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THE INCENTIVES TO PARTICIPATE IN AND THE STABILITY OF CLIMATE COALITIONS

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Motivation

A successful international climate policy framework needs to bring the main greenhouse gas (GHG) emitting countries together into a “climate coalition” that delivers ambitious emission reductions

Broad-based country participation is required for any coalition to be environmentally effective

Wide coalitions may be harder to achieve, reflecting the increasing incentive to free-ride

Against this background, this paper provides a numerical analysis in the WITCH model game-theoretic setting of three main issues:

The identification of potentially effective coalitions (PECs)

The incentives for main emitting regions to participate in climate coalitions

The internal stability of such PECs

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The Game Theoretic Structure of WITCH

The scenarios produced using WITCH are the outcome of a game in which world regions interact in a setting of strategic interdependence (climate, exhaustible natural resources, technology)

Structure of a game:

The players: Who is involved?

Outcomes: For each possible set of actions by the players, what is the outcome of the game?

Payoffs: What are the players' preferences over the possible outcomes?

The rules: Who moves when? When do they know when they move? What can they do? What are the rules of participation? Are there enforcement mechanisms?

[Mas-Colell, Whinston and Green, 1995, p.219]

The Players - 1

World countries, aggregated into 12 regions

New Regional Aggregation:

- United States (USA)
- Western EU countries (WEURO)
- Eastern EU countries (EEURO)
- Japan and Korea (JPNKOR)
- Australia, Canada and New Zealand (AUCANZ)
- Non-EU Eastern European countries, including Russia (TE)
- Latin America, Mexico and Caribbean (LAM)
- Middle East and North Africa (MENA)
- South Asia, including India (SASIA)
- China, including Taiwan (CHINA)
- Sub−Saharan Africa and South Africa (SSA)
- South East Asia (EASIA)

The Players - 2

World countries can form coalitions to control externalities

When formed, coalitions become players of the game

Regions that do not join the coalition are said to behave as singletons or as free-riders

WITCH can simulate all degrees of cooperation:

- Decentralized, non-cooperative solution
- Coalitions that co-exist with free-riders
- Fully co-operative solution (technically, not a game)

Actions and Outcomes

The action of each player consists in choosing the path of investments in key economic variables governing the economy and the energy sector

The economies are modeled coherently with a Ramsey-type optimal growth framework

Investments in the energy sector and in research and development determine regional GHG emissions

Economic activity is affected by global mean temperature, which depends on global concentrations of GHG

The outcome of the game is a consumption path over the whole simulation horizon

Payoffs

Players express their preferences over the outcomes of the game using a utility function

In particular, players evaluate the discounted sum of log per capita consumption over the entire simulation horizon

Coalitions evaluate the weighted sum of discounted per capita consumption, with weights calibrated to equate marginal utilities across members (Negishi weights)

The Rules - 1

The WITCH model analysis assumes a…

- Non-cooperative
- Simultaneous
- Open membership
- Full information

…game that leads to a Nash equilibrium

It allows for the possibility of international transfers – but not issue linkage – to enlarge climate coalitions

In essence, the framework considers immediate, irreversible and self-enforcing participation to climate change mitigation action, and abstracts from other possible bargaining options

The Rules - 2

The model is solved as a one-shot meta-game:

- First Stage: countries decide on their participation and coalitions are formed
- Second Stage: countries choose their optimal emission levels internalizing only the environmental externality
- The game is solved backward

In the second stage, coalition members maximize aggregate joint welfare, whereas non participants behave as singletons and maximize individual welfare

The Rules - 3

Equilibrium is found employing the <u>γ **-characteristic**</u> function approach (Chander and Tulkens, 1997):

- In the <u>unique Nash</u> equilibrium coalition members jointly play their best response to non-coalition members, who adopt individually their best-reply strategies

The game exhibits <u>positive spillovers</u>. When a new member joins the coalition all countries outside the coalition are better off because they benefit from:

- A better environment
- Technology spillovers (knowledge is not a club good)
- Lower fossil fuel prices

Non-Cooperative Coalition Theory

In order to exist, coalitions must be both **profitable and stable**: (Carraro and Siniscalco, 1993, Barrett, 1994)

- A coalition is said to be **profitable** if signatory countries jointly have a higher welfare than in a scenario where the coalition is not formed

- A coalition is said to be **stable** if it is internally and externally stable

  - A coalition is **internally stable** if signatory countries do not have the incentive to defect and to behave non-cooperatively when other coalition members cooperate

  - A coalition is **externally stable** if there is no incentive to enlarge the coalition by including non-signatory countries

A coalition may be **potentially internally stable** if it can be turned into a stable coalition through a set of self-financed financial transfers across participating regions

Participation Incentives

Broad-based country participation is required for any coalition to be environmentally effective.

At the same time, wide coalitions may be harder to achieve, reflecting stronger incentive to free ride.

Drivers of individual incentives to participate in international climate coalitions include *inter alia:*

1. The expected impacts of climate change;
2. The influence of distant impacts on current policy decisions (*i.e.* the discount rate);
3. Abatement costs both within and outside the coalition;

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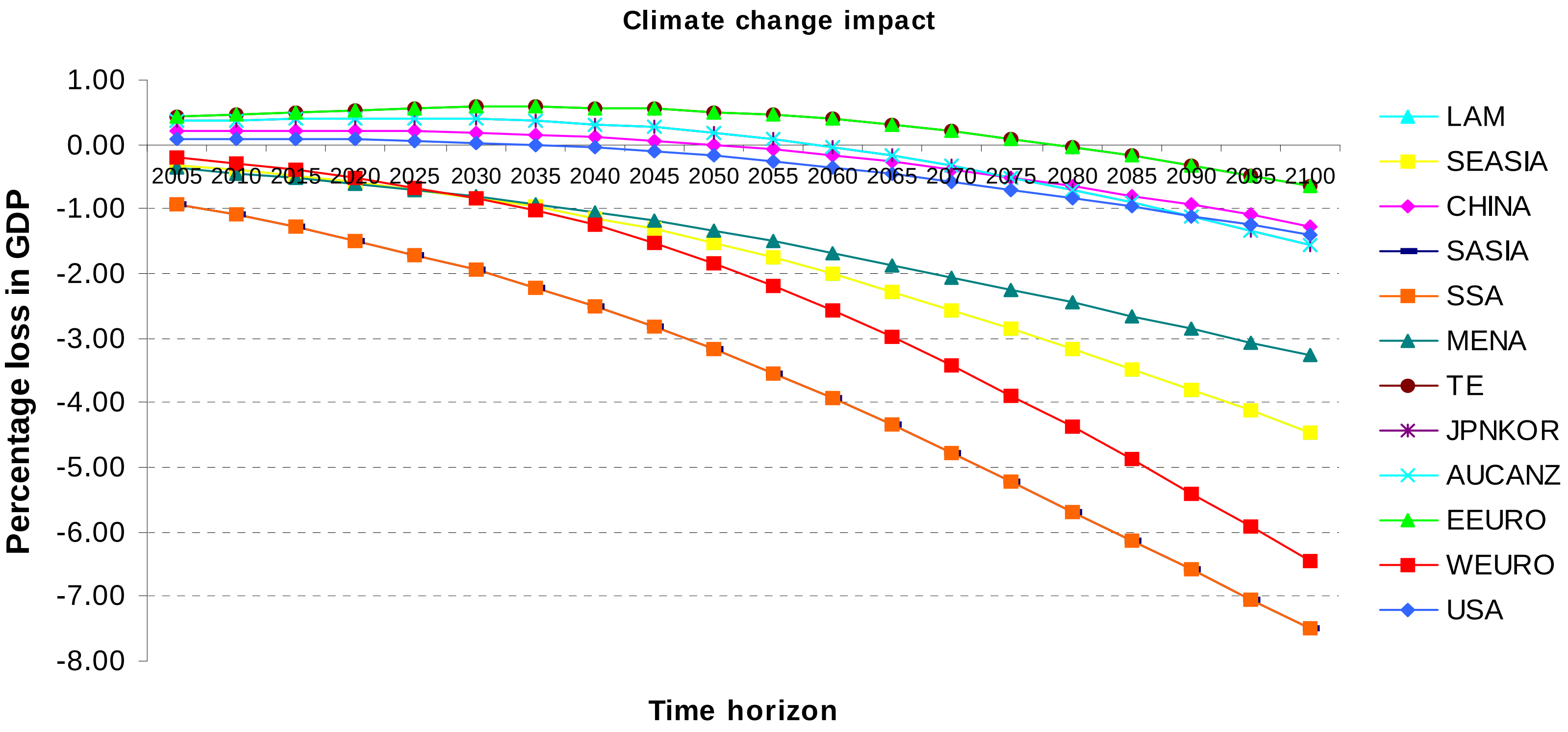
Climate change impacts in the WITCH model



The impacts of climate change are expected to vary widely across regions.

Developing countries would be more affected than their developed counterparts (Jamet et al. 2009)

Uncertainties are large, however, as reflected by the wide variance in damage estimates across studies

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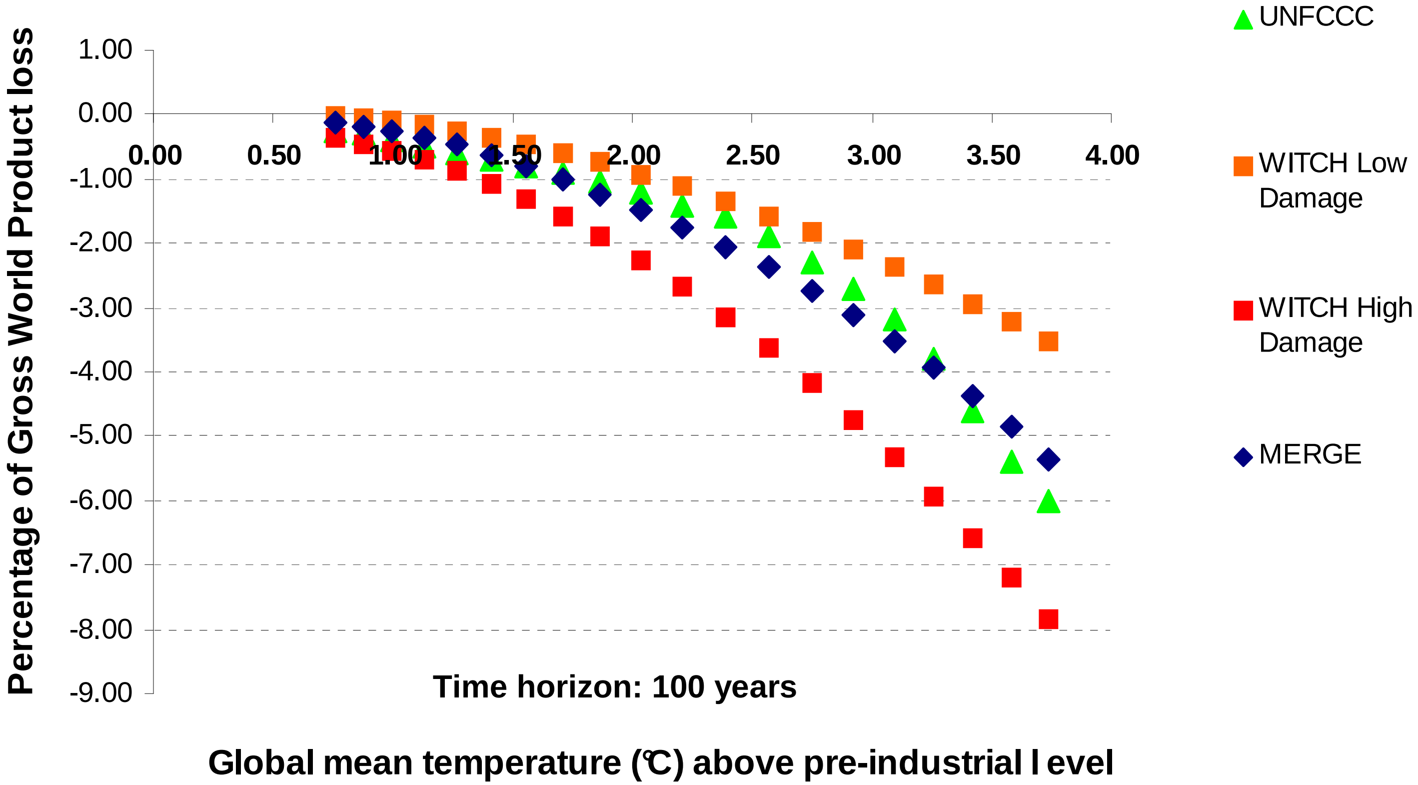
Climate change impacts: upper and lower bounds



A higher damage function reflecting upward revisions of recent estimates (UNFCCC, 2007; Stern et al. 2006) has been considered, so as to define an upper and lower bound around estimates available in the literature

Discount rate

In order to take into account the existing debate on the choice of the social discount rate, the analysis is performed here under two different assumptions regarding the pure rate of time preference, namely 3% and Stern's 0.1% assumption.

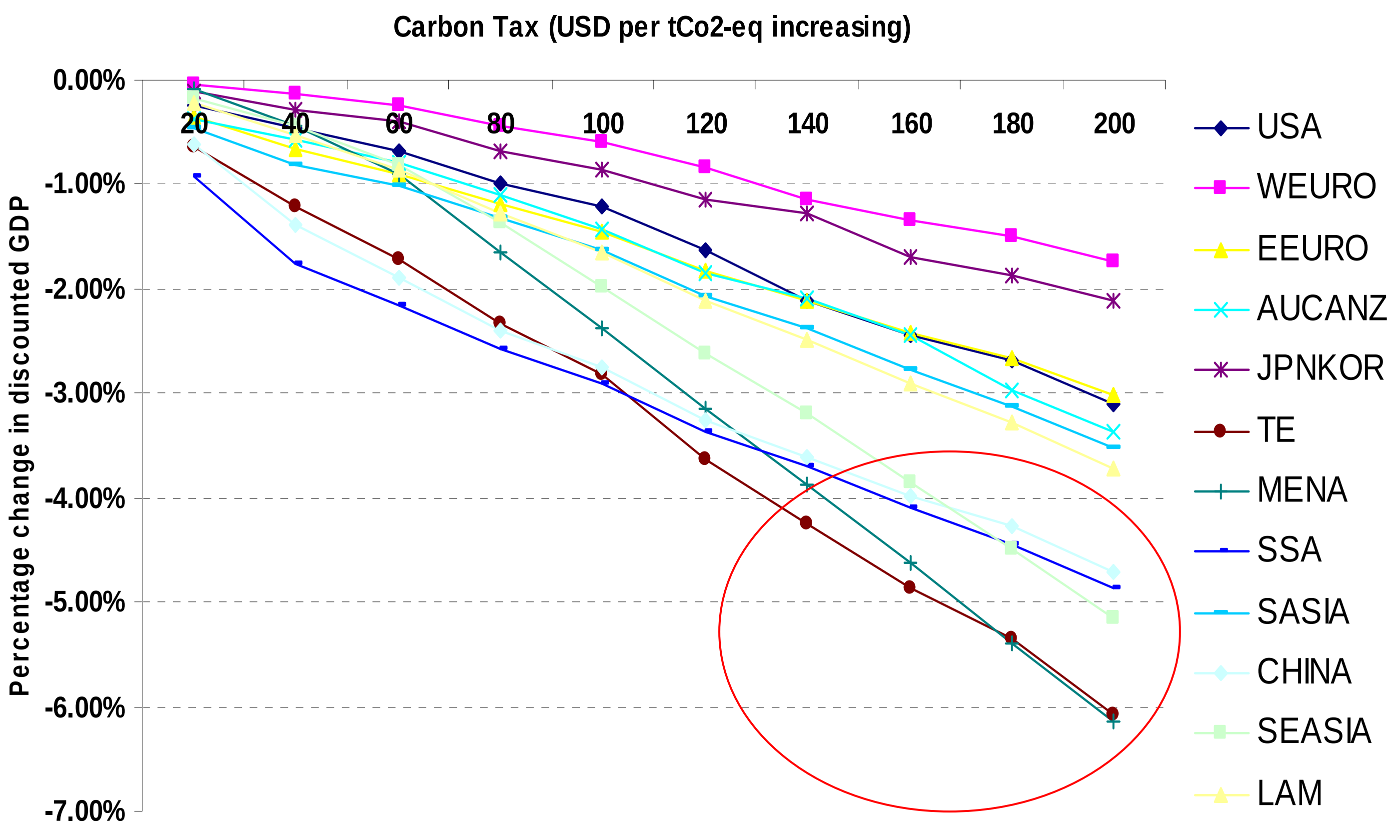
Pure rate of time preference (PRTP)	ρ= *3% declining (HDR)*	ρ= *0.1% declining (LDR)*

In order to account for uncertainty regarding both damages and inter-temporal preferences, the analysis of climate coalition will consider four cases:

1. Low damage - high discount rate (3%) *LDAM_HDR*
2. Low damage - low discount rate (0.1%) *LDAM_LDR*
3. High damage - high discount rate (3%) *HDAM_HDR*
4. High damage - low discount rate (0.1%) *HDAM_LDR*

Abatement costs

The costs of mitigation policies are also expected to vary widely across regions and to affect participation incentive



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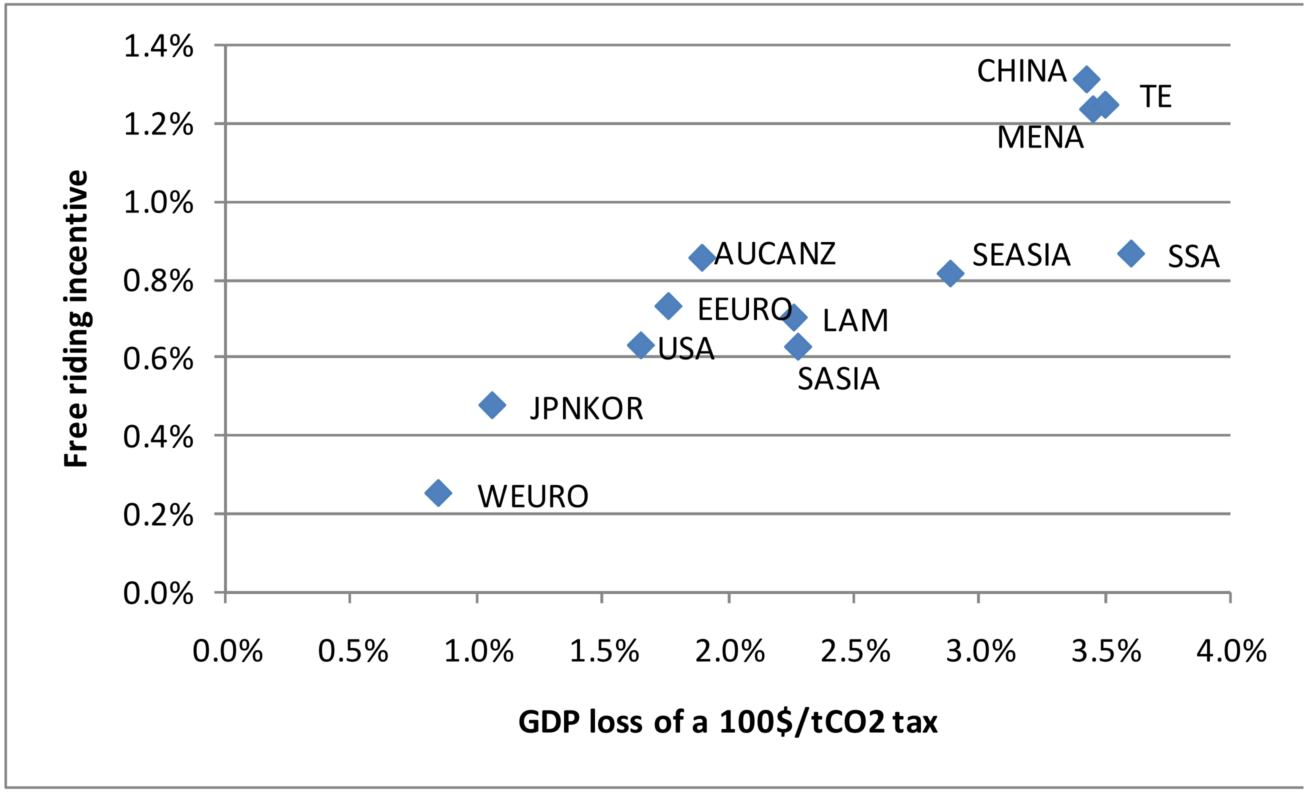
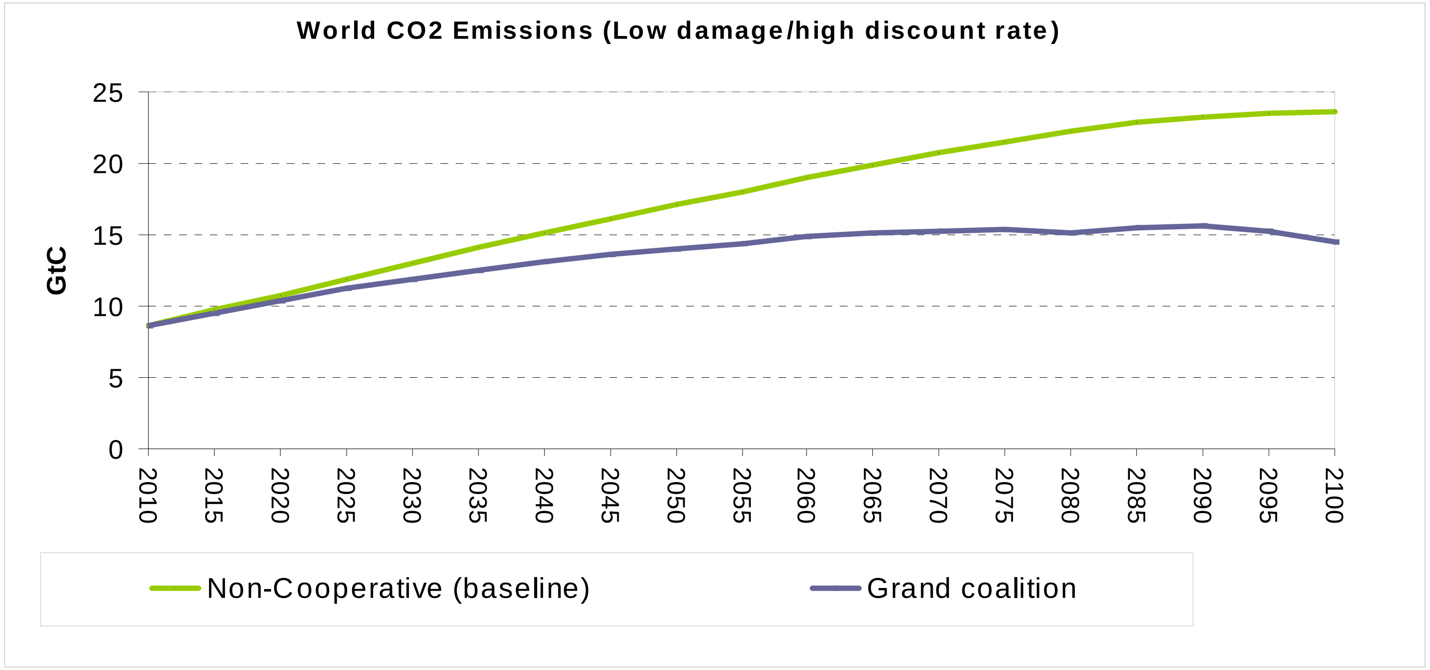
Abatement costs and free riding incentive



The larger a region's mitigation costs under a global carbon tax, the smaller its incentives to participate in a climate coalition, *ceteris paribus*.

Fully cooperative versus non-cooperative outcomes



A natural first step towards analysing coalition formation and stability is to determine the **optimal abatement policy** that would be implemented by a "**grand coalition**" of world regions that fully internalises the environmental externality due to GHG emissions

A second step, is to assess the sensitivity to damages and discounting

In both the non-cooperative and cooperative cases, the optimal emission path depends on the **damage** and **discount rate** assumptions.

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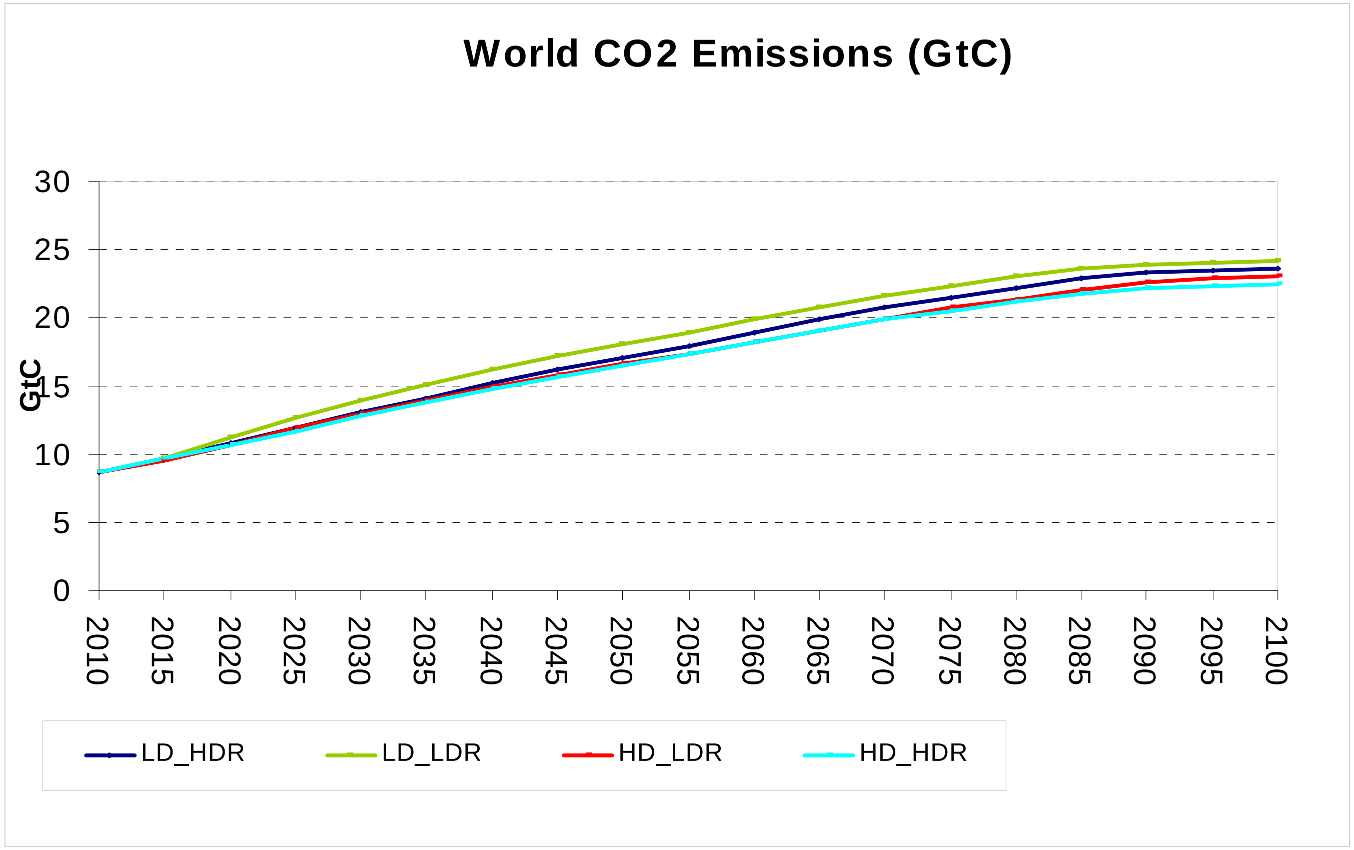
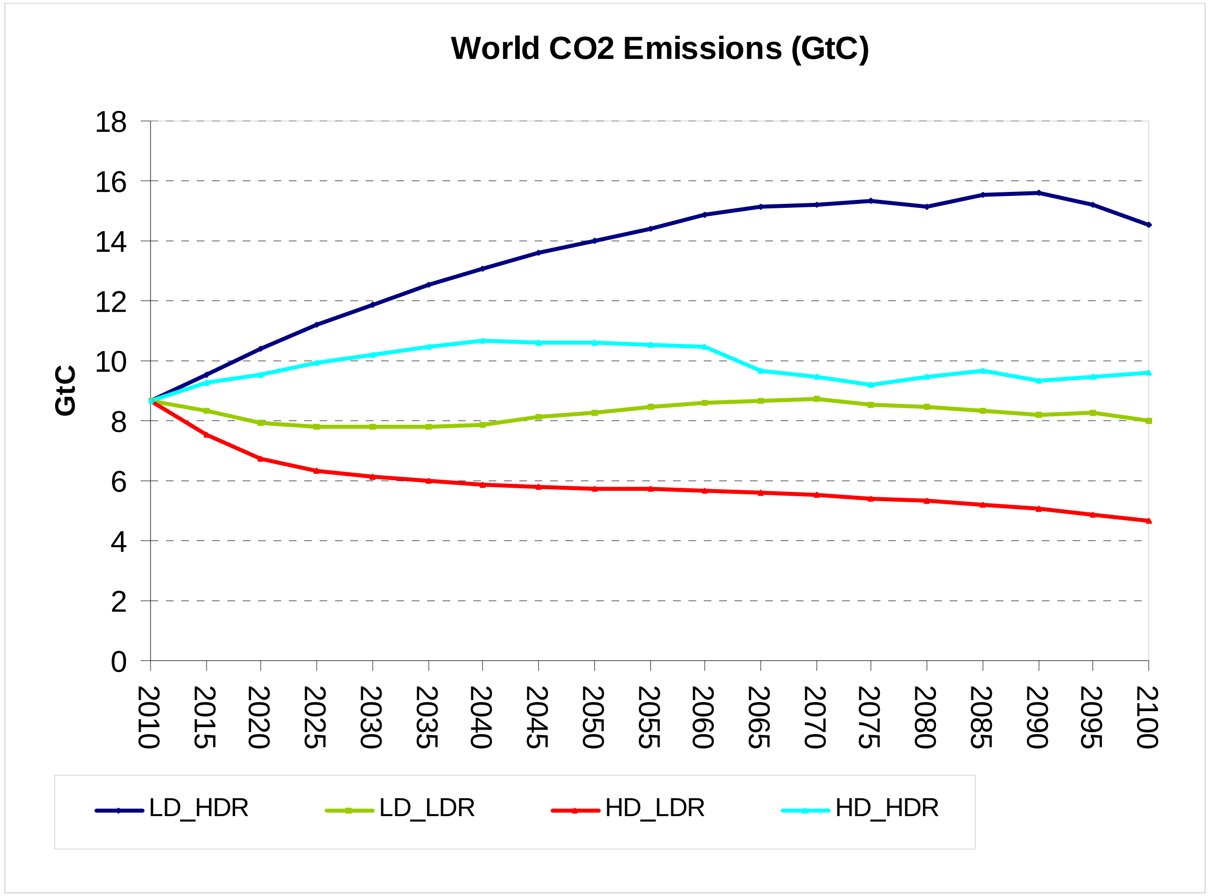
Non cooperative outcomes



The non-cooperative solution is also defined as the "**baseline**" because it best represents the nature of present international relations, far from being fully cooperative. Little variations are observed in a non-cooperative setting, reflecting the inability of individual regions to internalise the environmental externality

Cooperative outcomes



Sensitivity to these assumptions is far greater in the **cooperative case.** Damage and especially discount rate drive emissions down.

Summary

- In a non-cooperative world, externalities dominate and equilibrium emissions are not very sensitive to different assumptions on damages and discount rates.

- In a cooperative world, the internalization of the externality through the climate damage component provides enough incentive to moderate pollution. In particular, the HDAM-LD case leads to stabilization of emissions and concentrations in line with a 550 ppm CO_2 eq target.

Potentially effective coalitions: definition

Among the 4095 coalitions that are possible with 12 regions, only a subset is politically meaningful AND has the potential to stabilize GHG concentrations at a chosen target, in the present context, 550 ppm CO2eq

A coalition is defined as a Potentially Effective Coalition (PEC) if it could technically achieve a given world concentration target by bringing down its own emissions to zero whereas non-participating regions remain at their BAU levels.

Being a PEC is a necessary (but not sufficient) condition for the 550 ppm CO2eq target to be attainable (there are free riding incentives for singletons and technical unfeasibility of zero emissions for coalition members).

Definition of the target: three different metrics

2050 TARGET CO2 emission reduction in 2050 w.r.t. 2005	2100 TARGET CO2 emission reduction in 2100 w.r.t. 2005	Radiative Forcing in 2100 (W/m2)	Concentrations in 2100 (co2-eq. ppm)
-25 %	-50 %	3.7	550

The two targets together define environmentally effectiveness

They ensure with a sufficiently high probability the stabilization of radiative forcing at 3.7 W/m2

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PECs: methodology

We defined two groups of PECs: a **first group** achieving only **the 2050 target** and a **second group** achieving both the **2050 AND the 2100 targets**.

For each of the **four baseline scenarios** (High and Low Damage, High and Low Discount Rate), we considered the **minimum profile of global emissions** (as previously defined) for all coalitions (and related singletons) and computed the emission reductions that can be achieved both in 2050 and 2100.

We considered the union of PECs in the 4 different scenarios. We identified 36 PECs (i.e. achieve the required reduction in 2050) among which only 7 match the 2100 target as well.

Only 4 out of six politically important coalitions are PECs (i.e. can achieve the 2050 target). None of them can achieve the 2100 target except for the Grand Coalition.

Politically important coalitions

i) **Grand coalition (2100)**
ii) **Industrialised countries + China + India + Russia + Latin America (2050)**
iii) **Industrialised countries + China + India + Russia (2050)**
iv) **Industrialised countries + China + India (2050)**
v) Industrialised countries + China;
vi) Industrialised countries only;

Main Insights from PECs analysis

- If big emitters do not join the coalition, then the 2050 and 2100 targets cannot be achieved even under the extreme assumption of zero or negative emissions for coalition's members.
- A coalition consisting of industrialised countries only cannot, even potentially, meet the target at the 2050 horizon.
- The participation of both China AND India is needed to attain the 2100 target.
- When the goal is GHG stabilization in 2100, PECs are subsets of the 12 regions in which at most three regions are not included.
- Generally, only SSA or SSA plus another region (LAM, TE, MENA, SEASIA) can be singletons.

Cost-benefit analysis (CBA) of PECs

CBA analysis will illustrate how PECs underestimates the actual emission levels of both cooperating regions and singletons =>international coalitions will have to be larger than PECs in practice

Evaluate 36 PECs in a cost-benefit framework to check whether they actually attain the required environmental goal.

36 PECs:

- **7 coalitions that are PECs in 2050 and 2100**
- **3 politically important coalitions that are PECs in 2050 only**
- 26 other coalitions that are PECs in 2050 only

What does each coalition actually achieve in terms of emission reduction? How far from the stabilization goal is the equilibrium solution equalizing marginal costs and benefits?

We start the analysis from the high damage and low discount rate (HDAM_LDR) case, the most favourable to coalition formation

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CBA: Environmental effectiveness

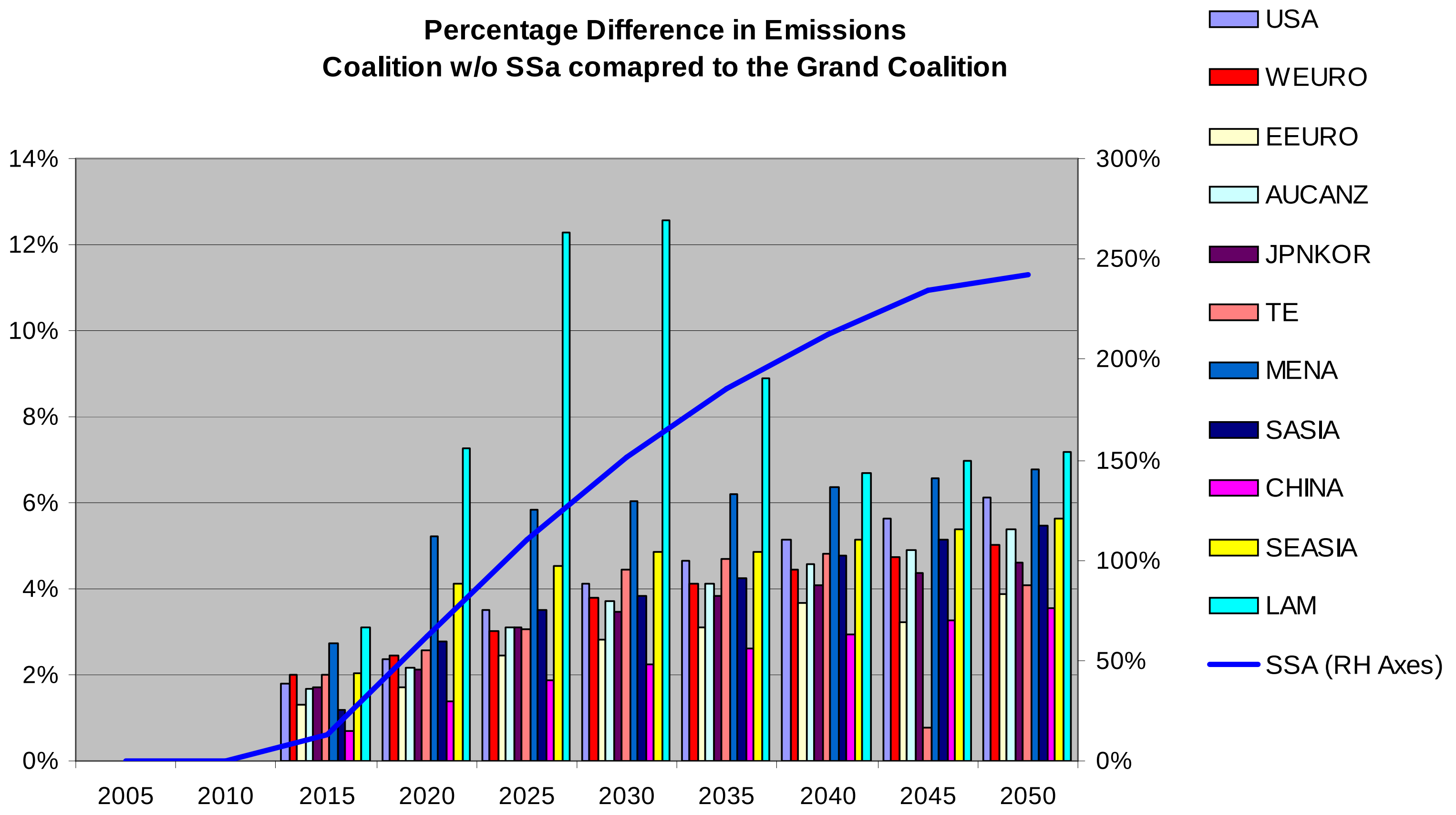
	Emissions		Radiative Forcing (W/m2)		Concentrations (ppm)	
	2050 wrt 2005	2100 wrt 2005	2050	2100	2050	2100
Grand Coalition (GC)	**-25.9**	**-39.9**	**3.21**	**3.61**	**507**	**546**
GC_SSA	**-15.5**	**-23.0**	**3.33**	**3.93**	**518**	**603**
GC_SSA_LAM	-4.1	1.3	3.47	4.22	532	612
GC_SSA_TE	-4.0	1.2	3.46	4.14	531	603
GC_SSA_MENA	-4.5	1.4	3.44	4.20	529	609
GC_SSA_SEASIA	-8.3	1.3	3.41	4.09	526	598
GC_SSA_SEASIA_TE	3.9	1.6	3.44	4.14	529	603
GC_SSA_SEASIA_MENA	**3.3**	**1.7**	**3.52**	**4.36**	**537**	**628**
GC_SSA_SEASIA_MENA_LAM	**11.5**	**2.0**	**3.64**	**4.61**	**549**	**659**
GC_SSA_SEASIA_MENA_LAM_TE	**17.5**	**2.1**	**3.67**	**4.66**	**552**	**665**

Ambitious mitigation action is economically rational at the world level in the high-damage/low-discounting case

CBA: What Drives Coalition's Emissions?

- The major incentive from reducing emissions comes from the size of climate damage for coalition's members
- The composition of damages within the coalition determines the benefit from emission reductions and thus the degree of emission reductions
- For example, when we consider the coalition composed by all countries but SSA (GC_SSA) and consider the difference in emissions w.r.t. the grand coalition, two forces are at play
  1. Countries in the coalition emit more because they do not internalize the high negative impact of climate change on SSA (damage effect).
  2. As expected SSA emits more (free riding effect), BUT less than in the non cooperative baseline (technological spillovers).

CBA: Free riding – the case of SSA



CBA: Profitability and Stability for the PECs

High Damage – Low Discount Rate	EFFECTIVE	PROFITABLE	STABLE	PIS
Grand Coalition (GC)	√	√		
GC_SSA		√		
GC_SSA_LAM		√		
GC_SSA_TE		√		
GC_SSA_MENA		√		
GC_SSA_SEASIA		√		
GC_SSA_SEASIA_TE		√		
GC_SSA_SEASIA_MENA		√		
GC_SSA_SEASIA_MENA_LAM		√		
GC_SSA_SEASIA_MENA_LAM_TE		√		

PROFITABILITY: environmental cooperation internalizes externalities and thereby increases collective welfare.

STABILITY: the overall welfare gain from the coalition relative to the non cooperative outcome is not large enough to find a set of transfers that would give each country/region its free-riding pay off. Having compensated all losers in the coalition to achieve profitability, the remaining surplus is too small to offset free riding incentives.

To stabilize the grand coalition, OECD countries would have to give up 3% of their GDP

Conclusions

- Ambitious mitigation action is economically rational at the world level in the high-damage/low-discounting case
- “Buying-in” all emitting regions will be challenging. While profitable to its member countries as a whole, the grand coalition is not found to be stable: coalition surplus is not sufficiently large to provide all free riders the incentive to join the coalition
- This is in line with previous literature, which finds international climate coalitions to be unstable or, when stable, to deliver only limited emission cuts
- These findings are subject to a number of limitations, however. One important caveat is that the co-benefits from mitigation action, e.g. in terms of human health, energy security or biodiversity, are not taken into account. A second limitation is the focus on immediate, self-enforcing and irreversible participation to the coalition

Thank you!

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