55**
FSU	362	**356**	266	**262**
EEX	353	**348**	110	**108**
CHN	2212	**2182**	192	**190**
IND	439	**432**	158	**156**
DAE	304	**299**	96	**94**
BRA	24	**23**	62	**61**
ROW	354	**347**	266	**262**

GC incentives

- In the case of no transfers only the USA, JPN and EU15 don't want to leave the coalition
- In the case of optimal transfers all regions want to leave: the coalition surplus is not enough to pay all regions their outside option payoffs making the GC unstable
- With no transfers JPN and EU15 have lower incentives with AS adaptation: they prefer higher mitigation commitments in GC
- Other regions prefer AS adaptation as the free rider incentives decrease as benefits of the coalition decrease (in line with Barrett 1994)

Stable Coalitions: top 10

Coalition members	performance
USA, EET, CHN, IND, DAE	48 %
EU15, EET, CHN, IND, DAE	47 %
USA, EET, EEX, CHN, DAE, BRA	46 %
USA, CHN, IND, BRA	45 %
USA, EEX, CHN, IND	44 %
EU15, EET, EEX, CHN, DAE, BRA	44 %
USA, FSU, EEX, CHN	44 %
EU15, OOECD, EEX, CHN, DAE	44 %
USA, FSU, EEX, CHN	43 %
USA, CHN, DAE, ROW	43 %

Stable coalitions: effect of adaptation

GC adaptation	AS adaptation
EU15, EET, FSU, EEX, DAE (18%)	JPN, EU15, CHN (35%)
JPN, EET, FSU, EEX (11%)	USA, IND, BRA, ROW (20%)
JPN, EET, EEX, ROW (11%)	EU15, FSU, IND, BRA (13%)
JPN, OOECD, **EET**, **DAE**, **BRA** (9%)	JPN, OOECD, EET, DAE (8%)
	JPN, OOECD, DAE, BRA (6%)
	JPN, OOECD, EET, BRA (5%)

- In AS case 173 stable coalitions are found, in the GC case 171
- Due to lower damages e.g. BRA, DAE and EET want to join making JPN, OOECD etc. unstable.
- With AS adaptation JPN, EU15 and CHN is stable

Best performing stable coalition

- Best performing stable coalition is between USA, EET, CHN, IND and DAE
- This coalition captures 48 % of the GC benefits
- We look at the effects of unilateral divergence from GC to AS adaptation in the BPSC

Payoffs with unilateral divergence
(% change)

diverging region	diverging region	coalition - div. reg.	coalition	singletons	global
USA	0.26	-0.15	0.12	-0.09	-0.03
EET	0.12	0.00	0.00	0.00	0.00
CHN	0.57	-0.03	0.06	-0.02	0.00
IND	0.36	-0.01	0.03	-0.01	0.00
DAE	0.25	0.00	0.01	-0.01	0.00

- Diverging region gains at the cost of other members of the coalition and singletons

Outside option payoffs (% change)

Diverger	USA	EET	CHN	IND	DAE
USA	**0.15**	-0.29	-0.23	-0.30	-0.28
EET	-0.01	**0.12**	0.00	0.00	0.00
CHN	-0.09	-0.08	**0.52**	-0.08	-0.08
IND	-0.04	-0.04	-0.03	**0.34**	-0.04
DAE	-0.02	-0.02	-0.01	-0.02	**0.24**

Conclusions

- Adaptation levels affect the GC payoffs and incentives: payoffs increase butincentives to join the GC decrease
- Adaptation affects the stable coalitions found: higher adaptation can increase incentives of low abatements level region to join a coalition
- Strategic over-adaptation by coalition members can increase their payoffs

Further research

- The scenarios run here represent only unilateral divergences and hence not a Nash equilibrium
- Further work is needed to incorporate strategic adaptation simultaneously for all players