# Lecture 19: Making non-cooperative games cooperative (2): Side payments and agreements

- Objectives
  - show how non-cooperative single shot games can yield cooperative outcomes when payoffs are altered through side payments or penalties
  - show the importance of safety levels and the negotiation room

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## Outline

- Starting point and motivation for moving from noncooperative to cooperative outcomes
- The Nash equilibrium (again, but not today)
- The game's safety level
- The negotiation space
  - room for Pareto improvements
  - issues related to "splitting the surplus"
- Cooperative non-repeated games in a RAM setting
- N-player cooperative games

## Starting point - cooperative games

- Why cooperation
  - noncooperative outcomes (like the Nash equilibrium) are rarely desirable from a welfare perspective = potential of making all players better off by cooperation
- Any agreement or cooperative effort starts from the noncooperative game setting
  - the safety level
    - ➡ the payoff the agents are guaranteed to get
  - the negotiation space
    - ➡ the strategy-payoff space towards a welfare enhancing outcome

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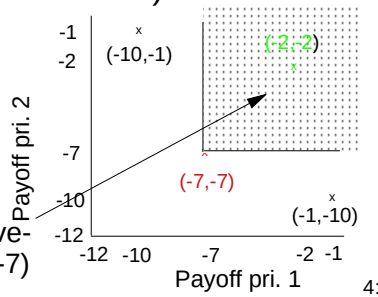
## Nash equilibrium - repetition

- Definition Nash equilibrium: The outcome that results when a player plays his/her **best reply strategy** given that all the other players play their best reply strategy
- Problem: Nash equilibria are rarely Pareto-optimal (in that sense a pessimistic outcome)

| | Prisoner 1 | |
|---|---|---|
| Prisoner 2: | Don't accuse | Accuse |
| Don't accuse | (-2,-2) | (-1,-10) |
| Accuse | (-10,-1) | (-7,-7) |




Region of potential Pareto improvement from non-coop solution (-7,-7)

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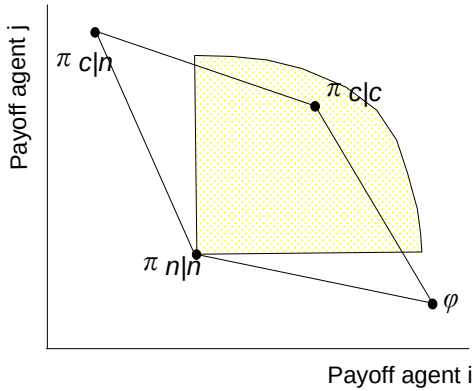
## The safety level in a game

- Best payoff that a player is secured without relying on cooperation from other players = safety level
- Here (for both players): $\pi_{n|n}$
- Rule: no agent accepts a payoff below his security level




(from agent i's perspective)

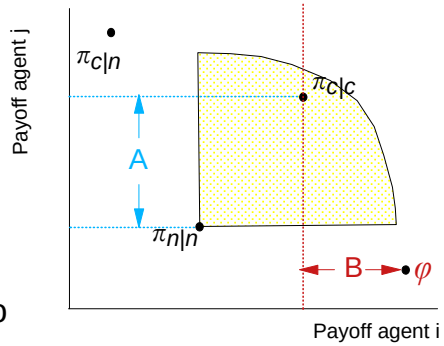


## The negotiation space (1)

- Folk theorem welfare ranking: $\varphi > \pi_{c|c} > \pi_{n|n} > \pi_{c|n}$ is the source to many of the difficulties in reaching welfare enhancing cooperative outcomes
- No general rule for obtaining cooperative outcomes in "nonrepeated" games
- ... but through side-payments/-penalties move the game to situations where solution is "trivial"
- Some key difficulties in the use of payments/ penalties
  - they reduce the payoff to the players who start using them
  - there is often "a last mover advantage"

## ... the negotiation space (2)

- B : the compensation needed for player *i* to refrain from playing $\varphi$ if *j* plays coop.
- A : the max payment *j* can offer *i* for i to sign an agreement of coop to be indifferent




Problem: who moves first (= offers a side payment)?

Here: payoff space rather symmetric e other player could be the one to offer payment

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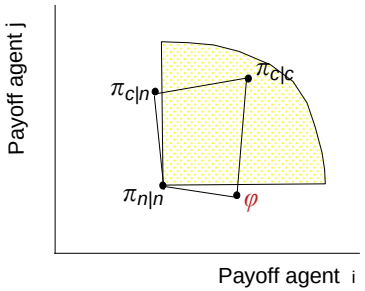
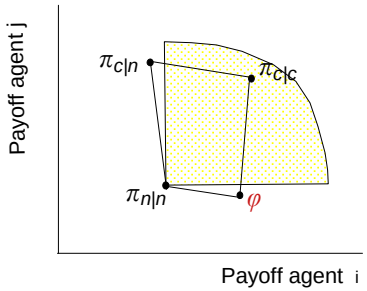
## ... the negotiation space (3)

Noncooperative games with "trivial" solutions
= breaking the payoff ranking $\varphi > \pi_{c|c} > \pi_{n|n} > \pi_{c|n}$ curse

Assurance game - solution given




Mixed game - side payment
+ given sequence of moves

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## Are the RAM criteria met (1)

1. the participation constraint (individual rationality)
   - yes, as no player accepts outcomes worse than his security level payoff

2. informational viability
   - necessarily not - players will shield their private information to try to extract information rents

3. incentive compatibility
   - no, as players have incentives not to reveal their private information to extract information rents

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## ... are the RAM criteria met (2)

The outcome is desirable (over the status-quo):

4. Informationally efficiency
   - no, negotiations require collecting more information than in the status quo setting
   - ... and negotioations are generally information demanding

5. Second Best Pareto optimality
   - yes, as there is a clear improvement in welfare for all agents over the status-quo in case of an agreement being made

6. relation to the budget constraint of P
   - there is no principal necessary in this setting
     e the question is irrellevant

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## N-player cooperative games (1)

- International environmental agreements
  a. self enforcing
     - ➡ once in place, nobody has incentives to deviate from the agreement
  b. all signatories are better off with than without the agreement
     - ➡ cfr. the Kaldor-Hicks (potential) compensation criterion
  c. environmental performance better than in status quo (non-cooperative) setting

- Difficulties
  - ➡ a-c hard to achieve jointly
  - ➡ how to agree to split net benefits

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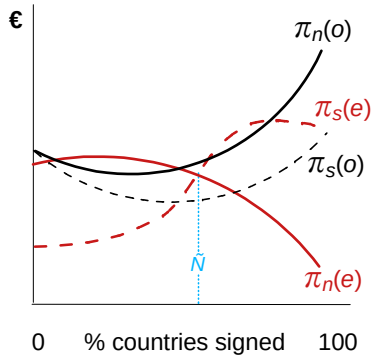
## ... N-player cooperative games (2)

- no super-national body ⇒ must be self enforcing
- how to achieve that ?
- assume N countries and treaty wo/ sanction (o)
- include a sanction (like a trade embargo - (*e*) )
- signing of treaties (two-step procedure)




  - ▸ sign conditional on sufficiently many others sign ($\tilde{N}$)
  - ▸ ratification ⇒ move to 100% of the countries signing (under those "rules" $\pi_s(e) > \pi_s(o)$ )

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## Applicability of cooperative arr. (1)

- No general solution approach available
  - case-to-case solution method makes achieving cooperative arrangements "very tricky"
    - problems vis-a-vis several of the RAM criteria demonstrate this
- Limitations
  - the welfare gains from cooperation must be sufficiently large to allow for sidepayments (or the use of penalties), parallell to the Kaldor-Hicks criterion in cost benefit analysis
    - modification from Kaldor-Hicks: payments / penalties may be used

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## ... applicability of cooperative arr. (2)

- Games with side-payments usually seen as games without a principal (regulator)
- How can regulators use side-payments among agents to get to cooperative agreements?
  - offering a subsidy to one party conditional on this party brokering cooperation ($\Rightarrow$ reduced transaction costs)
  - issuing taxes/other costs on agents that induce cooperation = places the game in a structure where the "Nash-deadlock" is broken

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## Concluding remarks

- Cooperative game theory important tool in international environmental agreements
  - the security level (in a game theory sense) makes it difficult to get cooperation in environmental matters
    - conventional environmental economics story: costs are immediate while gains are uncertain, and in the future
  - ... matters further complicated by controversy over and unequal distribution of gains from agreement

- What is most important
  - get a strong agreement on environmental aspects?
  - ... or get an agreement with clear principles, where environmental targets can be adjusted (as uncertainty is resolved)?

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## Concept questions

- Think of an environmental problem with a payoff structure that does not foster cooperation
  - what are necessary conditions for a regulator to break/modify the payoff structure to induce cooperation? (a short answer related to the regulator's powers)
  - think of the existing payoff structure in the game, and analyze the impacts of working one or both (all) parties

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