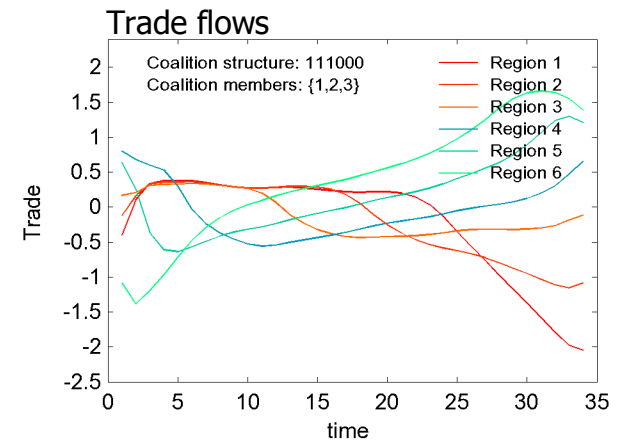


# Coalition Stability subject to Technological Change and Trade

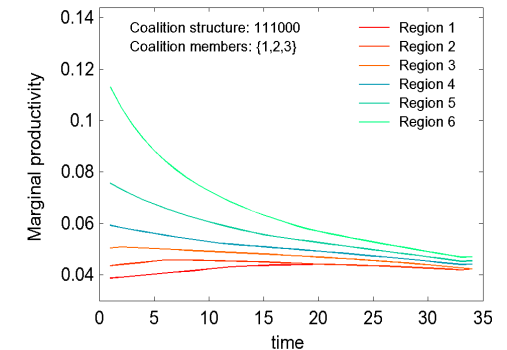
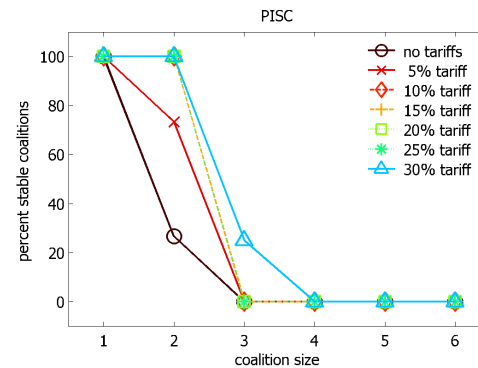
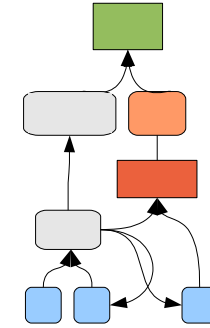
Presentation at Milan,  
December 4<sup>th</sup> 2006

Kai Lessmann  
Ottmar Edenhofer

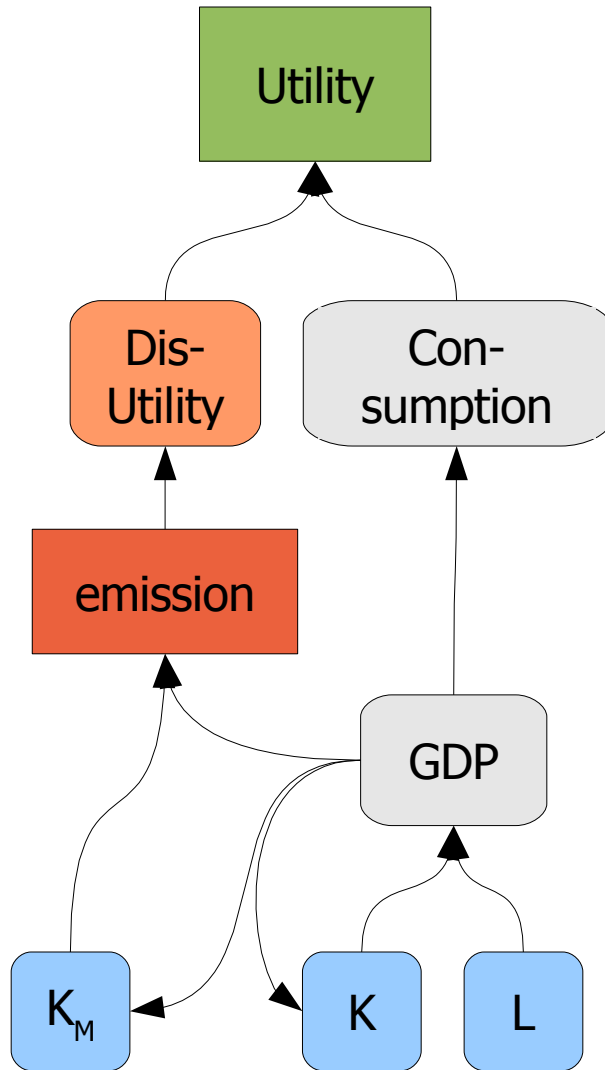


# Structure

- Model structure and algorithms
- Model behavior – Preliminary results
- Stability of coalitions



# Model structure: Regions



- Each region a Ramsey model
- Disutility from emissions

$$U_i = \ln C_i - \eta_i \left( \sum_{j \in N} E_j \right)^2$$

- Mitigation option

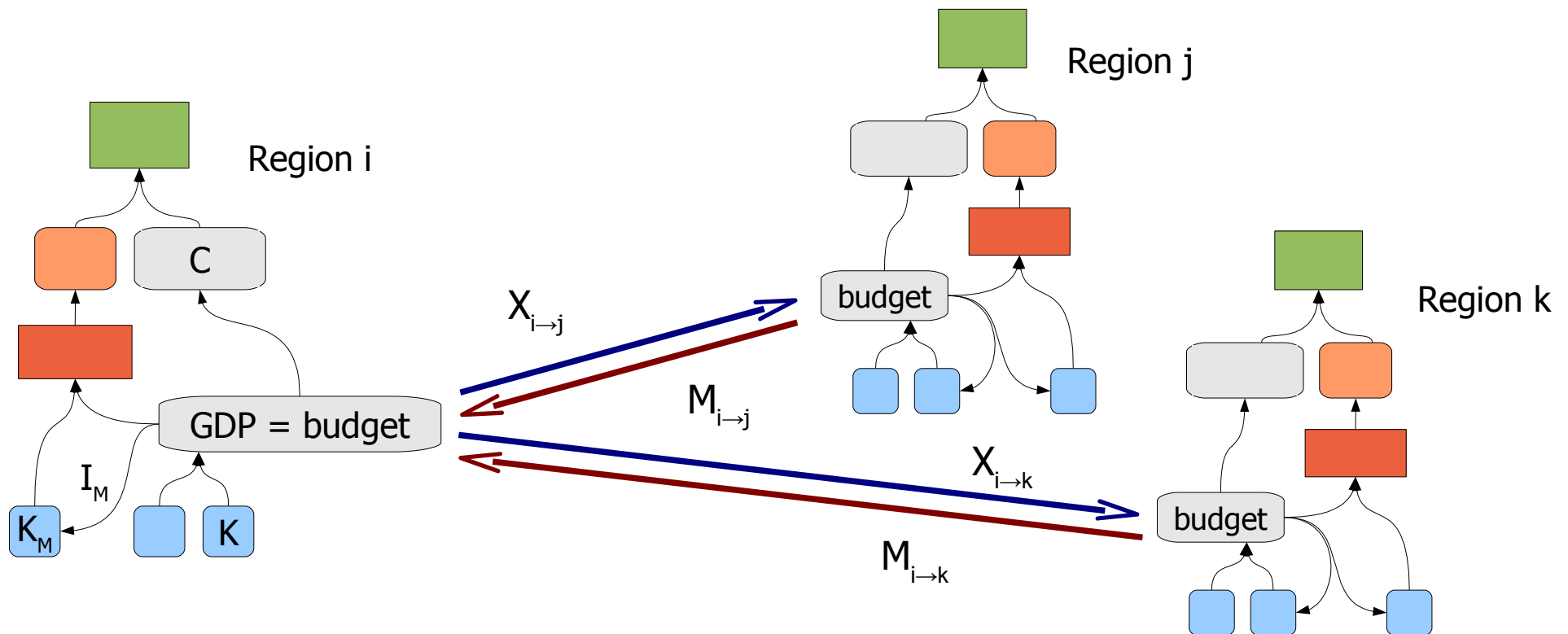
$$E_i = \sigma(K_{M,i}) F_i$$
$$\sigma(K_{M,i}) = 5 / (4 + K_{M,i})$$

# Model structure: Trade

- Trade in capital

$$\dot{K}_i = F_i(A_i L_i, K_i) - C_i - I_{M,i} - \sum_{j \in N} X_{i \rightarrow j} + \sum_{j \in N} M_{i \rightarrow j}$$

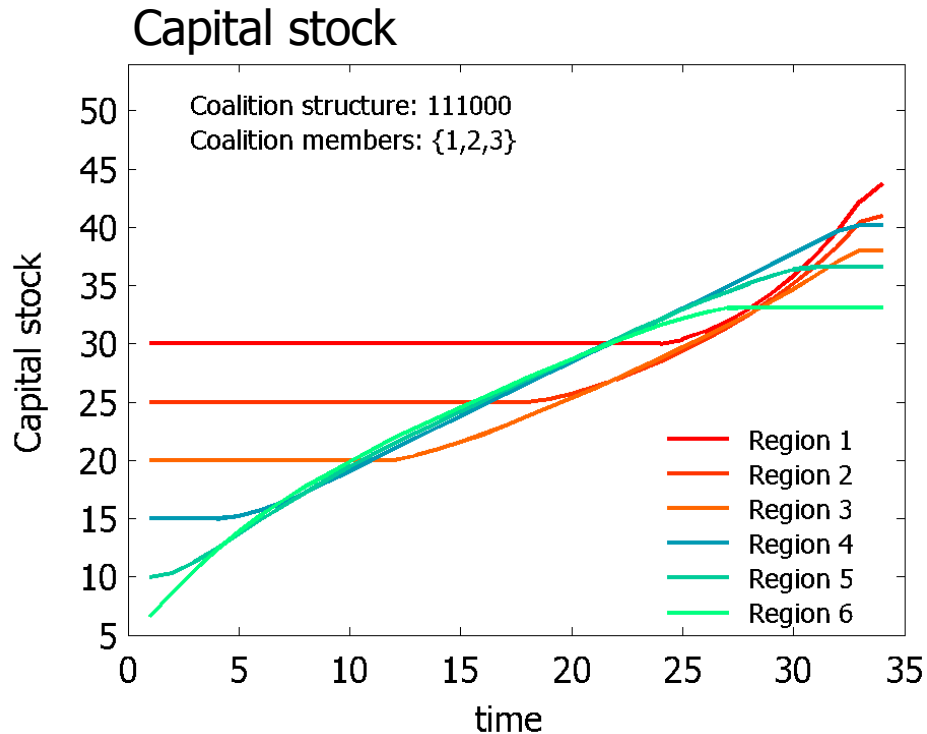
$$0 = \int_0^{\infty} p(t)(M_{i \rightarrow j}(t) - X_{i \rightarrow j}(t)) dt$$



# Nash, Pareto, P.A.N.E.

- **Pareto Optimum:**  
Negishi's weighted sum of utilities
- **Nash Equilibrium:**  
Trade Module (Iteration + Negishi)
- **Coalitions:**  
Partial Agreement Nash Equilibrium
  - coalition acts as one player in **Nash game** with non-members
  - during iteration, **social planner** mode is solved for coalition

# Model behavior: Capital stock



- Regions start with different initial capital
- Marginal productivities and capital stocks equalize
- Lower capital stock in coalition because adverse effects on all members are anticipated

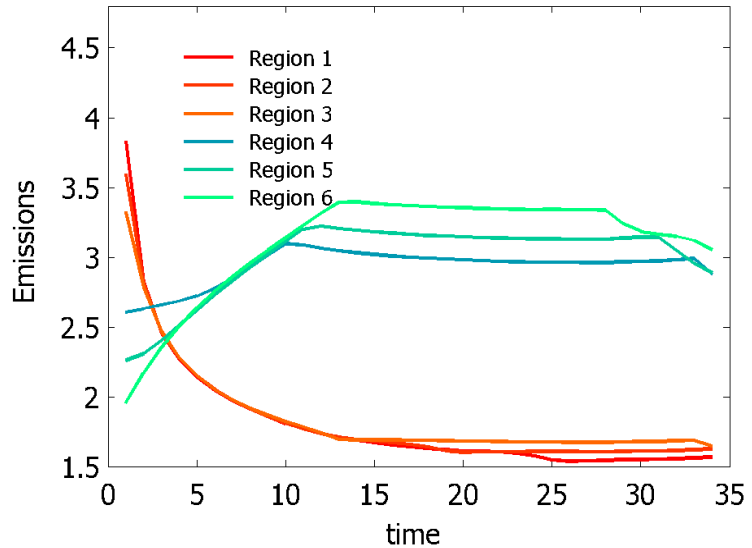
Exemplary coalition structure:

Coalition: **Regions 1-3**

Freeriders: **Regions 4-6**

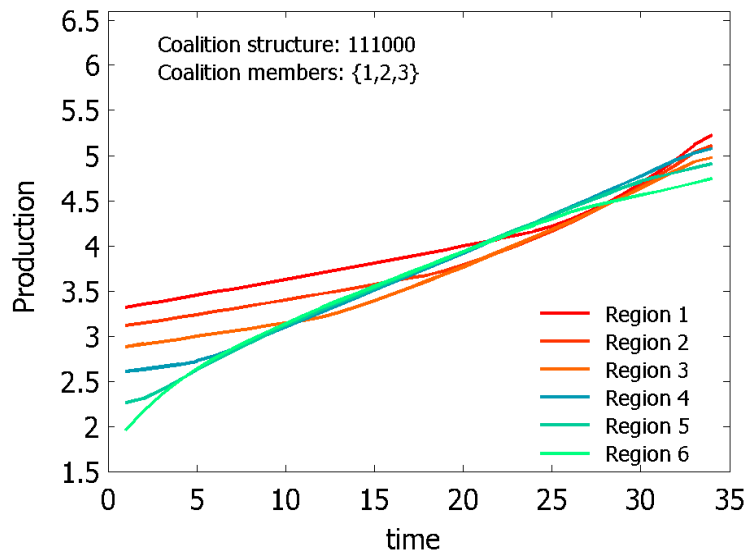
# Model Behavior: Emissions

## Emissions

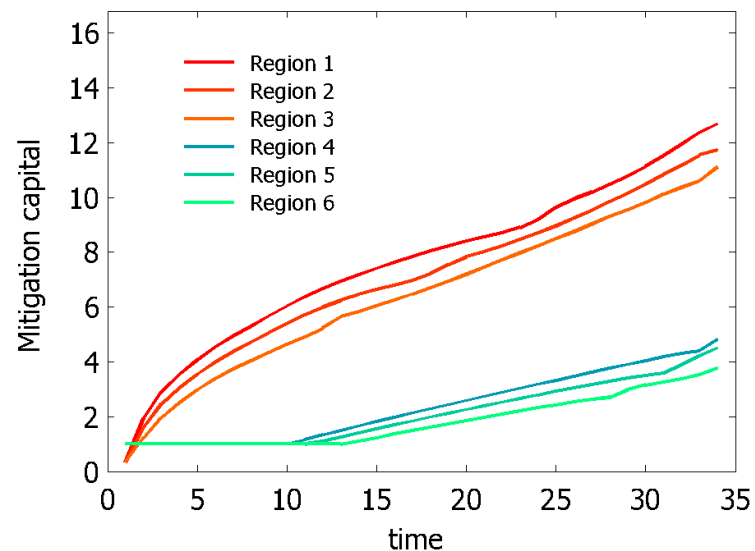


- Emissions are stabilized
- Mitigation decouples production and emissions
- Lower emissions in coalition due to anticipation of adverse effects

## Production



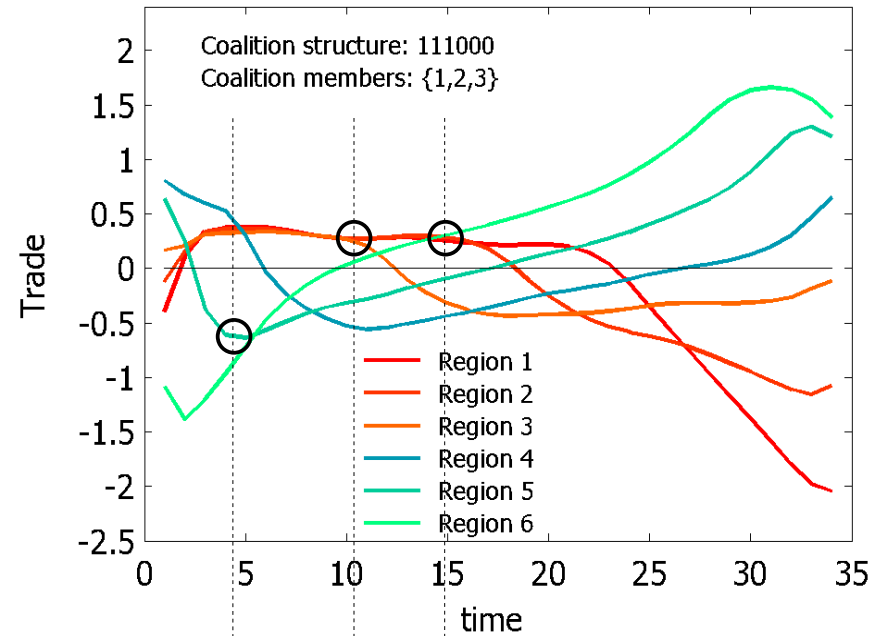
## Mitigation



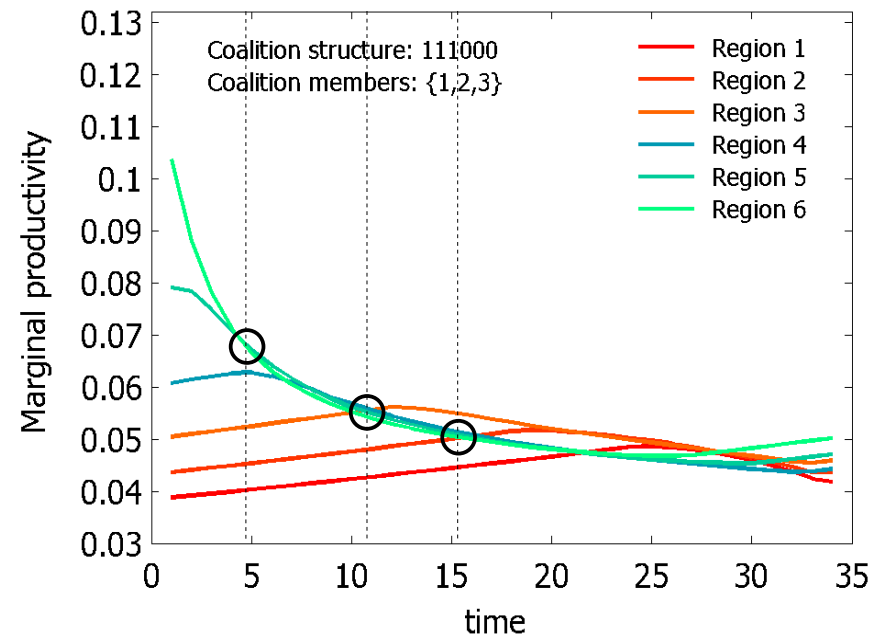
# Model behavior: Trade

- Trade is governed by
  - intertemporal budget constr. ("debts are repaid")
  - marginal productivity of capital
- Imports of Region 5 peak when marg. prod. is equal.
- Exports of Region 3 decline when prod. exceeds Regions 4-6
- Likewise for Region 2

## Capital exports

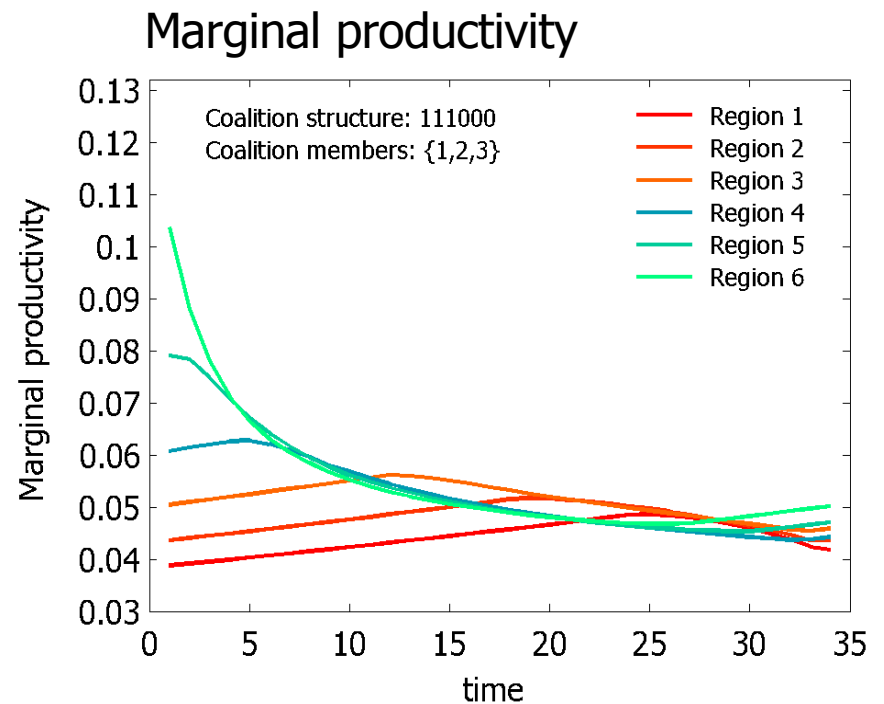
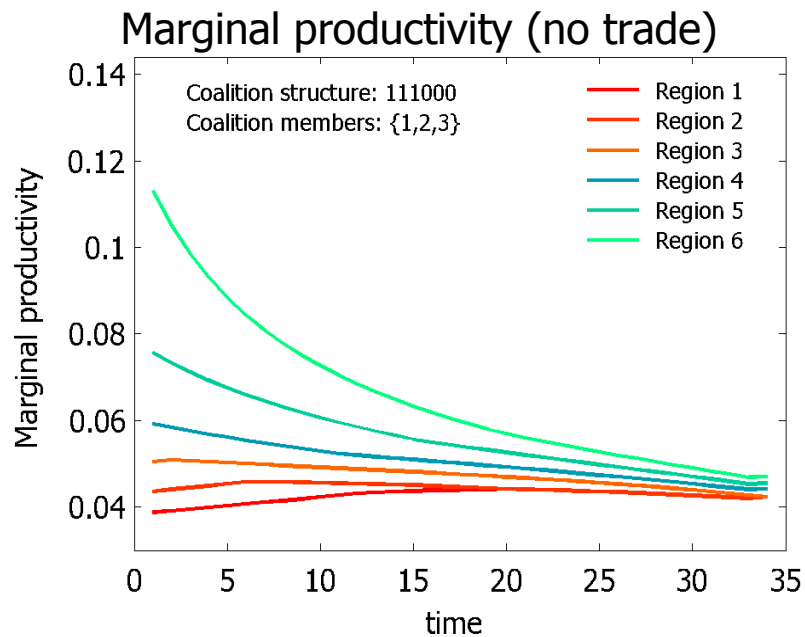
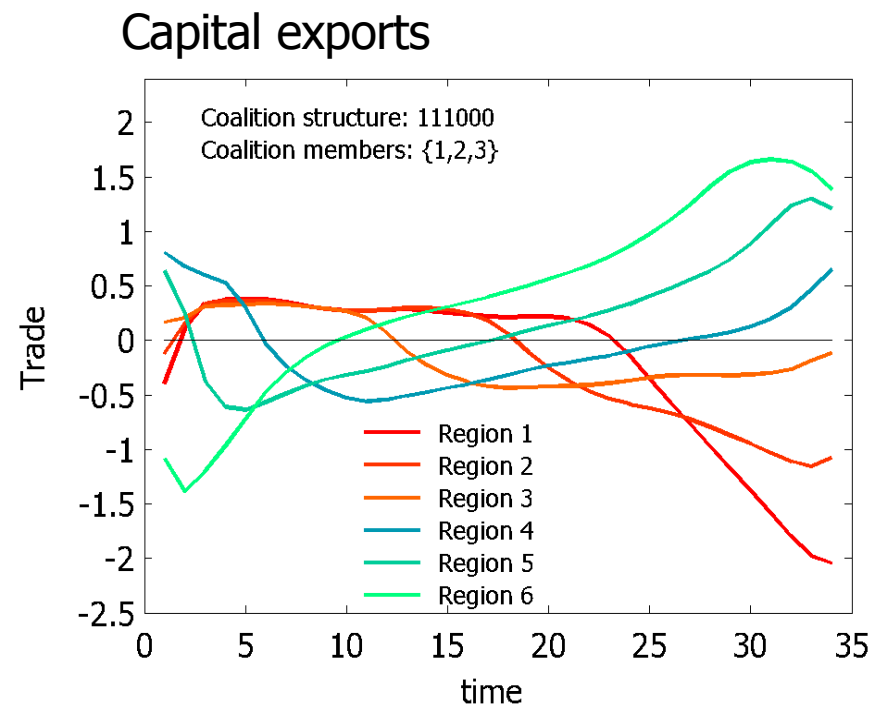
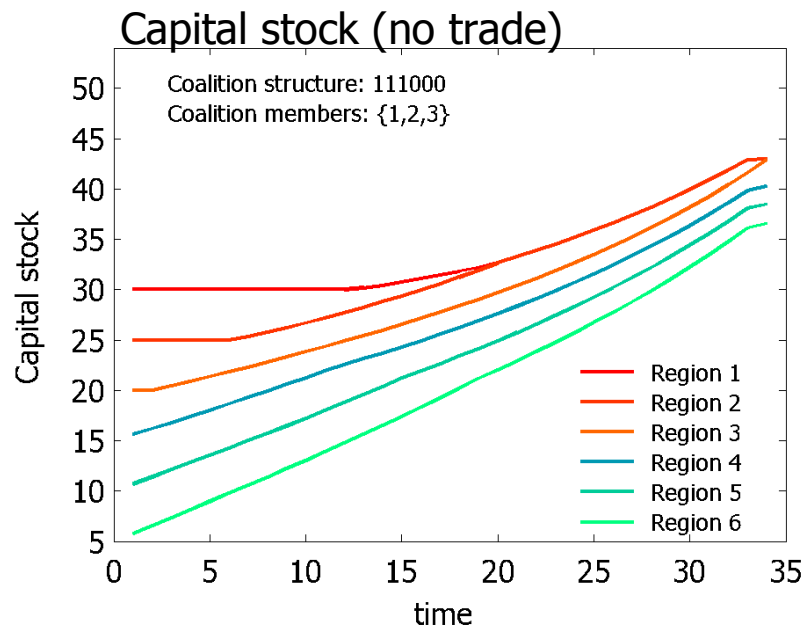


## Marginal productivity





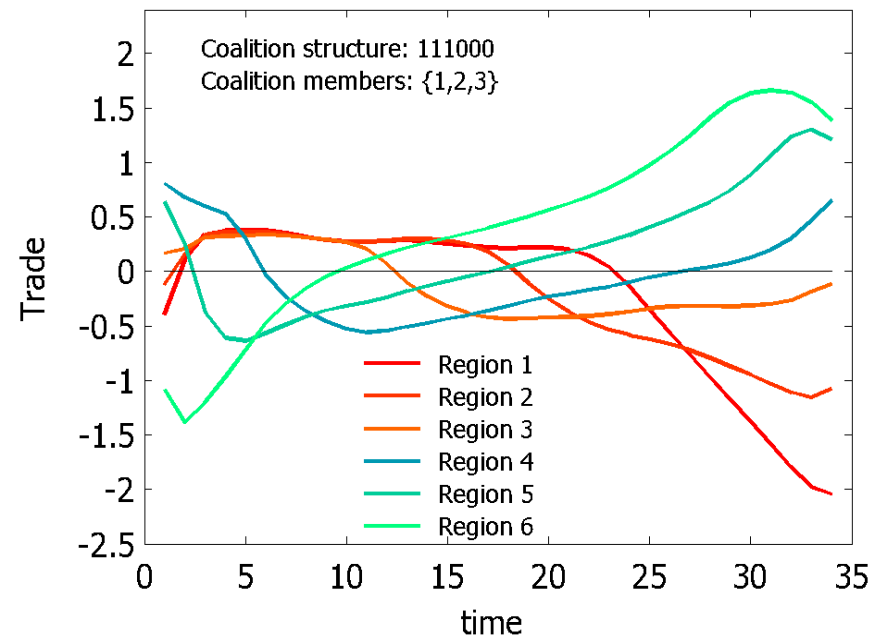
# Model behavior: Trade



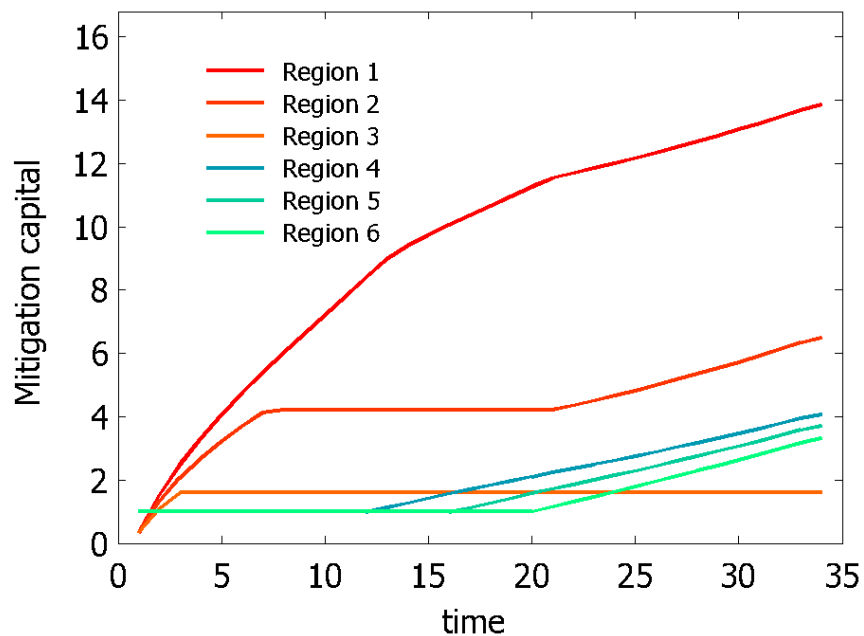
# Model behavior: Trade

- Mitigation under "no trade"
  - outside coalition: similar
  - inside coalition: mitigation is used to redistribute income

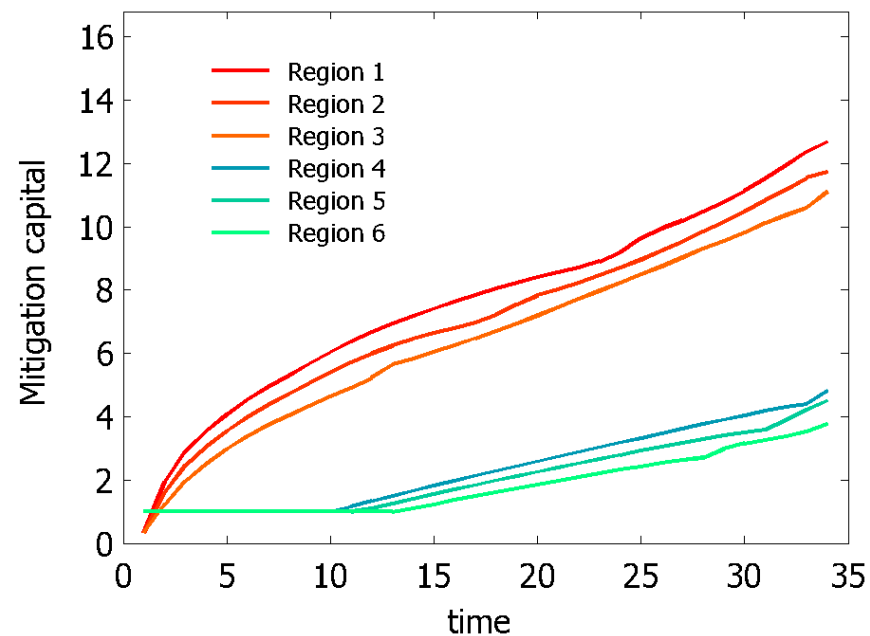
## Capital exports



## Mitigation (no trade)

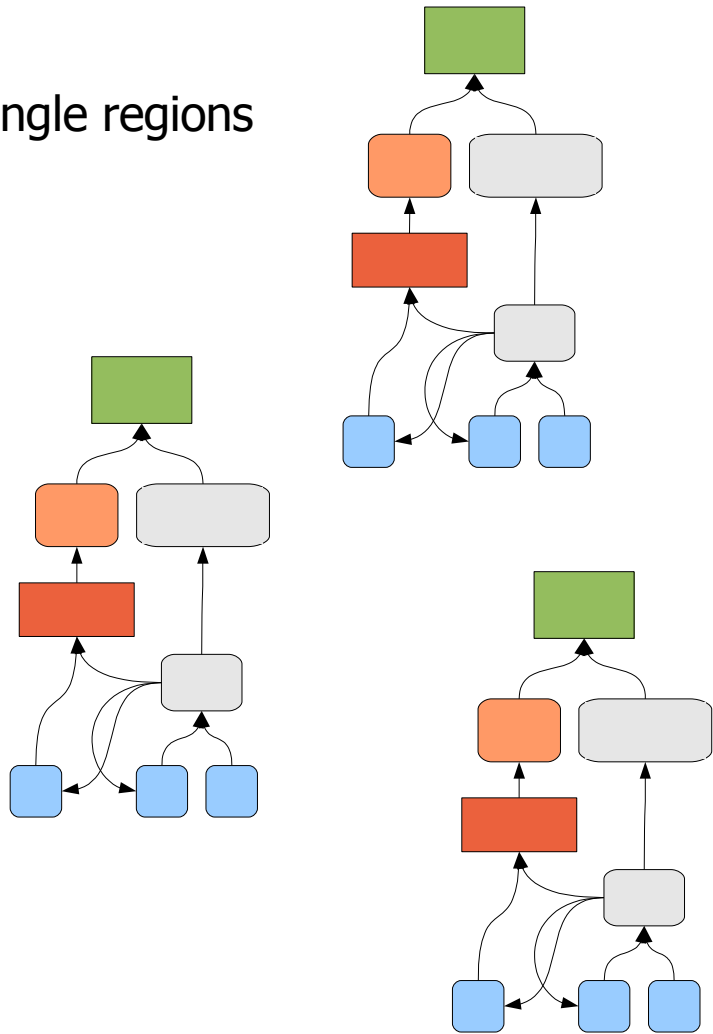


## Mitigation

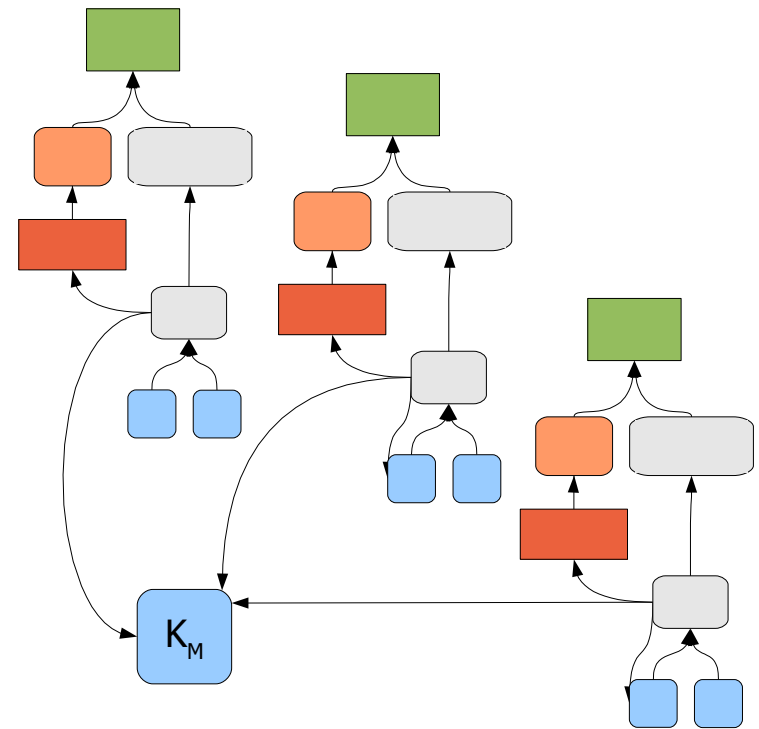


# Technological Change as a Club Good

Single regions

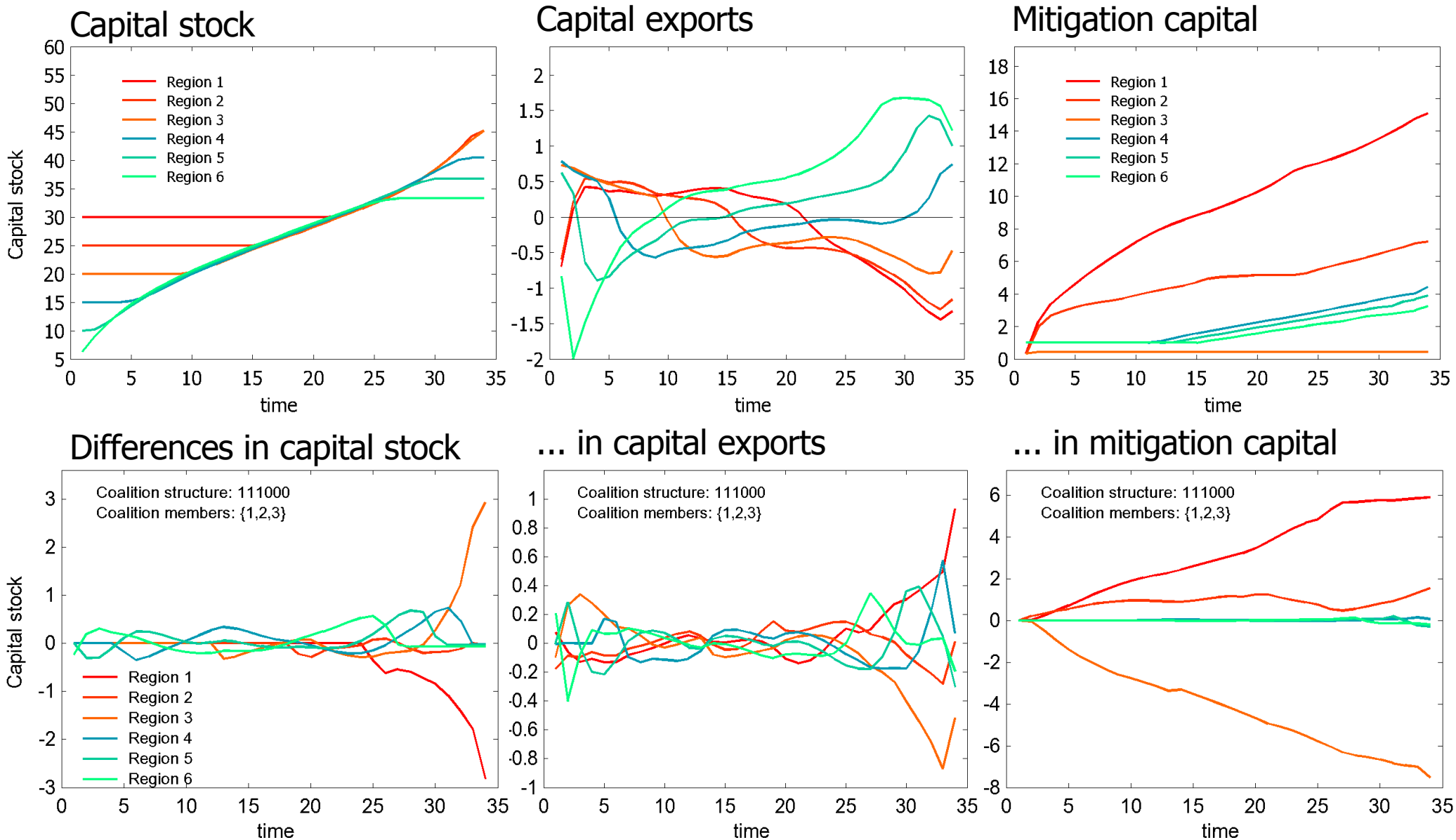


Coalition



$$\sigma(K_{M,i}) = \begin{cases} 5/(4 + \sum_{j \in S} K_{M,j}) & \text{if } i \in S \\ 5/(4 + K_{M,i}) & \text{if } i \notin S \end{cases}$$

# Differences to regular scenario



# Stability Concepts Reference Chart

- Internal Stability *"Nobody wants to leave"*
- External Stability *"Nobody wants to join"*
- Stability
- Potentially Internally Stable Coalitions (PISC) *"Enough coalition gain to pay members their freerider payoff"*
- Optimal Transfer Schemes (OPTS) *"Pay members their freerider payoff plus a share of the remaining payoff"*
- Nash Bargaining Rule *"Pay members their Nash payoff plus a equal share of the remaining payoff"*

(Source: Carraro, Eyckmans and Finus 2005)

# Stability Concepts Reference Chart

- Internal Stability  $v_i(S) \geq v_i(S \setminus \{i\}) \quad \forall i \in S$
- External Stability  $v_i(S) \geq v_i(S \cup \{i\}) \quad \forall i \notin S$
- Stability
- Potentially Internally Stable Coalitions (PISC)  $\sum_{i \in S} v_i(S) \geq \sum_{i \in S} v_i(S \setminus \{i\})$
- Optimal Transfer Schemes (OPTS) 
$$\hat{v}_i^{OP}(S) = v_i(S \setminus \{i\}) + \lambda_i(S) \left[ \sum_{j \in S} v_j(S) - \sum_{j \in S} v_j(S \setminus \{i\}) \right]$$
$$\sum_{j \in S} \lambda_j(S) = 1 \quad \forall i \in S$$
- Nash Bargaining Rule 
$$\hat{v}_i^{NB} = v_i(\{i\}) + \frac{1}{|S|} \left[ \sum_{j \in S} v_j(S) - \sum_{j \in S} v_j(\{i\}) \right]$$
$$\forall i \in S$$

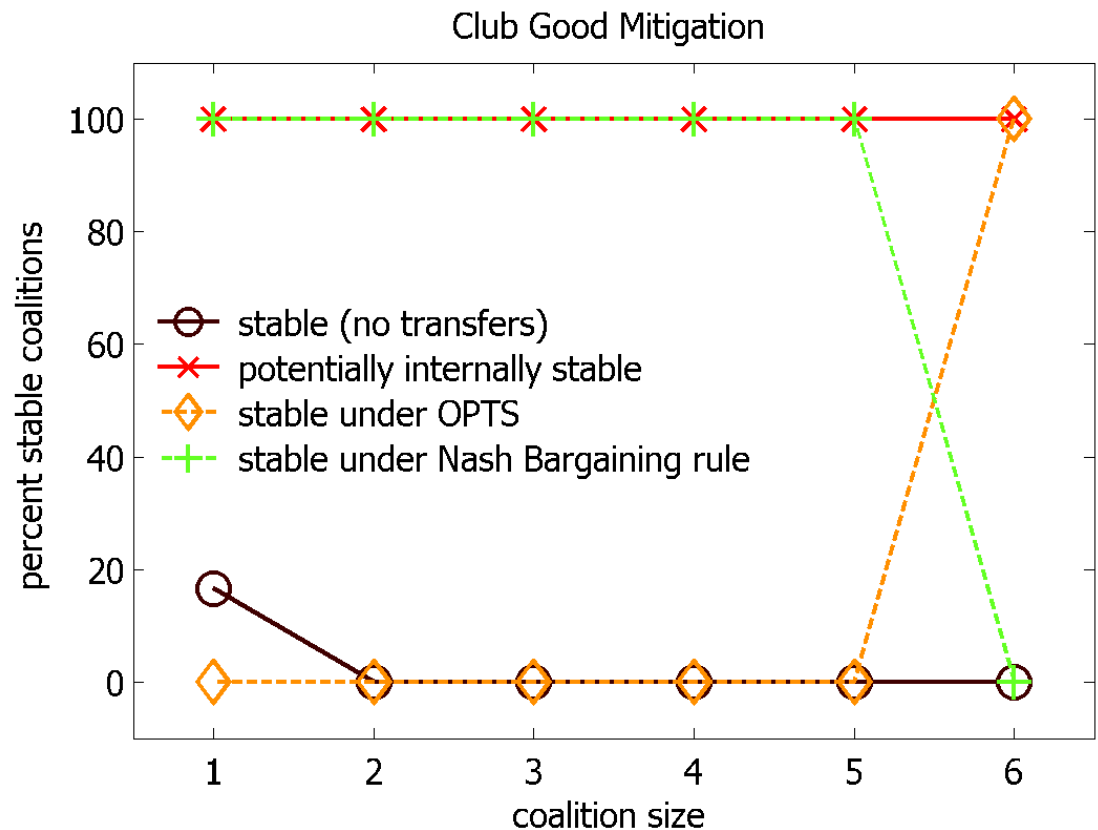
(Source: Carraro, Eyckmans and Finus 2005)

# Stability of Coalitions: Concepts

- Six regions → 64 coalition structures

- 1x Nash Eq.,
- 6x 1-coalitions
- 15x 2-coalitions
- ...
- 1x Grand Coalition

- Apply different stability concepts

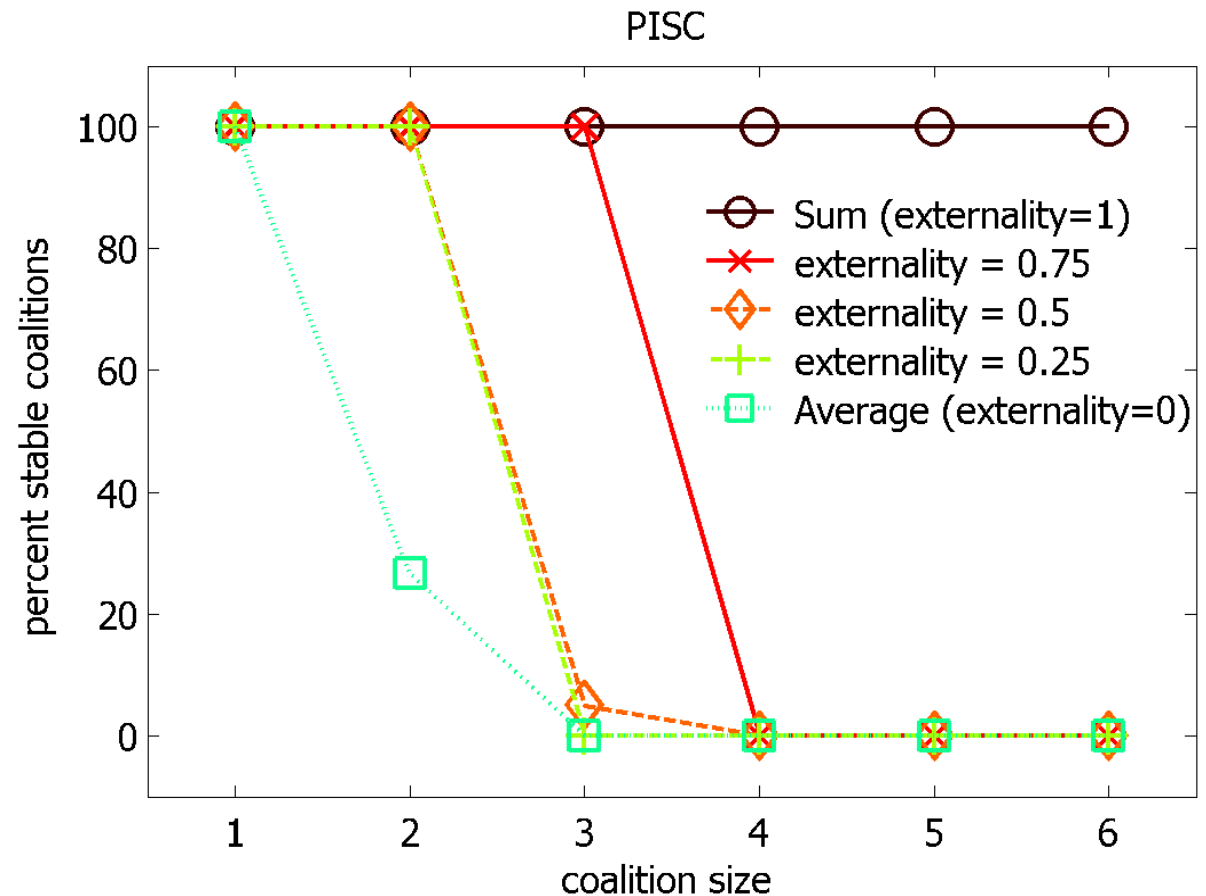


# Stability of Coalitions: Technological Change

- Focus on Potentially Internally Stable Coalitions (PISC)

- Reducing the Club  
Good externality

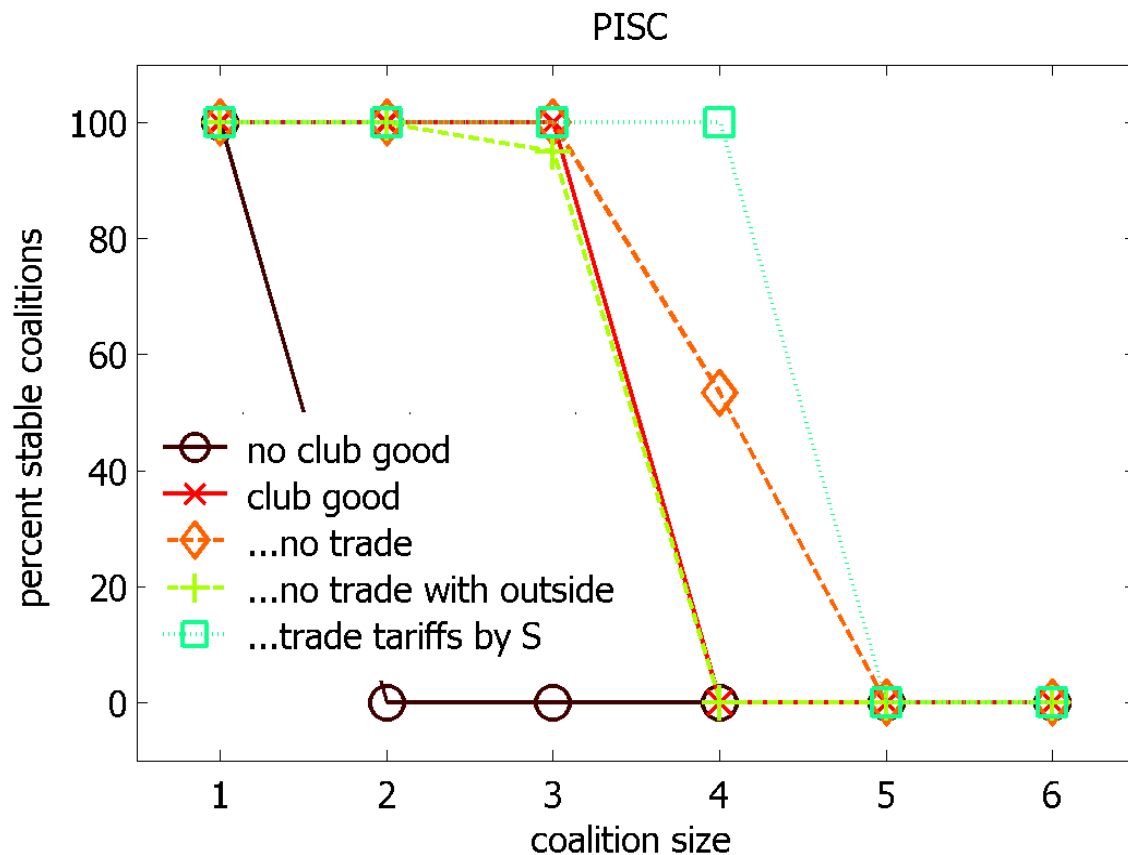
- Quickly reduces  
the effect on  
stability





# Stability of Coalitions: Trade

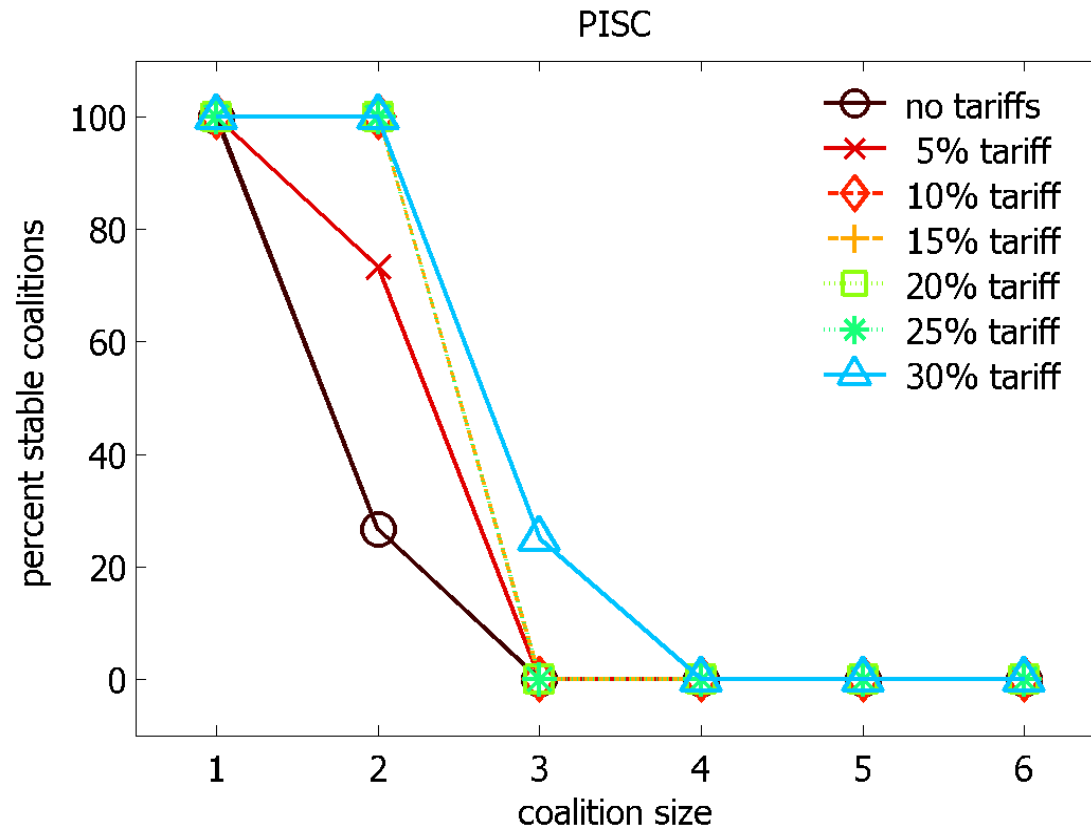
- Introducing restrictions on trade



- For the 0.75 club good scenario
- No trade
- No trade between coalition members and freeriders
- Trade tariffs imposed on trade from freeriders to coalition members (10%)

# Stability of Coalitions: Tariffs

- Trade tariffs on trade from freeriders to coalition members



# Conclusions

- Technological Change
  - Coalition stability is sensitive towards introduction and extent of externality/club good
- Capital Trade
  - Coalition stability is sensitive towards restricting trade, in particular import tariffs