Challenges for achieving cooperation in global agreements: Evidence from experimental economics, game theory, and numerical modeling

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Climate change as global challenge

- CO_2 as mixed pollutants affect global climate
- Benefits from own reduction relatively small, even for large countries
- Free riding incentive
  - "Tragedy of the commons"
- Economists use have long used game theory to analyze the problem, here new methods are applied:
  - Behavioral economics
  - Cooperative game theory
  - Informed by / informing numerical methods

Experimental economics

- Observed vs rational behavior
- Lab setting
- Play for real money to avoid “warm glow”
- Often students as test subjects

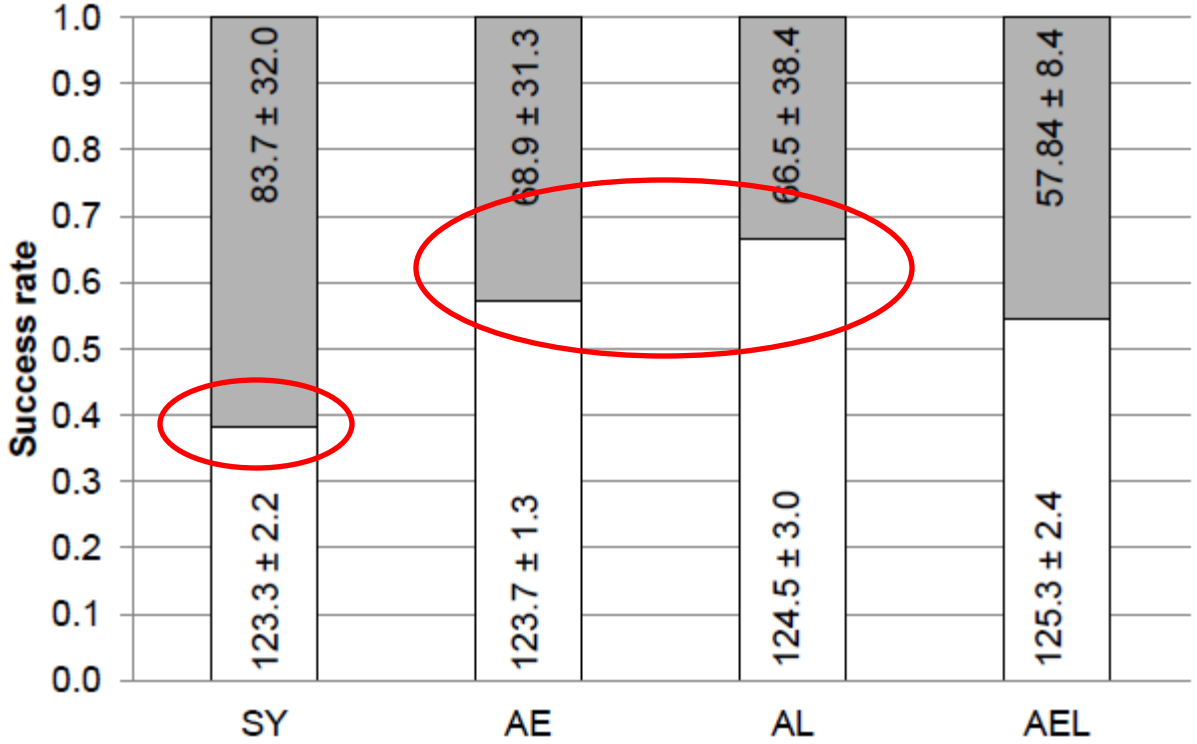
- Variations of setting to find stepping stones / stumbling stones for cooperation

Threshold Public Good Games

- Threshold games to model climate negotiations, basic setup:
  - Group of 6 players
  - Receive 40 tokens, in each of 10 rounds, 4 tokens have to be divided into private account and a joint prevention account
  - Group has to reach 120 tokens in a prevention account to avoid climate disaster
  - Climate disaster: With a given probability, loose a given share of private budget
- Several variations:
  - Communication (non-binding pledges, open chat)
  - Punishment
  - Asymmetries (rich/poor, high/low damages)

Results from asymmetries

- Success rate (Did the groups avoid the catastrophe?)



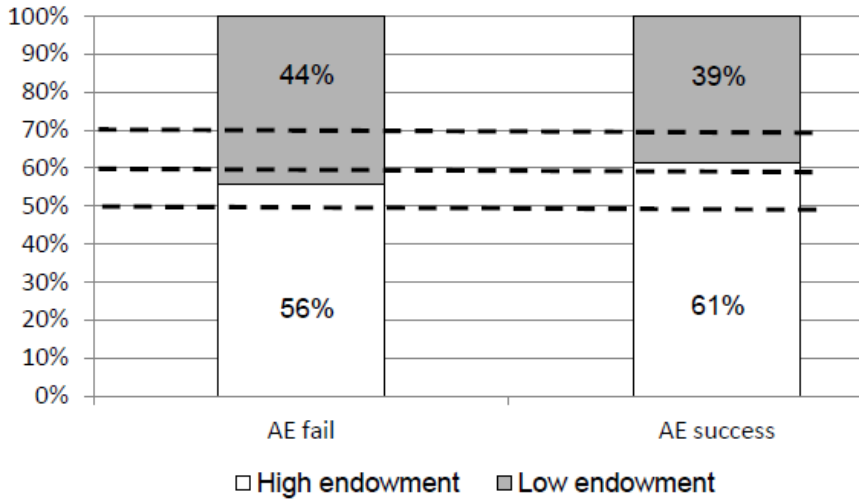
Note: "SY", "AE", "AL", and "AEL" denote "symmetry", "asymmetric endowment", "asymmetric loss" and "extreme asymmetry" treatments, respectively. The light (dark) sections indicate success (failure) rates per treatment. The average contribution to the prevention account and the average standard deviation are given for success and failure groups per treatment.

Waichman et al. 2014

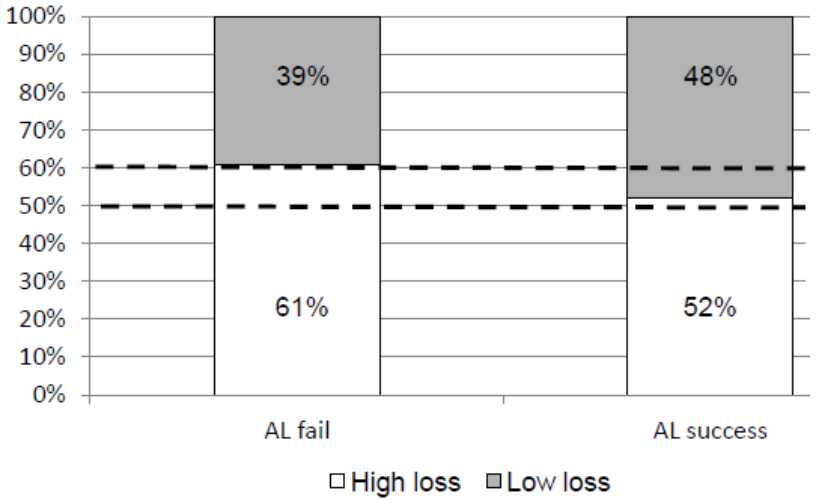
Results from asymmetries II

- How did successful groups share the burden?

Rich/poor asymmetry



High/low loss asymmetry



Waichman et al. 2014

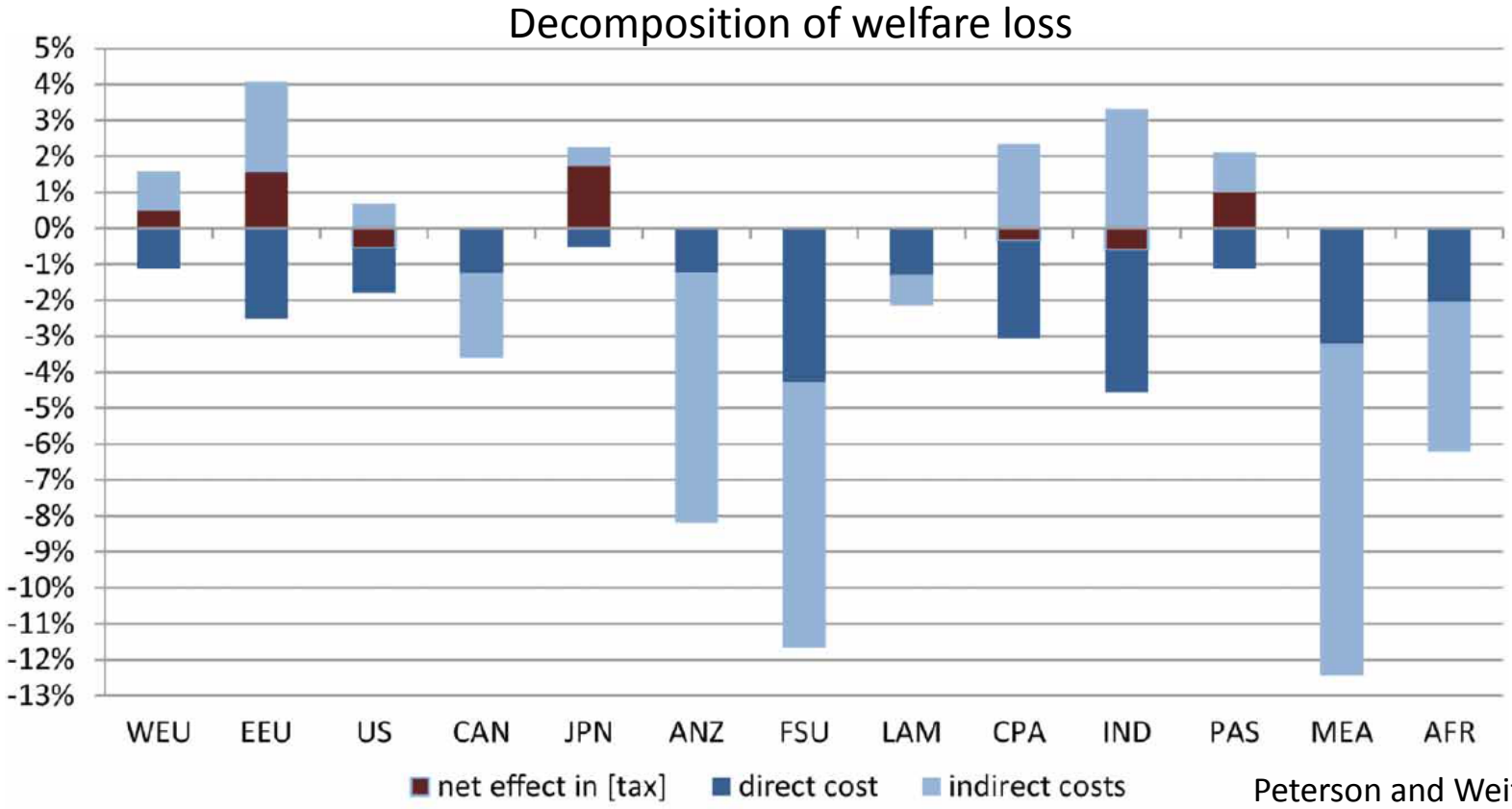
- Contribution proportional to initial endowment, also in asymmetric loss treatment

Translating into more realistic setting

- What would equal (relative) contributions mean?
- Same percentage loss of GDP / welfare
- Analysis in CGE model, cost consists of
  - Direct abatement costs
  - Lower value of fossil fuel reserves (indirect effect)

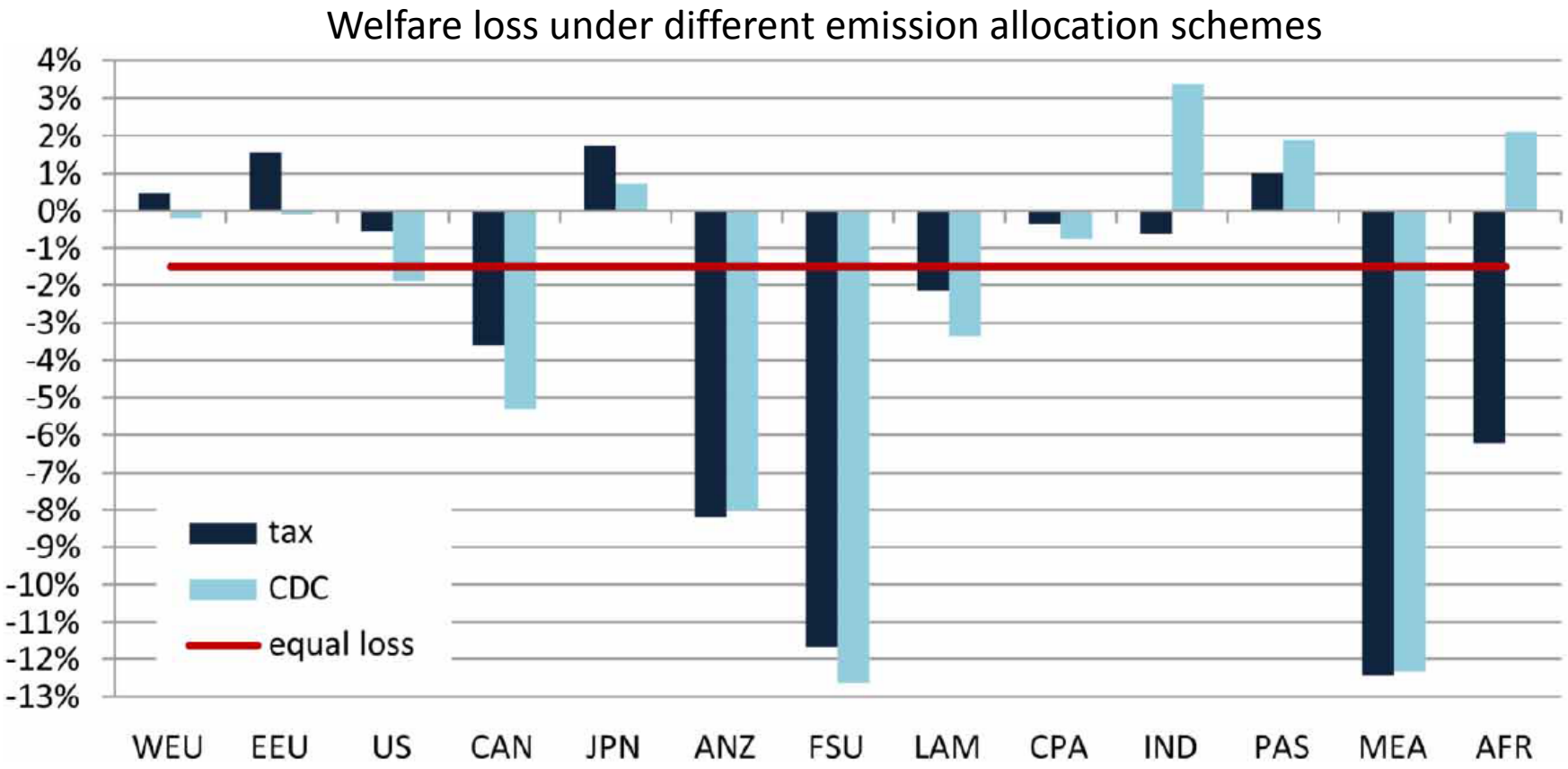
Abatement cost through 2050

- Assuming harmonized carbon tax
- For energy exporters, reduced fuel demand leads to large share of their costs; importers gain from this



Peterson and Weitzel 2015

High transfers to reach equal loss



Peterson and Weitzel 2015

- Equal loss scenario is quite different from conventional proposals of emission allocations

High transfers to reach equal loss

- Large transfers required to achieve equal loss via an emission allocations
- Transfers not only to poor regions, but also to relatively rich energy exporters FSU, MEA, ANZ
- Japan would need to buy almost all carbon permits, ANZ and MEA would receive more permits than BAU emissions
- Politically not feasible

Cooperative game theory

- Non-cooperative game theory:
  - Internal/External stability: Is joining/exiting coalition beneficial (assuming no further moves)?
  - Stability generally achieved only for small coalitions
  - Some improvements when models are extended with technology transfer, punishment via border carbon adjustments, …
- Cooperative (vs non-cooperative game) theory:
  - Coalition behavior can be enforced (binding commitments)
  - Assume consensus decision making as in UNFCCC
  - Deviation causes break-down of a Grand Coalition and raises the bar for free-riding
  - An imputation is stable if no coalition can improve upon the agreement by rejecting it (“blocking coalition”).
  - Results optimistic (always grand coalition), no extensions exist

Adding international repercussions: A game changer?

- Original game by Chander and Tulkens (1997) assumes consumption C depends only on own abatement level:
  - Coalition with joint maximization $\max_{(E_i)_{i\in S}} \sum_{i\in S}[C_i(E_i) - D_i(E_N)]$
  - Outsiders adjust their own utility $\max_{E_j}[C_j(E_j) - D_j(E_N)] \quad \forall\, j \notin S$
- But there are other elements of abatement cost, e.g. fossil fuel reserves are valued less when *other* regions are engaging in abatement
- Modify the original game as follows:
  - $\max_{(E_i)_{i\in S}} \sum_{i\in S}[C_i(\boldsymbol{E}) - D_i(E_N)],\ C_i = C_i(E), \boldsymbol{E} = (E_1, \dots, E_n)$
  - $\max_{E_j}[C_j(\boldsymbol{E}) - D_j(E_N)] \quad \forall\, j \notin S$

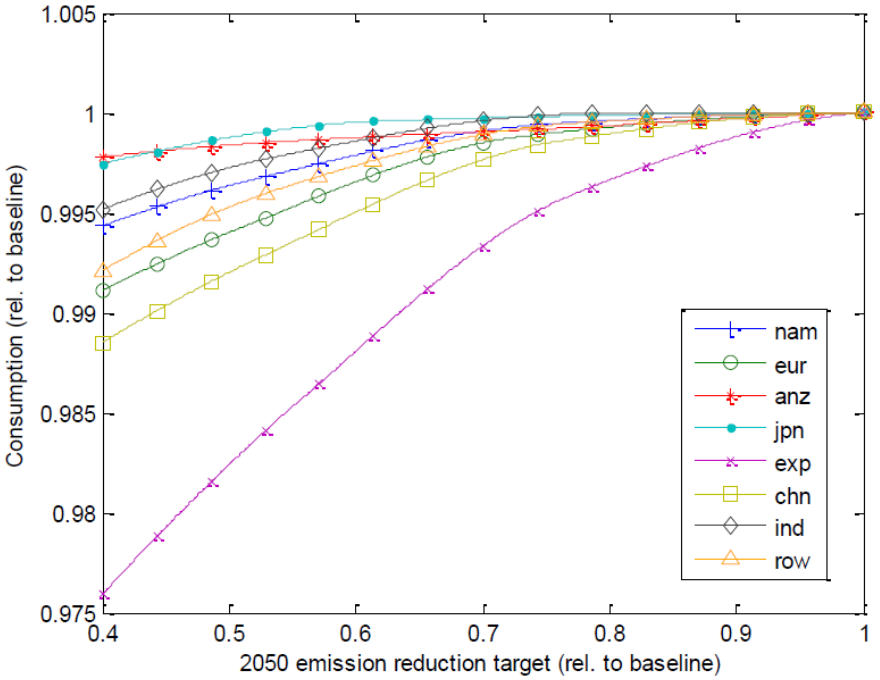
Numerical models

- Consumption (Cost) data from CGE model DART
- Damages data from RICE model for 8 regions
  - High vs low damages in RICE (2.0/0.2% at 2C)
- Cost of abatement includes specific functions for each possible coalition
  - 255 possible coalitions, different levels of abatement to fit coalition specific abatement cost curve
  - Many model runs…
- For each coalition, calculate equilibrium (level of abatement)
  - Simultaneous optimization of coalition and “outsiders”
  - Calculate value for “best partition” and grand coalition
    - No stable agreement exists when best partition is better than grand coalition

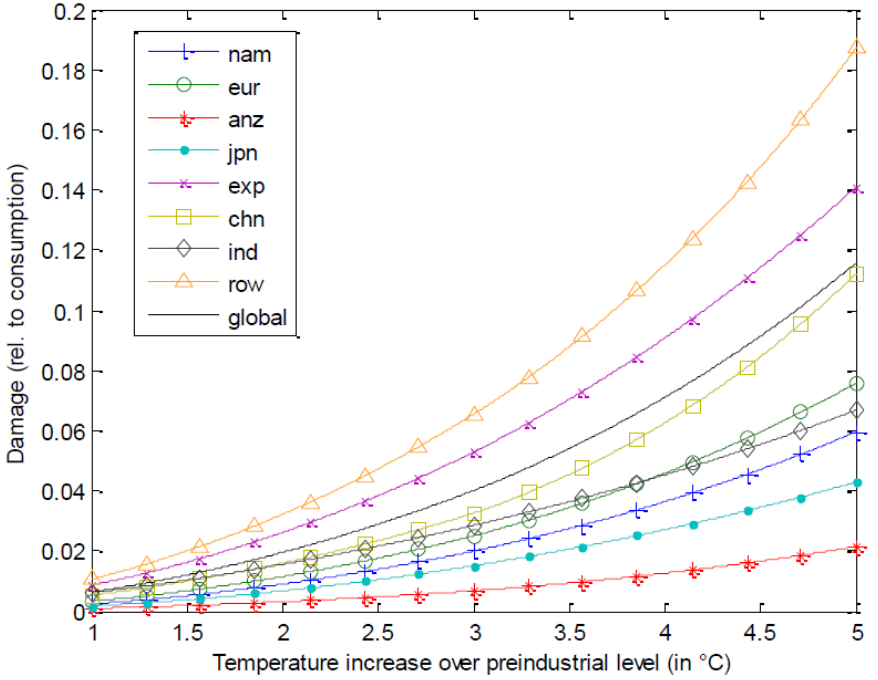
Cost and damages in numerical models

- Consumption loss based on single region abatement; high damage scenario

Consumption loss from mitigation

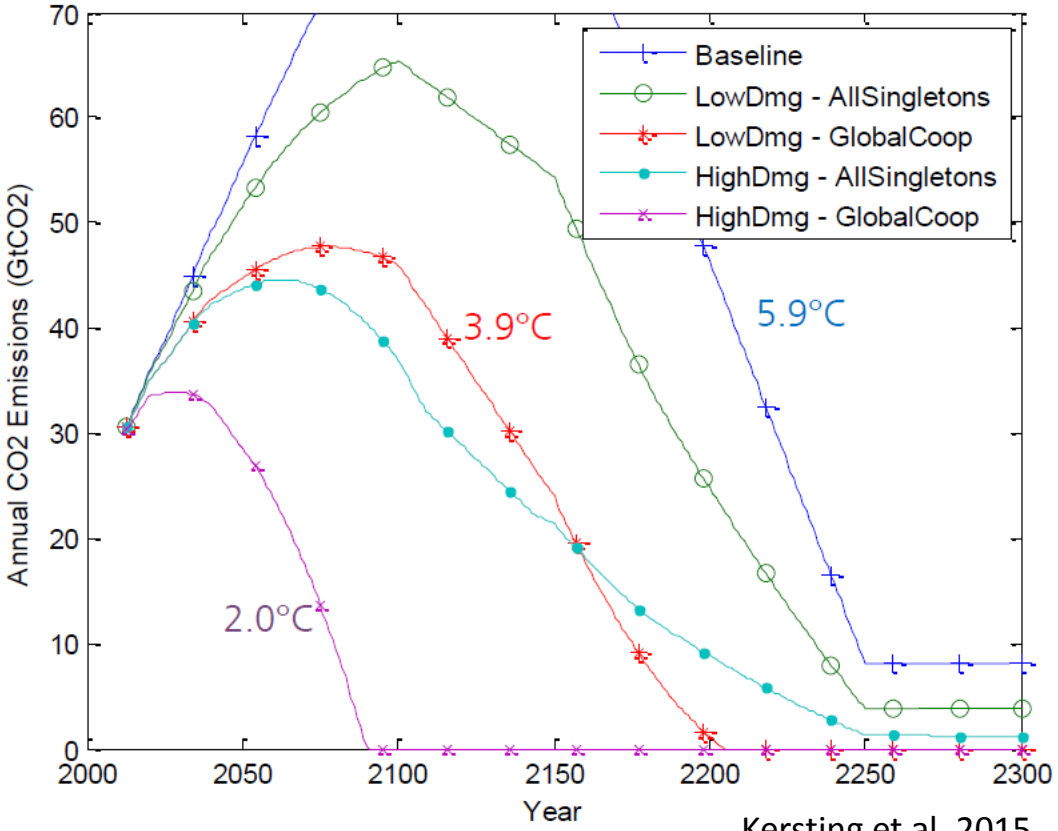


Damages from climate change



Kersting et al. 2015

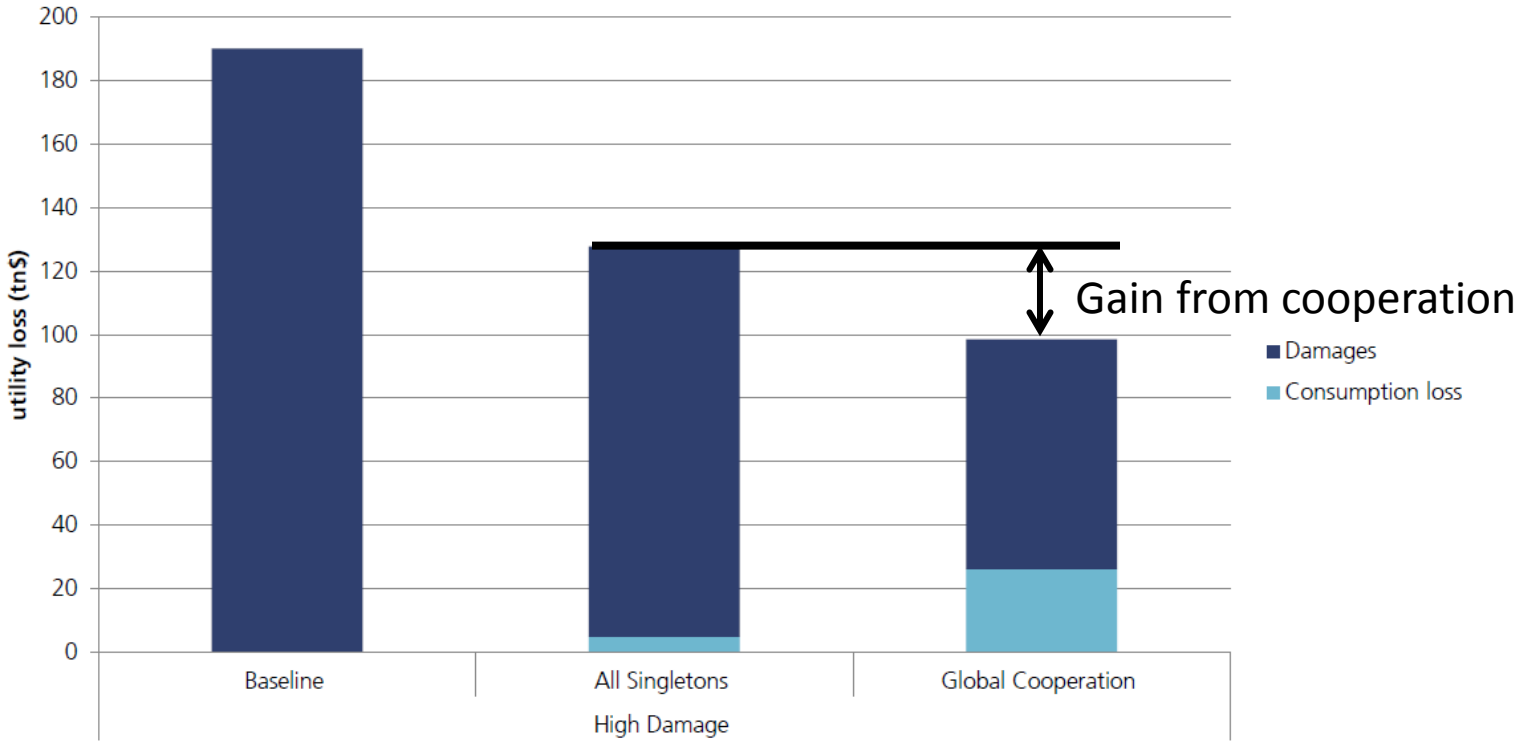
Results from numerical model Equilibrium CO_2 Emissions



Kersting et al. 2015

Results from numerical model Consumption loss

- Global cooperation is preferred outcome under high damage scenario



Kersting et al. 2015

Results from numerical model

- Coalition possible under high damages
- For low damages, there exists a blocking partition and thus no stable grand coalition agreement

		2050 emission target (rel. to baseline)	Utility loss (tn$2007)
Partition "Global Cooperation"		**80.26%**	**16.65**
Case "Global Cooperation"	N	80.26%	16.65
Partition "All except EUR, ANZ, EXP"		**82.05%**	**16.17**
Case "Partial Cooperation"	N \ {EUR, ANZ, EXP}	75.71%	12.62
Case "All Singletons"	{EUR}	100.00%	1.29
	{ANZ}	100.00%	0.03
	{EXP}	100.00%	2.24

- Fossil fuel exporters are blocking
  - Loss from reduced fossil fuel exports
  - ANZ also with low damages
  - EUR would not be a blocking region on its own, but would join EXP, ANZ when these are not abating

Results from numerical model

- Surplus from cooperation has to be divided to cover two cases simultaneously:
  - Case 1: “All Singletons“
    - Fossil fuel exporters (ANZ, EXP) suffer from drop in fossil fuel prices, if emissions are reduced globally -> prefer no cooperation
    - Due to unanimity requirement, they can block any global agreement, which does not compensate them adequately
    - Compensation would have to come from regions, which benefit from global emission reductions
  - Case 2: “Partial Cooperation”
    - Regions have alternative to form “coalition of the willing”
    - Global emissions are only slightly higher than in case of global cooperation
    - Additional benefit from move to global cooperation not enough to compensate fossil fuel exporters
- No global agreement for low damage case
- Our framework does not ensure stability of “coalition of the willing” because free-riding incentives arise

Possible ways forwards

- Compensating losers from mitigation
  - Politically infeasible high transfers if losses from lower fossil fuel prices are compensated for
- Climate clubs
  - Free riding incentives exist again
- Pledges, intermediate targets
- Focus on co-benefits
- Technology transfer