Coalition Stability subject to Technological Change and Trade

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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

$$E_i = \sigma(K_{M,i})F_i$$

$$\sigma(K_{M,i}) = \frac{5}{4 + K_{M,i}}$$
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 are stabilized
- Mitigation decouples production and emissions
- Lower emissions in coalition due to anticipation of adverse effects
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
Model behavior: Trade

Capital stock (no trade)

Marginal productivity (no trade)

Capital exports

Marginal productivity
Model behavior: Trade

- Mitigation under "no trade"
  - outside coalition: similar
  - inside coalition: mitigation is used to redistribute income
Technological Change as a Club Good

\[
\sigma(K_{M,i}) = \begin{cases} 
5/(4 + \sum_{j \in S} K_{M,j}) & \text{if } i \in S \\
5/(4 + K_{M,i}) & \text{if } i \notin S 
\end{cases}
\]
Differences to regular scenario

Differences in capital stock
Coalition structure: 111000
Coalition members: \{1,2,3\}

Differences in capital exports
Coalition structure: 111000
Coalition members: \{1,2,3\}

Differences in mitigation capital
Coalition structure: 111000
Coalition members: \{1,2,3\}
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: $\nu_i(S) \geq \nu_i(S \setminus \{i\}) \ \forall \ i \in S$
- External Stability: $\nu_i(S) \geq \nu_i(S \cup \{i\}) \ \forall \ i \notin S$
- Stability

- Potentially Internally Stable Coalitions (PISC): $\sum_{i \in S} \nu_i(S) \geq \sum_{i \in S} \nu_i(S \setminus \{i\})$

- Optimal Transfer Schemes (OPTS):

  \[
  \hat{\nu}_i^{OP}(S) = \nu_i(S \setminus \{i\}) + \lambda_i(S) \left[ \sum_{j \in S} \nu_i(S) - \sum_{j \in S} \nu_j(S \setminus \{i\}) \right]
  \sum_{j \in S} \lambda_j(S) = 1 \quad \forall \ i \in S
  \]

- Nash Bargaining Rule:

  \[
  \hat{\nu}_i^{NB} = \nu_i(\{i\}) + \frac{1}{|S|} \left[ \sum_{j \in S} \nu_i(s) - \sum_{j \in S} \nu_j(\{i\}) \right]
  \forall \ i \in S
  \]

(Source: Carraro, Eyckmans and Finus 2005)
Stability of Coalitions: Concepts

- Six regions \( \rightarrow \) 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 Internaly 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