Cooperation of climate clubs

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Outline

Background information

- Slow progress of climate negotiations under UNFCCC
- Calls for discussions in other, non-global fora - 'climate clubs'
- Two types of climate clubs [Widerberg and Stenson, 2013]
  - Focus on specific area (REEEP, REDD+ Partnership, CCAC)
  - State clubs of selected countries (G7/8, G20, MEF)
- Potential advantages [Biermann et al., 2009]: Speed, Ambition, Participation, Equity
- **Impact on existence of stable agreements?**

Some definitions

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- A *cooperative game* (N, v) consists of a set of players N and a *characteristic function* $v : 2^N \to \mathbb{R}$.
- $v(S)$ is called the *value* of coalition $S \subseteq N$.
- An allocation is a vector $x \in \mathbb{R}^n$ with $\sum_{i \in N} x_i = v(N)$.
- The *core* of the game is the set of all allocations from which no coalition has an incentive to deviate.

$$\mathcal{C}(N, v) = \{x \in \mathbb{R}^n \mid \sum_{i \in S} x_i \geq v(S) \ \forall S \subsetneq N\}$$

Basic model

Our setup is based on the model of transfrontier pollution by Chander and Tulkens [1997]:

- set of players $N = \{1, .., n\}$
- emissions E_i
- production function $P_i(E_i)$, depending on a country's own emissions. It is assumed to be monotonically increasing up to a baseline emission level E_i^0 and concave.
- benefit function $B_i(E_N)$, depending on global emissions E_N. It describes the virtues of a reduction in global emissions and is assumed to be monotonically decreasing and concave.

Basic model II

- Assume some set of countries $S \subset N$ forms a coalition.
- Countries determine their emissions by maximizing utility, the sum of production function and benefit function.
- Coalition members maximize joint utility of the coalition, while non-members maximize individual utility.

$$\max_{(E_i)_{i \in S}} \sum_{i \in S} [P_i(E_i) + B_i(E_N)]$$

$$\max_{E_j} P_j(E_j) + B_j(E_N) \quad \forall j \notin S$$

Basic model III

This behaviour of non-members is the γ-assumption by Hart and Kurz [1983]. The characteristic function of the associated game is defined by

$$v^{\gamma}(S) := \max_{(E_i)_{i \in S}} \sum_{i \in S} [P_i(E_i) + B_i(E_N)].$$

The core of this game (the γ-core) is shown to be non-empty for certain classes of games by Chander and Tulkens [1997]. This result is extended to standard convexity assumptions by Helm [2001].

Climate clubs

- We consider the **subgame** of the climate club $T \subset N$. Non-members are called $R = N \backslash T$.
- Check core of the subgame to see if a stable agreement among the club members exists.
- Important assumption of cooperative game theory: club-members are fixed.

Theoretical results

For our analysis, we use quadratic functions

$$P_i(E_i) = P_i^0 - \mu(E_i^0 - E_i)^2$$
$$B_i(E_N) = B_i^{max} - \pi E_N^2,$$

with

- Baseline production P_i^0 (in monetary units).
- Baseline emissions E_i^0.
- Abatement cost parameter $\mu_i > 0$ (in $\frac{\text{money}}{\text{emissions}^2}$).
- Maximal environmental benefits B_i^{max} (in monetary units). This level is reached for zero global emissions.
- Vulnerability parameter $\pi_i > 0$ (in $\frac{\text{money}}{\text{emissions}^2}$).

Symmetric countries

- We start the analysis with the assumption of symmetric countries inside each group (T and R).
- Crucial parameter: ratio of vulnerability and abatement cost parameter π/μ. Set $\mu \equiv 1$ without loss of generality.

Results:

- Contrary to global negotiation model by Chander and Tulkens, the core of the subgame can be empty.
- Only the values of single countries ('singleton coalitions') determine the (non-)emptiness of the core.
- Parameters of both groups influence the existence of a stable agreement in opposite directions.

Visualization - symmetric countries

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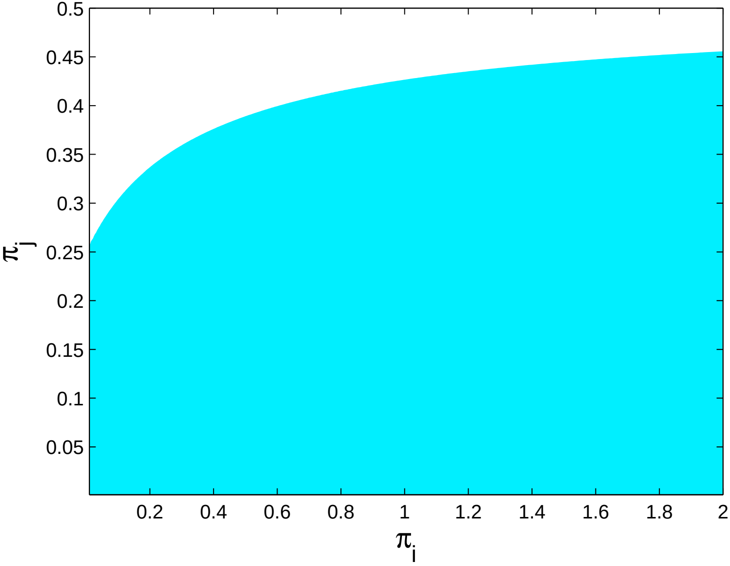


Asymmetric countries - Methodology

- Calculation of the core for asymmetric countries is highly complex.
- We only check the value of singleton coalitions vs. the value of the club grand coalition. This is only a necessary condition for core non-emptiness.
- Therefore, the model provides an 'upper bound' of the parameter set with non-empty core.
- Starting with the symmetric case, we increase heterogeneity between countries.

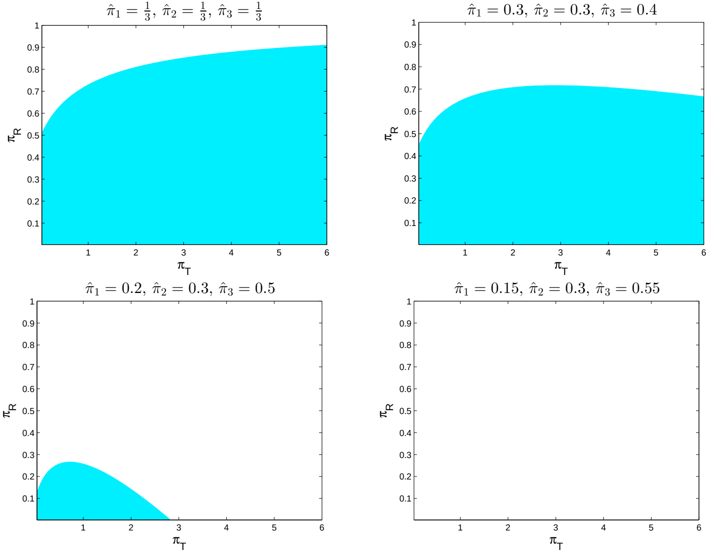
Asymmetric countries - Results

- Global emissions in the case of cooperation among all club members only depend on the sums of parameter ratios, π_T and π_R.

$$E_N = \frac{E_N^0}{t\pi_T + \pi_R + 1}.$$

- Heterogeneity of non-club members does not influence the existence of a stable agreement among members.
- Increased heterogeneity among club members leads to a smaller parameter set with non-empty core of the subgame.

Visualization - asymmetric countries



Conclusion

- Global Chander / Tulkens game has non-empty core.
- Subgame of non-global negotiations can cause an empty core for certain parameter combinations.
- In this situation a high vulnerability / low abatement cost parameter of non-club members leads to 'less cooperation'.
- High heterogeneity of club members causes a smaller parameter set with non-empty core. This can outweigh all other factors and lead to an empty core for all parameter combinations.
- When the model is applied to the G20, the last situation arises: no stable agreement exists among club members.

Thank you!

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Excess by heterogeneity