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Mercator Research Institute on
Global Commons and Climate Change gGmbH

The strategic dimension of financing global public goods

Ulrike Kornek and Ottmar Edenhofer

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Outline

1. Problem set: the Paris Agreement

2. How to ramp up ambition in the public goods game?

3. The public goods game with strategic transfers

4. Designing strategic transfers: Carbon Price

   a) Transfers from a fund of fixed size

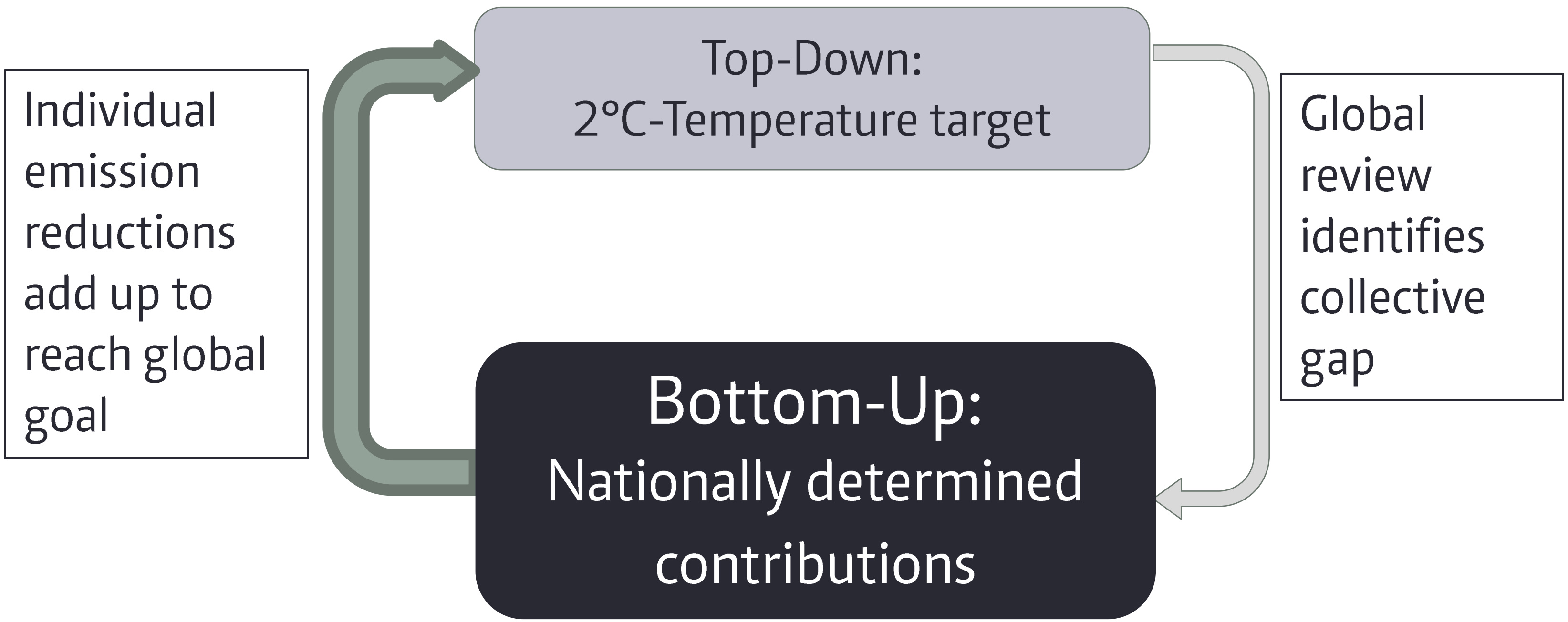
   b) Transfers based on differences in marginal costs

   c) Transfers based on differences in total costs

5. Conclusion/Outlook

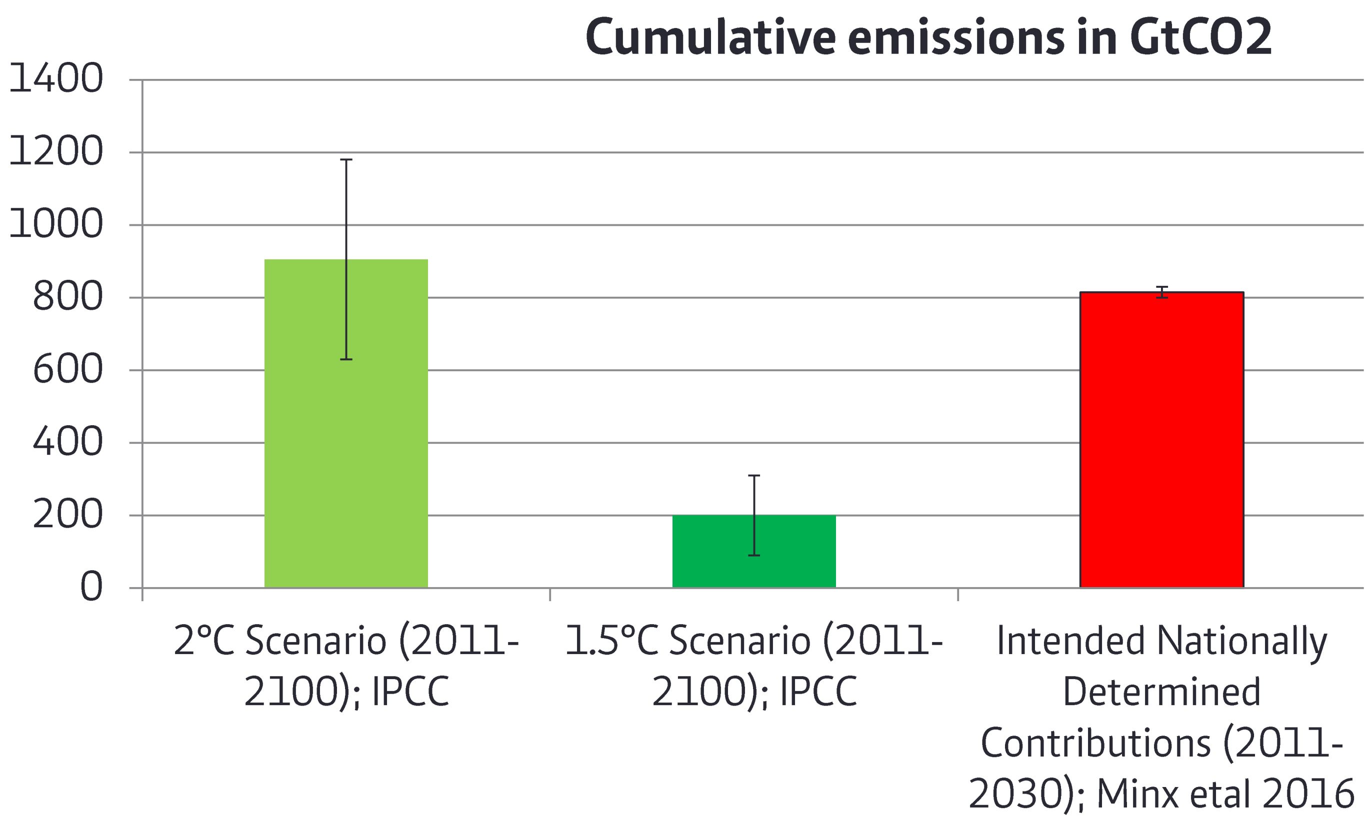
The Paris Agreement

- Voluntary contributions to 2°C-temperature objective
- Only informal mechanisms as punishment/incentives
- Closing the gap based on individual decisions: relies on reciprocity
- **Efforts are so far not credible**



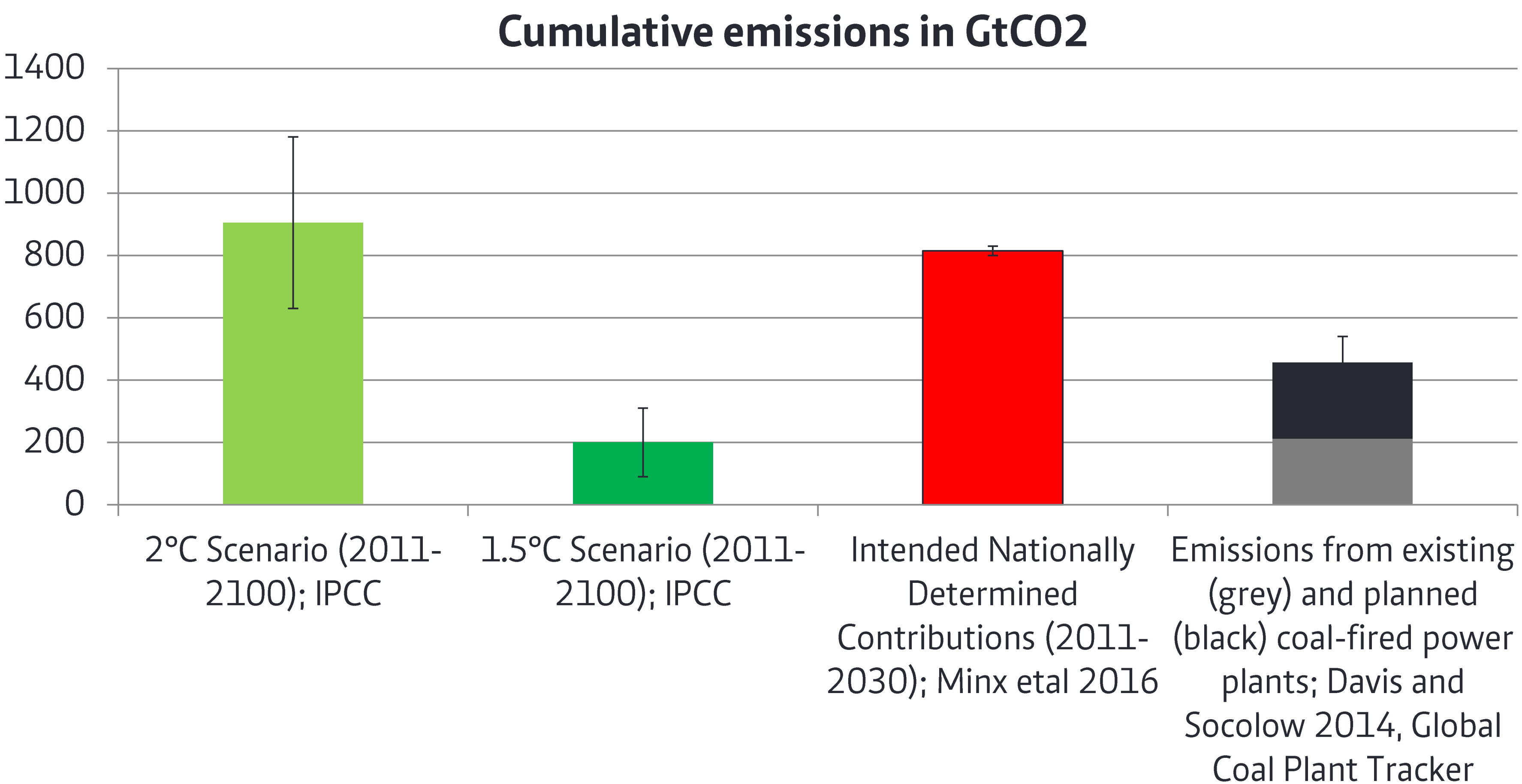
The Paris Agreement

- Intended Nationally Determined Contributions are inconsistent with the temperature target



The Paris Agreement

- Intended Nationally Determined Contributions are inconsistent with current energy-policy



The Paris Agreement

- How do you ramp up nationally determined contributions?
- Problem with voluntary emission reductions: they are a public good
- Free-riding incentives
- Cooperation is difficult so sustain

The public goods game

- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i)$, $B_i' > 0, B_i'' \leq 0$ $C_i' > 0, C_i'' > 0$

  Sum of individual contribution to public good q_i $Q = \sum_{j=1}^{N} q_j$

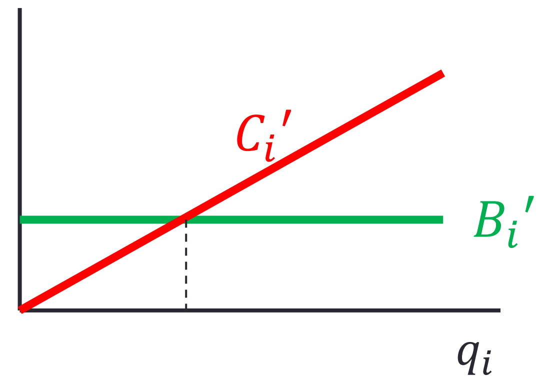
q_i

The public goods game

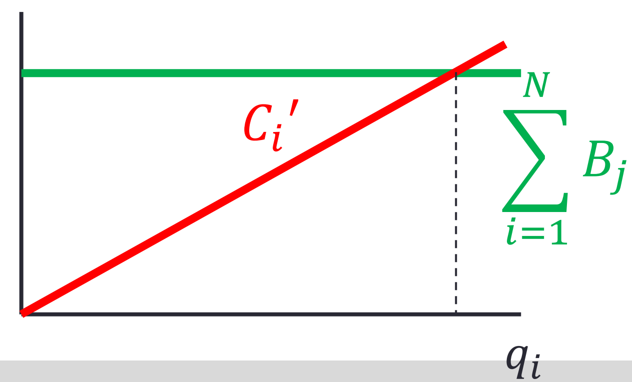
- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i)$, $B_i' > 0, B_i'' \leq 0$, $C_i' > 0, C_i'' > 0$

  Sum of individual contribution to public good q_i $\quad Q = \sum_{j=1}^{N} q_j$

- Non-cooperative: $B_i'(Q) = C_i'(q_i)$



- Cooperative: $\sum_{i=1}^{N} B_j' = C_i'(q_i)$



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2. **How to ramp up ambition in the public goods game?**
3. The public goods game with strategic transfers
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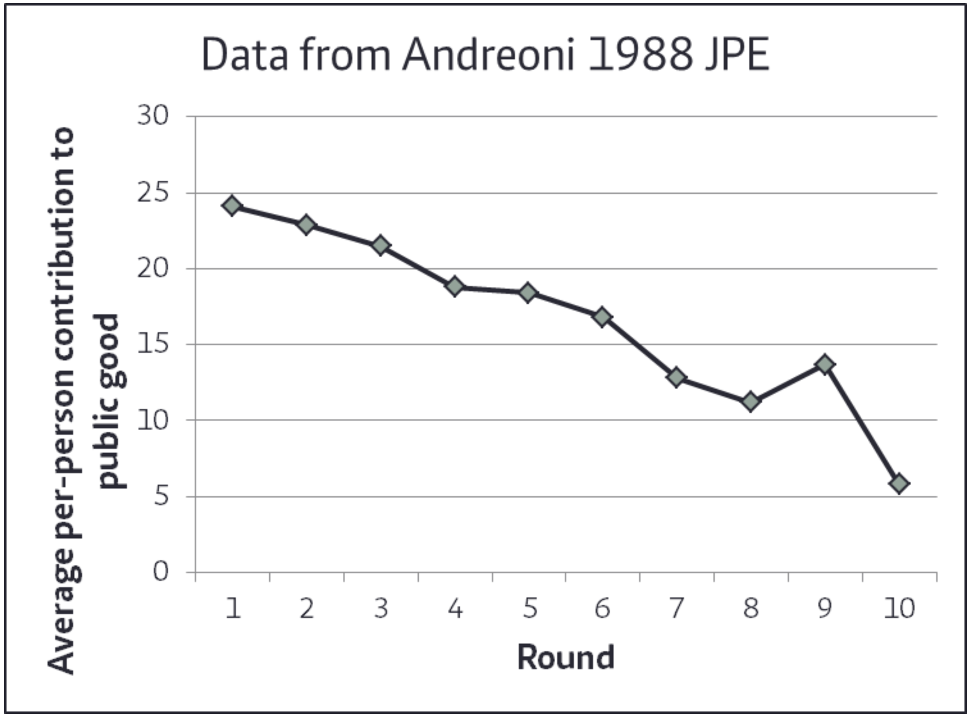
The public goods game

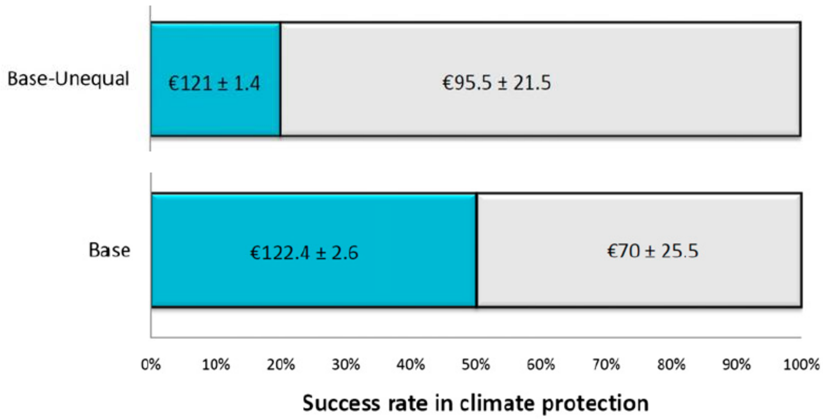
Conditional cooperators



- Large group of people are willing to cooperate when others also cooperate
  - I provide 40 amounts of the good, when you provide those
- People start out by giving something
- contribution drops, when free-riding is observed
- How to sustain conditional cooperation for climate change mitigation?

The public goods game

Conditional cooperators under heterogeneity



Source: Tavoni etal 2011 PNAS

- Inequality in endowment decreases cooperation
- What is the level of the good to establish conditional cooperation?
  - Emission reductions for different countries?
- Redistribution necessary

The public goods game

- Can you institutionally support conditional cooperation?
- How can you address heterogeneity?

Set up of strategic transfers through compensation fund.

Strategic: more transfers with more of the good provided.

Compensation fund: Either contribution through public good provision or compensatory payments

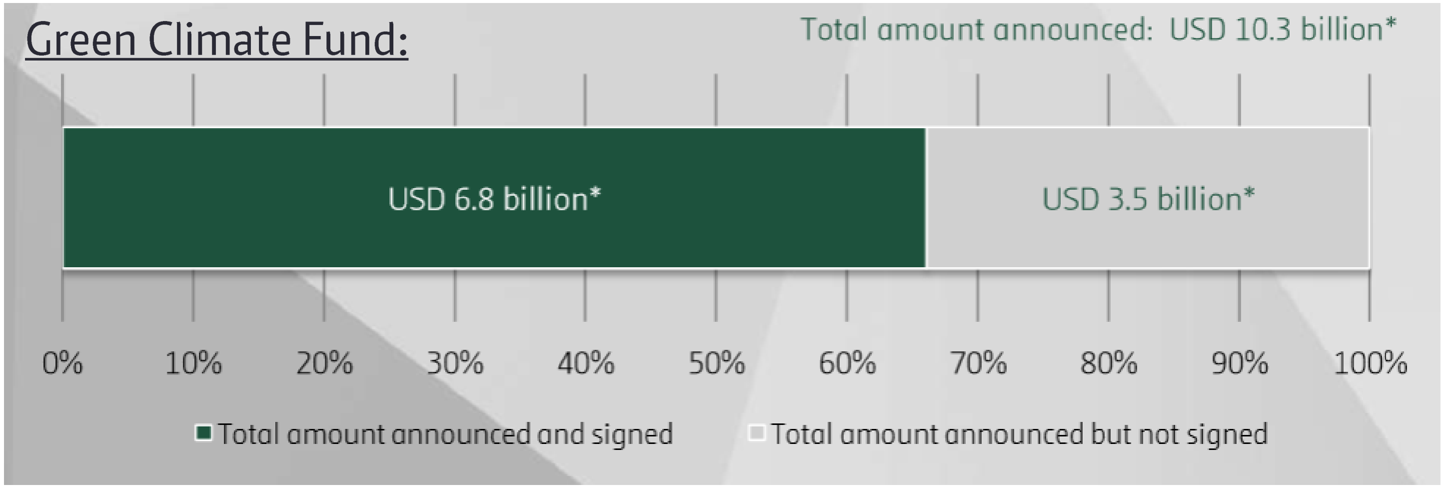
The public goods game

- Measure for climate change: carbon price p_i
  - Level of price is a proxy for effort
  - Higher price: more public good provision

$$\boxed{\frac{\partial}{\partial p_i} q_i > 0}$$

The Paris Agreement and the public goods game

- Prime example: climate finance
  - 100 bln USD North to South flow
  - Recipients and donors have to have an incentive to participate



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The public goods game with transfers

Transfers: cooperative

- Requires authority to implement transfer scheme
- Equity-principles
- Everyone profits from cooperating

Transfers: non-cooperative

- Strategic/Game-theoretic
- Taking into account sovereignty of countries in:
  - Contribution to public good
  - Participation

The public goods game with transfers

Set up of compensation fund:

- 3-stage game:
    1. **Countries decide on intensity of compensation through the fund**
    2. **Countries decide on participation**
    3. **Countries decide on individual level of public good provision**

The public goods game with transfers

The 3rd stage

- Given from the second and first stage of the game:
  - S: set of countries participating in the fund
  - t: magnitude of compensation
- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i) + \mathcal{T}_i$
- Compensation fund: $\sum_{k \epsilon S} \mathcal{T}_k = 0$, $\mathcal{T}_k = 0, k \notin S$
  - Multilateral payments among S, $\mathcal{T}_k \lesseqgtr 0$

The public goods game with transfers

The 3rd stage

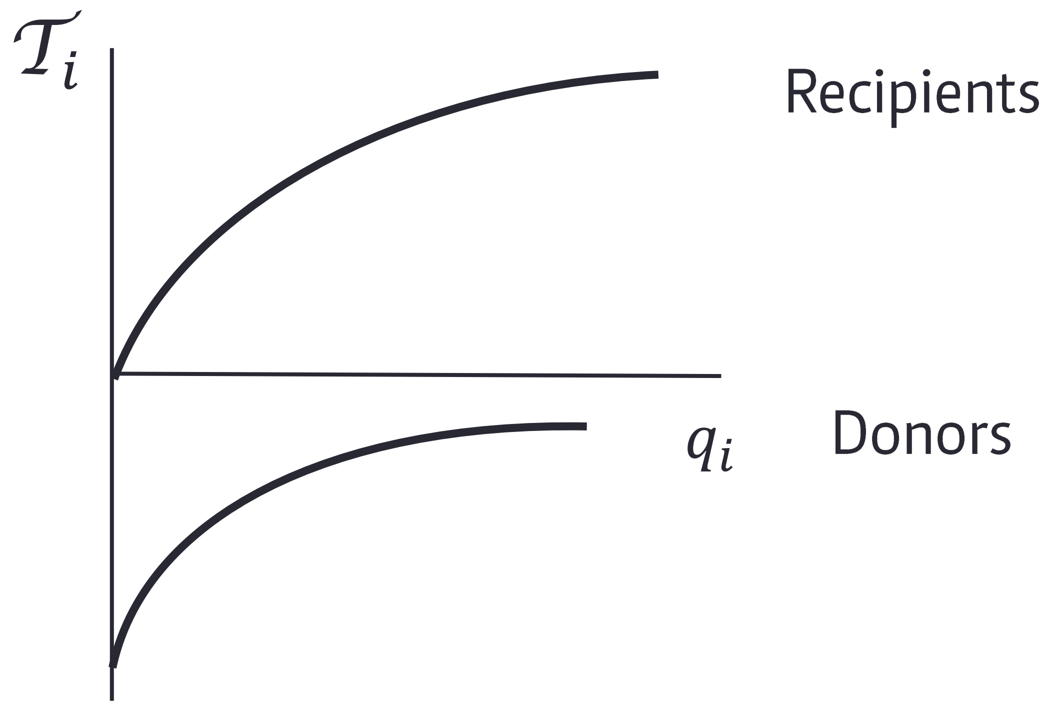
- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i) + \mathcal{T}_i$
- Strategic transfers: $\mathcal{T}_i = \mathcal{T}_i(q_i, q_{-i}, t, S)$
    - q_i: individual level of public good provision
    - q_{-i}: level ofpublic good provision by others
    - t: parameter „intensity of compensation“ (first stage)
    - S: participating countries (second stage)

The public goods game with transfers

The 3rd stage

- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i) + \mathcal{T}_i$
- Strategic transfers: $\mathcal{T}_i = \mathcal{T}_i(q_i, q_{-i}, t, S)$
- Positive marginal transfers

$$\boxed{\frac{\partial}{\partial q_i}\mathcal{T}_i \geq 0}$$



The public goods game with transfers

The 3rd stage

- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i) + \mathcal{T}_i$
- Strategic transfers: $\mathcal{T}_i = \mathcal{T}_i(q_i, q_{-i}, t, S)$

<u>Example with linear quadratic payoff: fund of fixed size, donors pay, recipients' payment proportion to costs:</u>

$$\mathcal{T}_i(q_i, q_{-i}, t, S) = \underbrace{t \cdot \sum_{j \in S} \text{size}_j}_{\text{Total resources in fund, proportional to participating countries}} \underbrace{\frac{c_i q_i^2}{\sum_{j \in R} c_j q_j^2}}_{\text{Transfers proportional to costs}}, \; i \in S_R$$

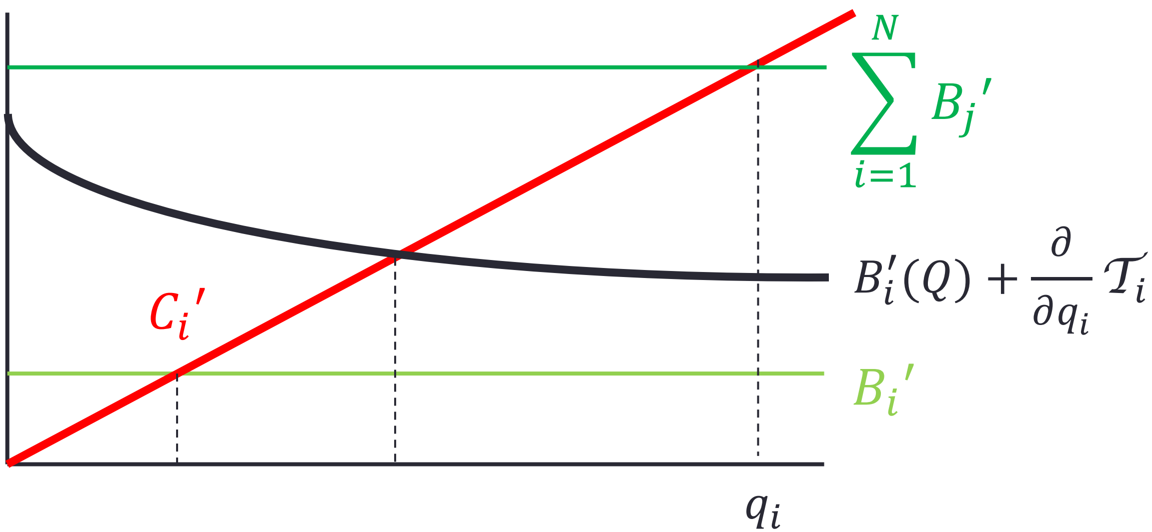
The public goods game with transfers

The 3rd stage

- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i) + \mathcal{T}_i$

- Non-cooperative with transfers:

$$B_i'(Q) + \frac{\partial}{\partial q_i}\mathcal{T}_i = C_i{}'(q_i)$$



- Strategic transfers enhance voluntary contribution to public good

The public goods game with transfers

The 3rd stage

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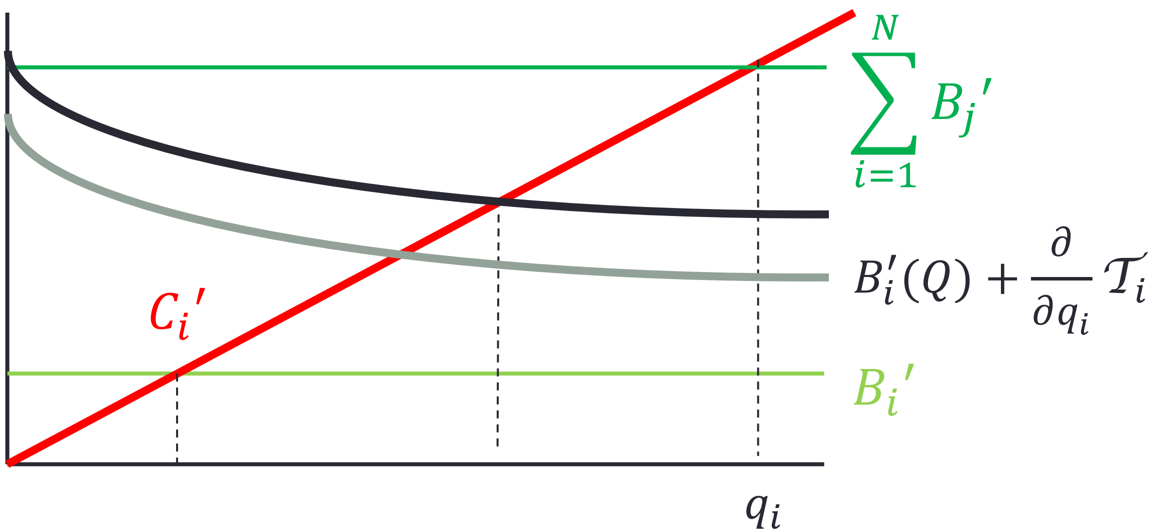

- Strategic transfers enhance voluntary contribution to public good
- How much
  → choice of intensity of compensation t

The public goods game with transfers

The 3rd stage

- Payoff structure: $\pi_i = B_i(Q) - C_i(q_i) + \mathcal{T}_i$

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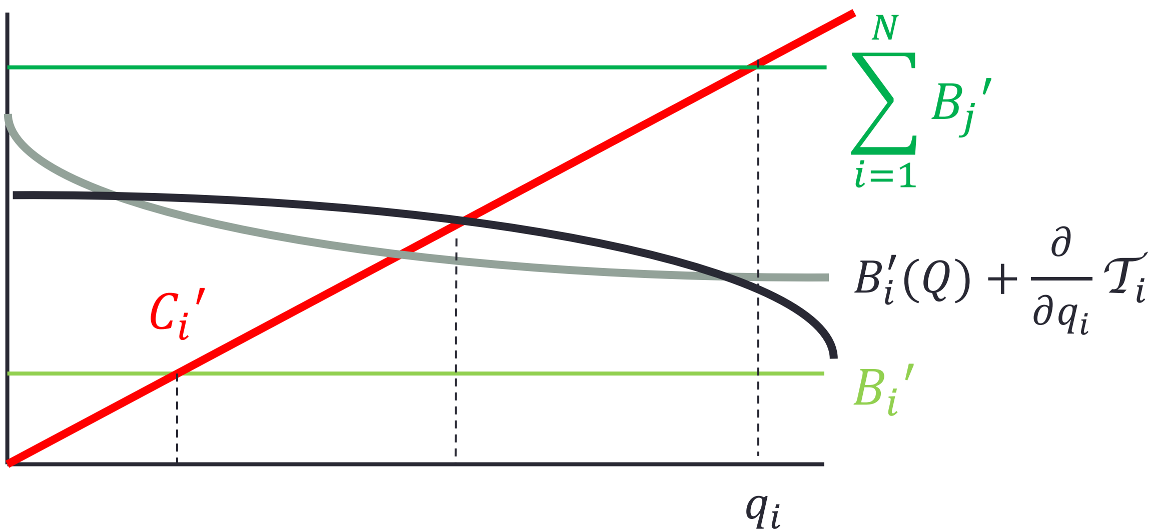


- Strategic transfers enhance voluntary contribution to public good
- How much
  → choice of intensity of compensation t
  →design of transfers

The public goods game with transfers

The 2nd stage

- Participants: provide more of the public good
  - When choosing t, any ambition level could be implemented
- BUT: free-riding incentives
  - A country can stay out of the compensation fund: no extra payments, enjoy higher public good provision by others
- 2nd stage: studies the incentive to actually take part in fund and provide more of the good
  - We explicitly look into fragmented regimes

The public goods game with transfers

The 2nd stage

- Comparison of payoffs:

$$\Delta \pi_i = \underbrace{\pi_i(S)}_{\text{Payoff when participating}} - \underbrace{\pi_i(S \backslash \{i\})}_{\text{Payoff when free-riding}}$$

The public goods game with transfers

The 2nd stage

- Comparison of payoffs:

$$\triangle \pi_i = \pi_i(S) - \pi_i(S \backslash \{i\})$$

→ Take the example of a donor country: **Why would it join?**

- Transfers: decreases incentive to join
- Increase in costs as strategic transfers increase level of public good provision
- Increase in benefits: only gain for donor countries if other participants increase their level of public good provision!

The public goods game with transfers

The 2nd stage

- Comparison of payoffs:

$$\triangle\, \pi_i = \pi_i(S) - \pi_i(S\backslash\{i\})$$

- FOCs for all other participants besides i

$$B_k'(Q) + \frac{\partial}{\partial q_k}\mathcal{T}_k(q_k, q_{-k}, t, S) = C_k{}'(q_k)$$

The public goods game with transfers

The 2nd stage

- Comparison of payoffs:

$$\triangle\, \pi_i = \pi_i(S) - \pi_i(S\backslash\{i\})$$

- FOCs for all other participants besides i

$$B_k'(Q) + \frac{\partial}{\partial q_k}\mathcal{T}_k(q_k, q_{-k}, t, S) = C_k{}'(q_k)$$

$$\updownarrow$$

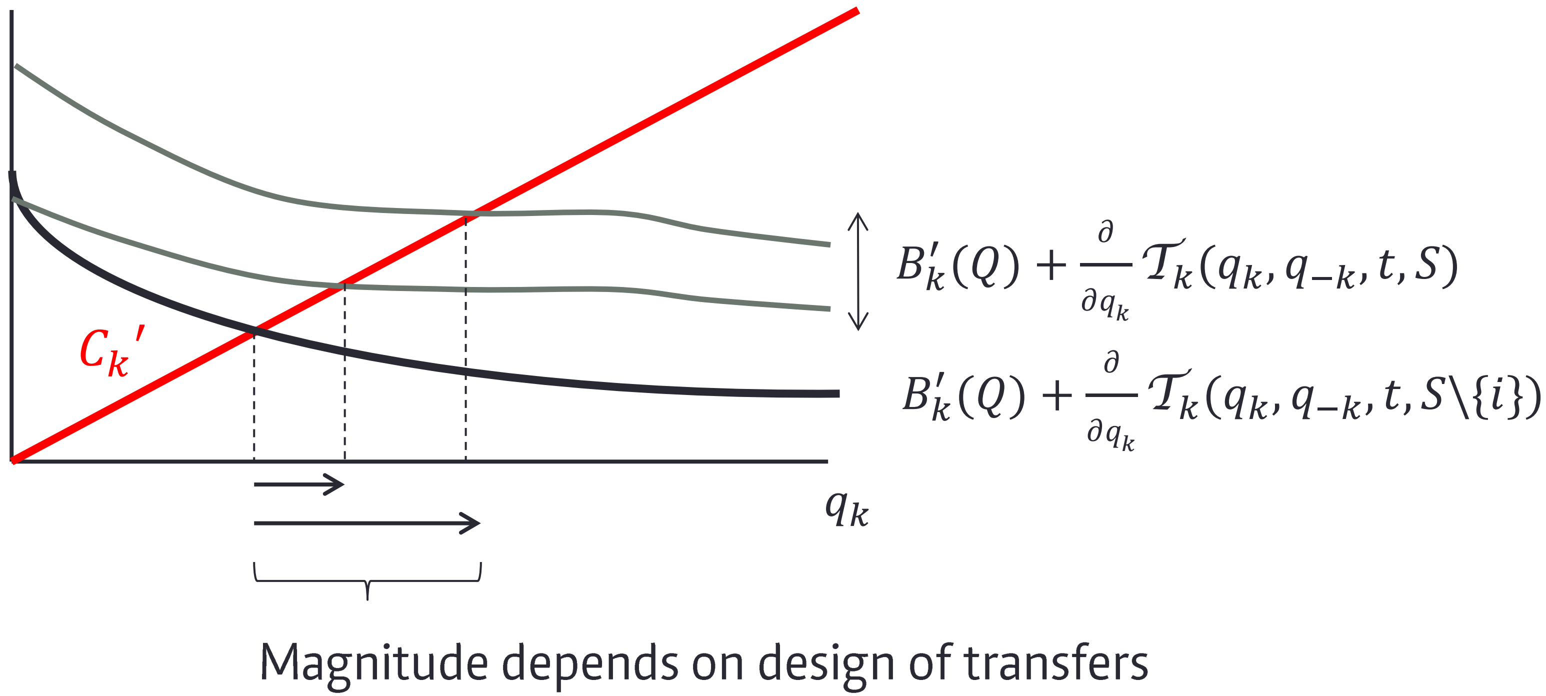
$$B_k'(Q) + \frac{\partial}{\partial q_k}\mathcal{T}_k(q_k, q_{-k}, t, S\backslash\{i\}) = C_k{}'(q_k)$$

- Change in ***marginal transfers***

The public goods game with transfers

The 2nd stage

- Marginal transfers: $\dfrac{\partial}{\partial q_i} \mathcal{T}_k(q_k, q_{-k}, t, S)$



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5. Conclusion/Outlook

Transfers from a fund of fixed size

- Designated donor countries pay into a fund
  - First stage t: amount of donation per size
- Recipients: receive payment proportional to their costs of public good provision:
  - $p_i = C_i{}'(q_i)$
  - Linear-quadratic example: $C_i(q_i) = \frac{1}{2}\frac{p_i^2}{c_i}$

$$\mathcal{T}_i(q_i, q_{-i}, t, S) = \underbrace{t \cdot \sum_{j \in S} \text{size}_j}_{\substack{\text{Total resources in fund,} \\ \text{proportional to participating} \\ \text{countries}}} \underbrace{\frac{c_i q_i^2}{\sum_{j \in R} c_j q_j^2}}_{\substack{\text{Transfers proportional} \\ \text{to costs}}}, \; i \in S_R$$

Transfers from a fund of fixed size

- Marginal transfers: $$\frac{\partial \mathcal{T}_l}{\partial q_l} = \underbrace{2t(k_R + k_D)}_{\text{Total magnitude of compensation, proportional to participating countries}} \underbrace{\frac{k_R - 1}{k_R^2} \frac{1}{q_R^s}}_{\text{Decreases with level of public good provision!}}$$

- If a donor joins:
  - Resources in fund increase

    → increase in marginal transfers
  - Recipients initially increase provision of public good, but anticipate that all other also increase their level

    → Decrease in marginal transfers

Transfers from a fund of fixed size

- Fund of fixed size works against interest of donors to a certain extend→ large transfer payments necessary to enhance public good provision
- Only little change in public good provision → large free-riding incentives
- In equilibrium of the entire game:
    - likely all donors and recipients join, but public good provision hardly enhanced if many countries participate

Transfers from a fund of fixed size

- Large valuation of public good of donors necessary, so that they have an incentive to provide the resources
- Donors have to provide almost the entire costs of recipient countries so that they provide their cooperative level of public good
- However, each donor would have to have a valuation of the public good that is at least as high as the **sum** of all valuations of recipients to find it optimal to provide the resources
  - Large unilateral incentives for public good provision!

Transfers based on differences in marginal costs

- No restriction in amount of transfers
- Compensation based on differences in carbon price level p_i to average:

$$\mathcal{T}_i = \underbrace{t \cdot \sum_{j \in S} \text{size}_j}_{\substack{\text{Total magnitude of} \\ \text{compensation, proportional} \\ \text{to participating countries}}} \cdot \underbrace{\left[p_i - \frac{1}{|S|} \sum_{j \in S} p_j \right]}_{\substack{\text{Transfers proportional to difference of} \\ \text{marginal costs } p_i \text{ to average among} \\ \text{participating actors } S}}$$

Transfers based on differences in marginal costs

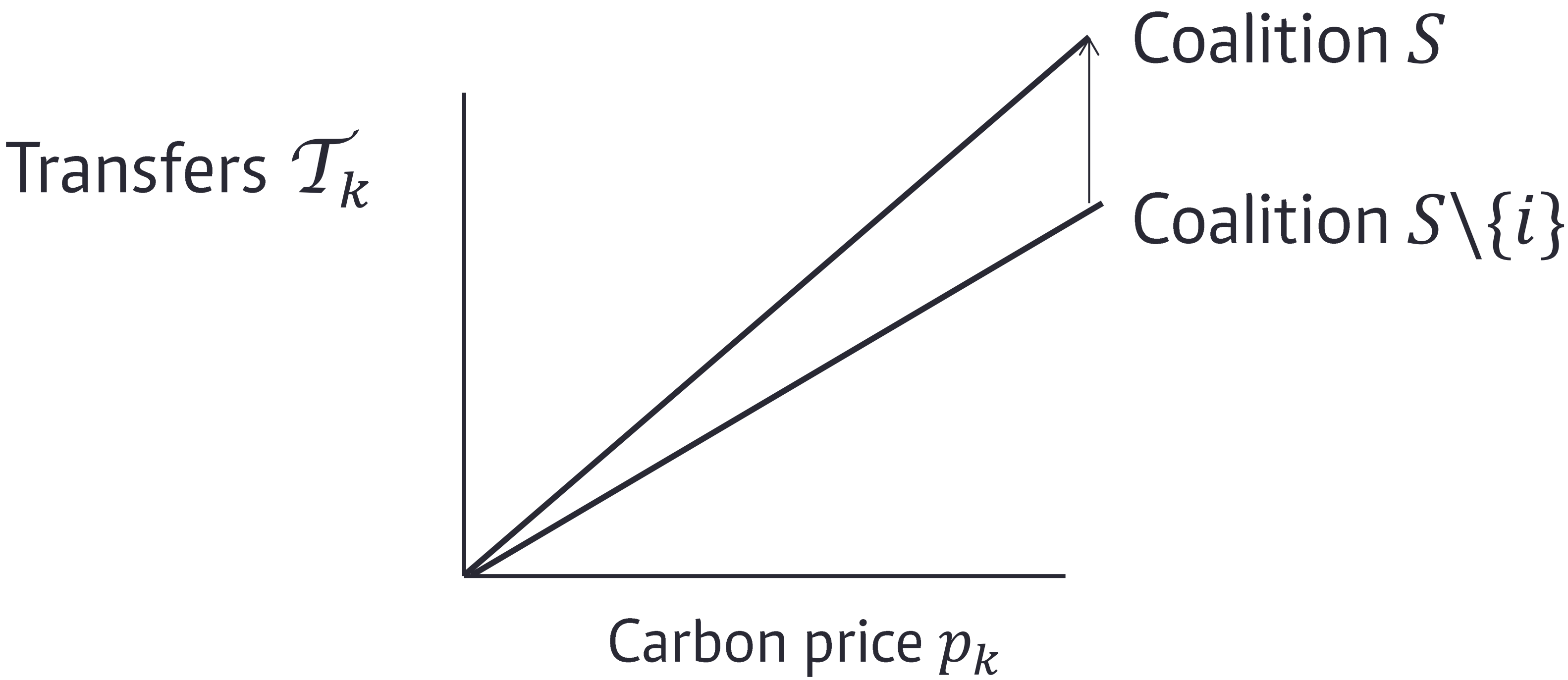
- Marginal transfers:

$$\frac{\partial}{\partial q_l}\mathcal{T}_l(q_l, q_{-l}, t, S) = \underbrace{t \cdot \sum_{j \in S} \text{size}_j}_{\substack{\text{Total magnitude of} \\ \text{compensation, proportional} \\ \text{to participating countries}}} \underbrace{\cdot\, c_i \left(1 - \frac{1}{|S|}\right)}_{\approx 1}.$$

- If a donor country joins:
  - Intensity of compensation increases → marginal transfers increase
  - Hardly any other change

Transfers based on differences in marginal costs

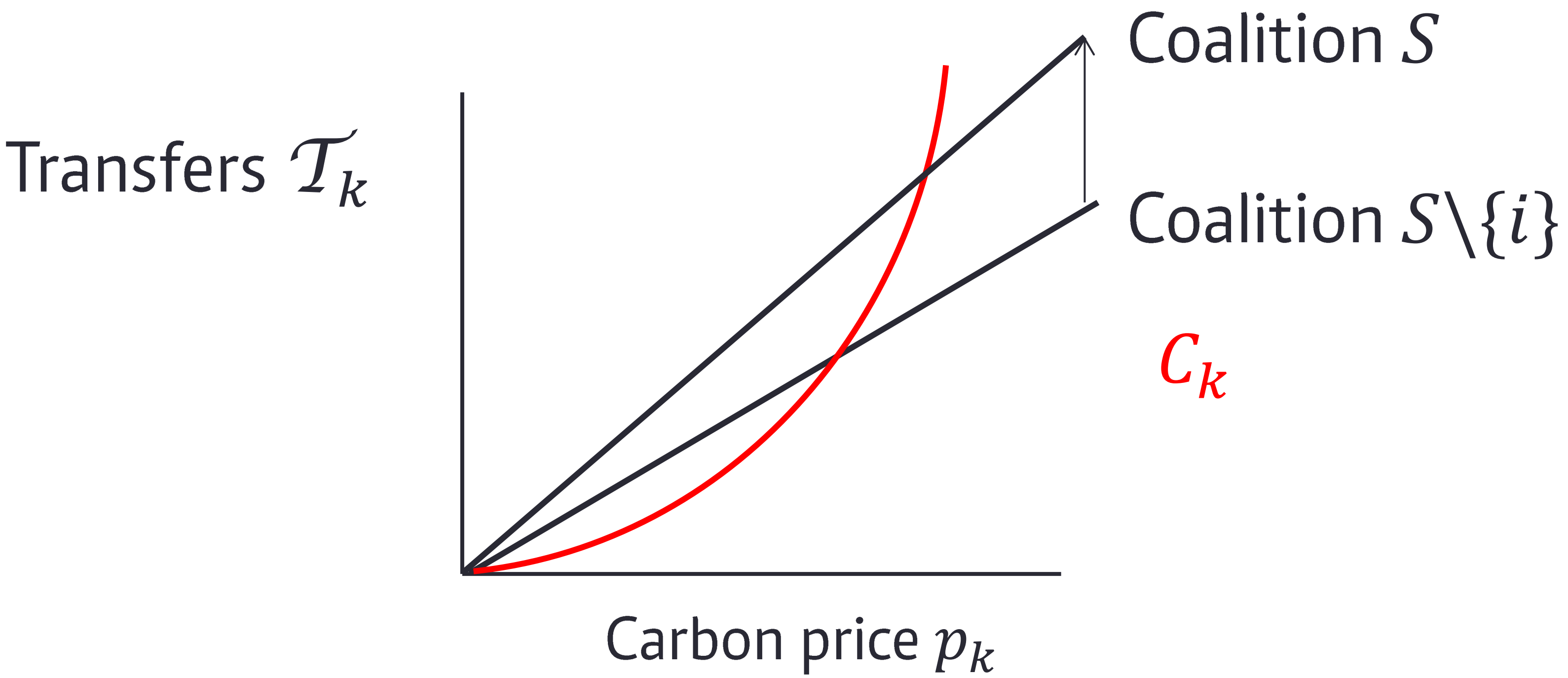
- Transfer payments increase through increase in magnitude of compensation



Transfers based on differences in marginal costs

- Transfer payments increase through increase in magnitude of compensation

  →transfers increase linearly with carbon price BUT costs are convex, only moderate increase in public good provision when a donor country joins



Transfers based on differences in marginal costs

- Example with symmetric countries
- In equilibrium of the game:
  - All countries participate in the compensation fund and implement moderate levels of public good provision

- Participants under heterogeneity:
  - Countries with steep marginal costs are recipients
  - Countries with large valuation of the public good

Transfers based on differences in total costs

- No restriction in amount of transfers
- Compensation based on differences in total costs to average
- We assume that costs are efficient:
  - $p_i = C_i'(q_i)$
  - Linear-quadratic example: $C_i(q_i) = \frac{1}{2}\frac{p_i^2}{c_i}$

$$\mathcal{T}_i(q_i, q_j, t, S) = \underbrace{t \cdot \sum_{j \in S} \text{size}_j}_{\text{Total magnitude of compensation, proportional to participating countries}} \cdot \underbrace{\text{size}_i \left(\frac{C_i(q_i)}{\text{size}_i} - \frac{1}{\sum_{j \in S} \text{size}_j} \sum_{j \in S} C_j(q_j) \right)}_{\text{Transfers proportional to difference of total costs to average among participating actors } S}$$

Transfers based on differences in total costs

- Marginal transfers

$$\frac{\partial \mathcal{T}_l}{\partial q_l} = t \cdot \underbrace{\sum_{j \in S} \text{size}_j}_{\text{Total magnitude of compensation, proportional to participating countries}} \underbrace{c_l q_l \left(1 - \frac{\text{size}_l}{\sum_{j \in S} \text{size}_j}\right)}_{\text{Proportional to level of public good provision!}}$$

- Marginal transfers increase both with the total magnitude of compensation and with the level of public good provision

Transfers based on differences in total costs

- Due to design of transfers: If all countries pay the same costs after redistribution

  →large incentive to increase own level of public good provision as only $\frac{1}{|S|}$ of increase in costs

  → this incentive increases with number of participating countries!

- As also magnitude of compensation increases

  →When a donor country joins, large increase in total level of public good provision

Transfers based on differences in total costs

- Example with symmetric countries
- In equilibrium of the game:
  - **<u>Social optimum uniquely implemented</u>**
- Participants under heterogeneity:
  - Countries with flat marginal costs are recipients
  - Countries with large valuation of the public good
- Countries with low valuation of the public good but high costs would simply stay out as an endogenous decision, that is anticipated by all other countries

Comparison of different strategic transfers

Donors have to gain from increased provision of public good

A compensation fund of fixed size:

- Increase is limited due to anticipation of shared resources

A compensation fund based on differences in marginal costs:

- Transfers increase linearly, costs are convex: only moderate increase in public good provision
- Countries with steep marginal costs are recipients

A compensation fund based on differences in total costs:

- Transfers are now also convex – Increase in public good provision is non-linear in participation: Anticipation that only a share of increased costs has to be paid individually
- Countries with flat marginal costs are recipients

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Conclusion/Outlook

- Using carbon price can establish reciprocity
- Strategic transfers can increase cooperation and ramp up ambition of NDCs
- Design of transfers critical to shape overall incentives
- Drawback: formulation of game; costs as measure
- BUT: general section revealed important characteristics
  - Transfers need to be strategic
  - Distributing the climate rent: donors with large valuation
  - Marginal transfers need to increase with participation

Thank you for your attention!