

# Multilateral versus Sequential Negotiations over Climate Change: Are Gradually Expanding Regional Agreements a Better Option?

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# Motivation

- Free Trade Agreements
  - Multilateral
  - Regional (sequential)
- Climate Change Negotiations
  - Multilateral
  - Regional (sequential)

# Free Trade Agreements

- Aghion, Antras and Helpman (2007), AAH
  - Focus on free-trade - partition function
  - Take-it-or-leave-it-offers from the leader (*who gets all the surplus*)
  - Positive coalition externalities: multilateral
  - Negative coalition externalities: sequential
  - The grand coalition (GC) is always achieved
- Saggi and Yildiz (2010 and 2011)
  - Free trade, with trade models
  - Self-enforcing
  - Bilateral sometimes only way to achieve global agreement
- Sen and Biswas (2015)
  - Extend AAH to different bargaining structures, but keeping take-it-or-leave-it-offers from the leader

# International Environmental Agreements

- Carraro (2005)
  - Focus on the simultaneous formation of different coalitions
- Finus et al. (2010)
  - Sequential move unanimity game (Bloch, 1995)
  - Initiator proposes and if all agree the coalition is formed. Then, a new proposer is selected from those not participating.
  - Simulations
- Caparrós et al. (2004); Caparrós and Péreau (2013)
  - Bargaining theory applied to climate change negotiations

# Climate change negotiations

- 1992: United Nations Framework Convention on Climate Change: *encourages* the 'stabilization of greenhouse gas concentration in the atmosphere'
- 1997: Kyoto Protocol signed: it *commits* industrialized countries to reduce overall emission by five per cent in 2012 compared to 1990
- 2015: Paris Agreement: pledge and review
- EU played a leader role after withdrawal of US from Kyoto
- US played a leader role for the Paris agreement. Trump?

## (Non)-binding agreements

- Some agreements are *binding* (Kyoto Protocol), although with limitations:
  - In most cases countries comply
  - However, each country maintains the option to withdraw (Canada)
- Other agreements are *not binding* (Paris Agreements)
  - Intended National Determined Contributions (INDC) are not binding
  - Article 6: countries may cooperate to increase abatement targets. It allows for bilateral and regional agreements (these agreements could potentially be binding)
  - Article 9: transfers from developed to developing countries

# Gradual coalition formation and IEA

- IEA are generally single agreements that are gradually extended to cover more countries.
- Examples where coverage evolved over time:
  - ozone depleting substances (the Montreal Protocol and related treaties),
  - sulphur reduction (the Helsinki Protocol and related treaties),
  - nitrogen oxide (the Sophia Protocol and related treaties).
- Main interpretation: gradual formation of IEA, with one country playing a leader role

# Gradual expansion of emission trading scheme

- Alternative interpretation: gradual expansion of an emission trading market to other regions
- EU has a clear leader role in emission trading (EU ETS)



## Preview of results: The grand coalition is likely to be the outcome of a gradual process

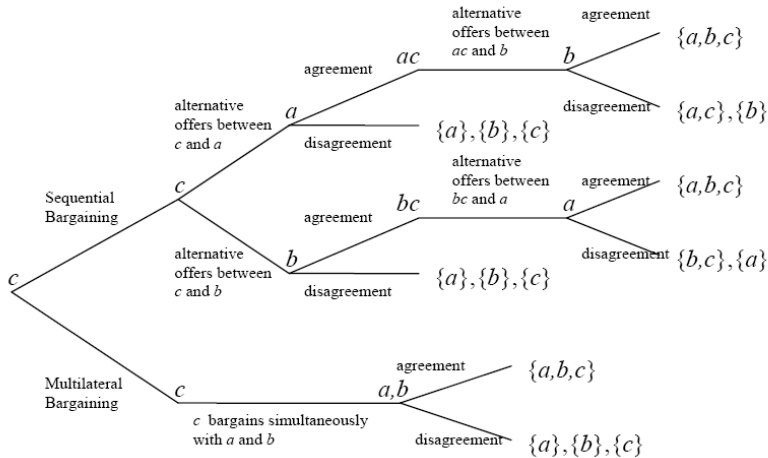
- If we consider IEA binding agreements:
  - The grand coalition will be the outcome
  - The leader will frequently choose a sequential path
- If we consider IEA are not binding, and that self-enforcing agreements are needed:
  - The grand coalition will be the outcome if superadditivity holds
  - Even if a self-enforcing multilateral agreement in one step is not possible, a gradual process may yield self-enforcing agreements in which all countries cooperate.

## Preview of results: Is there a role for a mediator?

- In most cases, yes, there is a role for a mediator (e.g. UNFCCC Secretariat)
- Speed up negotiations within each round:
  - fast offers and counteroffers within a round
- Delay the start of new negotiation rounds:
  - long periods between rounds

# Benchmark model

- Three players  $\{a, b, c\}$  and  $c$  is the leader (only agenda setter)
- Transferable-utility game
- Partition function form: assigns a value to each coalition in every coalition structure (Thrall and Lucas, 1963)
- Offers and counter-offers
- Development of AAH, with discounting and giving bargaining power to followers



# Notation

- $v(j; \Gamma)$ , the value function assigns a payoff to  $j$  given the coalition structure  $\Gamma$
- Surplus generated by an intermediate coalition:

$$\Delta_{ij} = v(ij; \Gamma_{ij}) - v(i; \Gamma_\phi) - v(j; \Gamma_\phi)$$

- Surplus generated by the grand coalition:
  - from all singletons

$$\Delta_{abc} = v(abc; \Gamma_{abc}) - \sum_{i=a,b,c} v(i; \Gamma_\phi)$$

- from intermediate structure

$$\Delta_{-ij} = \Delta_{abc-ij} = v(abc; \Gamma_{abc}) - v(ij; \Gamma_{ij}) - v(k; \Gamma_{ij})$$

# Definitions

## Definition

Positive Coalition externalities. There are positive coalition externalities in country  $j$  when  $E(j) = v(j; \Gamma_{kl}) - v(j; \Gamma_{\phi}) > 0$ .

## Definition

The game is cohesive if  $\Delta_{abc} > 0$  and  $\Delta_{-jc} > 0$ , for all  $j \neq c$ . The game is superadditive if, in addition,  $\Delta_{jc} > 0$ , for all  $j \neq c$ .

## Definition

The game is convex if  $\Delta_{-kc} > \Delta_{jc}$  and concave if the opposite relation holds, for all  $j \neq k$ .

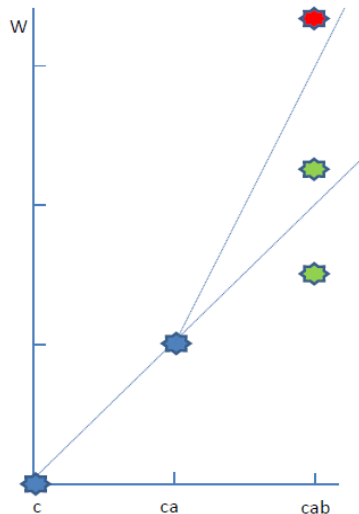
# Benchmark

## Proposition

*Assume that the game is cohesive and that the discount factors tend to one. Then, the grand coalition is formed in all cases and the leader prefers multilateral bargaining iff*

$$[\Delta_{-ac} - 2\Delta_{ac}] + 4E(b) > 0 \quad (1)$$

*and sequential bargaining iff the opposite relation holds. Thus, convexity of the game and positive coalition externalities in the follower countries favor multilateral bargaining.*



Green = sequential; red = multilateral.



# Convexity

- The first term is only positive when the surplus generated by moving from the intermediate coalition to the GC is twice as large as the one generated by forming the coalition  $\{ac\}$  ("strongly" convex)
- As the leader approaches first the country to which it adds more, without externalities:
  - multilateral if the marginal contribution of the other follower is much larger when moving from partial cooperation to full cooperation than its contribution to a partial coalition
- The more heterogeneous the follower countries, the more difficult to get a "strongly" convex game

## Extending Rubinstein's model to N players

- Rubinstein's model yields multiple equilibria for more than three players
  - Patient players and conditional offers, cycles
- Huang (2002)
  - Players talk following any protocol (bargaining over cake)
  - Conditional offers, only bind if both countries accept the offer
  - Unconditional offers, the proposers 'buys out' the right of the country accepting the offer and continues negotiating with
  - Both types of offers, or only unconditional: **uniqueness restored**

# Extending Rubinstein's model to N players

- Unconditional offers (or the option of) are reasonable representation of international negotiations
- We provide the necessary extensions of Huang's (2002) paper, taking into account that:
  - the surplus shared is not 1 but the surplus generated by moving from the all singletons situation to the grand coalition
  - the reservation payoffs are not zero, and are different for each player.
- The analysis is rather technical and I will skip it here

# Extending Huang (2002): Cyclical protocol

- When  $\delta \rightarrow 1$ 
  - multilateral  $(c, a, b, c, a, b\dots)$ :

$$\lim_{\delta \rightarrow 1} \Phi(c, m) = \lim_{\delta \rightarrow 1} \frac{1}{1 + \delta + \delta^2} = \frac{1}{3}$$

- bilateral  $(c, a, c, a, \dots)$ :

$$\lim_{\delta \rightarrow 1} \Phi(c, s) = \lim_{\delta \rightarrow 1} \frac{1}{1 + \delta} = \frac{1}{2}$$

# Extending Huang (2002)

- Huang's solution has the following welcome features:
  - it degenerates to the Rubinstein Bargaining Solution (RBS) for the case of two players;
  - it tends to the Nash Bargaining Solution (NBS) if the discount factor tends to one; and
  - if all players are allowed to talk once in the cycle, the equilibrium is the same as the unique Stationary SPE of the unanimity game (stationary strategies is a strong assumption)
- It is therefore an adequate generalization of the RBS to more than two players

# The role of assumptions

- *Binding (bargaining)*
  - all countries believe that if they break an agreement all other countries will go back to their all-singletons behavior
  - agreements are binding
  - bargaining up to now
  - core
- *Self-enforcing*
  - all countries believe that if they break an agreement the remaining countries of the coalition will continue to cooperate
  - agreements are not binding
  - internal - external stability
  - consolidation of coalitions is key

# Self-enforcing

- In the multilateral case  $\{a, b, c\}$ , after the agreement, country  $i$  has two options:
  - stick to the terms of the agreement, including the lump-sum transfers
  - leave the agreement without its transfer but under the assumption that countries  $j$  and  $k$  stay as a coalition, i.e. as  $\{j, k\}$ , and abate at the level that is optimal for this coalition

# Self-enforcing

- This implies that any agreement where player  $i$  receives less than  $v(i; \Gamma_{jk})$  will not be honoured
  - hence, in an equilibrium agreement each player has to receive at least  $v(i; \Gamma_{jk})$  after transfers.
- Thus, the equilibrium payoff in a multilateral agreement is  $v(i; \Gamma_{jk})$  plus a share of the remaining surplus after granting each player  $v(i; \Gamma_{jk})$ .
  - we denote this remaining surplus by

$$\Delta_{abc}^F = v(abc; \Gamma_{abc}) - \sum_{i=a,b,c} v(i; \Gamma_{jk})$$

- for positive externalities:  $\Delta_{abc}^F < \Delta_{abc}$



# Self-enforcing

- For sequential bargaining, results depend on whether intermediate coalitions "consolidate"
- A coalition "consolidates" if it cannot break up in subsequent negotiations
- The period  $\theta$  between negotiation stages is long enough to ensure that the coalition  $\{ac\}$  cannot break up during the second negotiation.

# Self-enforcing

- Cohesiveness is no longer sufficient to ensure the formation of the grand-coalition
  - cohesiveness implies that the GC generates more surplus than any intermediate coalition structure, not that there is enough to grant each country its free-rider payoff
- However, if coalitions "consolidate", the grand coalition is still the outcome if superadditivity holds (s.c.).
  - the reason is that at least a one-by-one enlargement is always self-enforcing

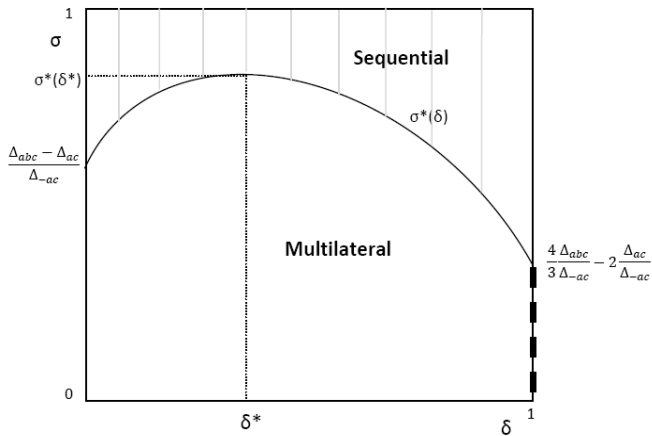
# Discounting

- $\delta$ : intra-stage discount factor (between offers and counteroffers):  $\delta = e^{-r\tau t}$
- $\sigma$ : inter-stage discount factor (from one negotiation to the next negotiation in sequential bargaining):  $\sigma = e^{-r\theta t}$
- where  $r$  is discount rate,  $\tau$  is time between offers and  $\theta$  time between stages.

# Mediation

- International facilitating agency or mediator (UNFCCC secretariat) is interested in multilateral bargaining (sequential implies welfare loss with  $\theta \neq 0$ ):
  - The mediator organizes the meetings of the parties and decides the periodicity of those meetings
- In our model the mediator decides
  - duration of the period between offers ( $\tau$ ) in the intra-stage negotiations, or  $\delta$
  - duration of the period between stages ( $\theta$ ), or  $\sigma$
- The mediator's utility function (Camiña and Porteiro, 2009) implies that it:
  - positively values the additional surplus created
  - and negatively values the unequal distribution of this additional surplus

# Mediation



# Mediation

- speed up negotiations within each stage (i.e. increase  $\delta$ ), fast offers and counteroffers
- delay the start of new negotiation rounds (i.e. reduce  $\sigma$ ), long periods between stages
  - although indifferent for many values
  - note that one of the optimal equilibria is to set  $\sigma = 0$  (block any possibility to negotiate in future rounds)

## General model: features

- 1 leader and N followers.
- Stage 1: Leader decides to bargain with all or with a subset. Bargaining as above.
- Stage 2: After a period with a discount factor of  $\delta$ , the coalition decides to bargain with all or with a subset of the remaining followers. Bargaining as above.
- Stage3: ... (potentially up to N stages)
- Number of stages endogenously determined
- Any cyclical bargaining protocol on each stage.
- Only one coalition can be formed
- All the results hold, just more complicated. See the paper.

## Illustration with particular functions

- Quadratic functions for heterogeneous countries
  - taken from McGinty (2007), but coalition plays Nash (McGinty used Stackelberg)
- Individual gross payoff (before any transfers) are given by:

$$B_i(Q, \lambda_i) - C_i(q_i, \zeta_i) = \lambda_i \beta \left( \gamma Q - \frac{Q^2}{2} \right) - \frac{\zeta_i}{2} q_i^2$$

where  $Q = \sum_{i \in C_G} q_i$ , each nation receives a share of the benefit equal to  $\lambda_i$ , with  $\lambda_i > 0$ , and  $\gamma$ ,  $\beta$  and  $\zeta_i$  are strictly positive parameters.



# Simulations

- To simplify, we focus on a game with 5 players (one leader,  $c$ , and 4 followers  $a_i$ ,  $i = 1..4$ )
- Three examples and Monte-Carlo simulations, with 1000 repetitions
- $\lambda$  values are randomly selected, ensuring that  $\sum \lambda_i = 1$ .
- The remaining parameters are randomly selected from the following intervals:  $\gamma \in [1, 10]$ ,  $\beta \in [1, 100]$ ,  $\zeta \in [10, 100]$ ,  $\delta \in [0.95, 1]$ ,  $\sigma \in [0.8, \delta]$ , ensuring that  $Q(\Gamma_{C_G}) < \gamma$ , where  $Q(\Gamma_{C_G})$  is  $Q$  for the GC (Diamantoudi and Sartzetakis, 2006).
- The game is superadditive in 583 of the 1000 cases considered and, as expected, always cohesive.

## Simulations - benchmark

- As the game is cohesive, the grand coalition is always formed. However, the path depends on the parameters
- As predicted, lowering the discount factors reduces the number of stages
- Sequential bargaining is chosen by the leader in 879 out of 1000 cases.
- Although not in one step, in all these cases the GC is the final outcome.
- Multilateral bargaining is the option selected in the remaining 121 cases (yielding the GC).

## Simulations - self-enforcing

- The leader selects sequential bargaining in 930 cases.
  - Out of these, only in 10 cases is the GC not achieved, yielding an intermediate coalition as the final outcome
- Multilateral bargaining is selected in 63 cases, yielding always the GC
- Finally, the leader decides to remain as a singleton in 7 cases.
- That is, only in 17 cases is the GC not achieved.
- This is a remarkable result considering that the GC is PIS in a multilateral setting only in 113 out of the 1000 cases considered.

# Conclusions

- A general and flexible model of gradual coalition formation with positive externalities in which a leading country endogenously decides whether to negotiate multilaterally or sequentially over global public goods
- The two features driving the results are:
  - how much bargaining power the followers have
  - the assumption about the behavior of the remaining players if one player breaks an agreement

# Conclusions

- Mediation can minimize welfare losses in well defined cases.
  - Thus, the UNFCCC Secretariat has a role to play.
- Assuming followers with no bargaining power and binding agreements, Aghion et al. (2007) show that the leader always prefers a multilateral negotiation process.
- Relaxing the bargaining power assumption, the leader may prefer a sequential path even with positive externalities.
- This could explain future bilateral or regional binding climate change agreements (Article 6 in the Paris agreement)

# Conclusions

- Requiring agreements to be internally stable, reaching a stable grand coalition is only guaranteed if superadditivity holds.
- Even the grand coalition is not stable in a multilateral setting, the sequential approach may reach a stable global agreement.
- Furthermore, our simulations have shown that this is in fact the case for most parameter values.
- Thus, in some cases sequential negotiations may be the only option to reach the grand coalition
- In this path, the leader approaches first the country to which it adds more

# Conclusions

- For this path to be feasible, coalitions need to consolidate.
- In real-life negotiations, consolidation implies giving intermediate coalitions time to build up common institutions, such an emissions trading market, to make it difficult to break up in subsequent negotiations
- Our results show that a multilateral approach is not necessarily the best strategy to negotiate a climate change agreement, and provides a rationale for focusing on linking the EU ETS to other schemes in a sequential process.
- Nevertheless, it also implies that this needs to be a slow process, to ensure that intermediate coalitions (agreements) can consolidate.

# Conclusions

- Take the EU, as originally a Free Trade Agreement.
- It has been a prime example of gradual expansion of cooperation.
- However, maybe the last expansions were too fast, which has ultimately been one of the causes of the failure to consolidate (Brexit)
- Expanding the EU ETS needs to be done at a pace that allows consolidation



Thank you for your attention  
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## Positive externalities

- Positive coalition externalities in the follower country  $b$ ,  $E(b) > 0$ , favor multilateral bargaining:
  - the larger these externalities are the larger is the disagreement point of player  $b$  in the second negotiation of a sequential process, and the lower the payoff obtained by the leader in this second negotiation (inducing it to adopt a multilateral approach).