Is it possible to attain large stable IEAs: Insights from other sources of interdependencies

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IEAS – Bridging the Gap
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Motivation

- Climate Change and Global Warming
  - **Reality** or **Hoax**

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IEAs Prospect - Experience

- Urge for a collective action
- Failure of past attempts
- The Paris Agreement?
- Entered into force on November 4, 2016
  - U.S. withdrew on June 1, 2017, representing 17% of global emissions.
    - Because of "the draconian financial and economic burdens the agreement imposes on our country"

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Cont'd

- The E.P.A. proposals in 2018:
  - July- weakening a rule on carbon dioxide pollution from vehicle tailpipes.
  - August- replacing the rule on carbon dioxide pollution from coal-fired power plants with a weaker one.
  - Sept- Make it easier to release methane into air.

IEAs Prospect - Theory

- Game Theory
- Selfenforcing and stable
- Barrett (1994), Diamantoudi and Sartzetakis (2006), Finus (2003) and (2008)....

More Optimistic Cases

- Improvement in design:
  - Transfers: e.g. Carraro and Siniscalco (1993)
  - Ratification threshold (a minimum clause): e.g. Rubio and Casino (2005), Courtois and Haeringer (2005), Carraro et al. (2009)
  - Open versus Exclusive Membership - Single versus Multiple Coalitions: e.g. Finus (2003 and 2008)
- Other routes:
  - Barrett (2013) and (2016): If the threshold that triggers climate catastrophe is known with certainty, and the benefits of avoiding catastrophe are high relative to the costs
  - Experiments and Tipping points (e.g. Barrett and Geoff Heal)
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More Optimistic Cases, Cont'd

- Masoudi and Zaccour (2018): Adaptation and international environmental agreements
- Masoudi and Zaccour (2017): Adapting to climate change: Is cooperation good for the environment?
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- **IEAs and two layers of interdependence among countries**

Evolving (Perceived) Environmental Cost

- 'As incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment' (World Bank, 1992: 39).

- Standard Two-Player Differential Game
- Developing countries need a period of time [0, T] to accomplish a desired level of development. Or equivalently needs to achieve $\bar{Y}_2$ the threshold value of cumulative revenues before fully accounting for the environmental damage

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Evolving environmental cost, Cont'd

- The "perceived" damage-cost function of the developing country (player 2)

$$D_2(S(t), Y_2(t)) = \begin{cases} d_2(S(t), Y_2(t)), & \forall Y_2(t) < \bar{Y}_2, \\ D_2(S(t)) & \forall Y_2(t) \geq \bar{Y}_2, \end{cases}$$

- $S(t)$: Pollution stock at time t, $Y_2(t)$: Cumulative income of Developing country at time t.

Model

- Damage

$$D_1(S) = \beta_1 S, \tag{1}$$

$$D_2(S(t), Y_2(t)) = \begin{cases} \frac{t}{T}\gamma\beta_2 S, & \forall Y_2(t) < \bar{Y}_2, \\ \beta_2 S & \forall Y_2(t) \geq \bar{Y}_2. \end{cases} \tag{2}$$

- $\gamma \in \{0, 1\}$. A value $\gamma = 0$ means that player 2 completely ignores the environmental damage before reaching T.

Results

Cooperative (C) vs. non-cooperative (N) solutions

- **Claim**

  - $T^N < T^C$.
  - *- Global welfare could be higher if developing countries are given time to achieve* $\bar{Y}_2$.

Policy Recommendation

Asking developing countries to take environmental cost into account sooner is not necessarily the best course of action.

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Income interdependence

IEAs and two layers of interdependence among countries

Income interdependence

- Two projects:
  1. Interdependencies over income generation.
  2. Competition over resources and IEA

Model

M-player static game, players (countries), indexed by $i = 1, ..., M$
R_i: Revenue - e_i: emission

$$R_i(e_i) = e_i\left(\alpha - \frac{1}{2}e_i - \gamma\sum_{j\neq i} e_j\right)$$

$\mathscr{E} = \sum_{i=1}^{M} e_i$.
Environmental Damage

$$D_i(\mathscr{E}) = \beta(\mathscr{E})$$

Interpretation of γ

$$R_i(e_i) = e_i\left(\alpha - \frac{1}{2}e_i - \gamma\sum_{j\neq i} e_j\right)$$

$$\gamma\begin{cases} > 0 & \text{substitutes} \\ = 0 & \text{none} \\ < 0 & \text{complements} \end{cases}$$

A two-stage game

- Stage I - Membership.
- Stage II - Emission (production) choice

Stage II

- Assumptions
  - S countries cooperated (signed the treaty) during stage I, $N = M - S$ didn't.
  - Cournot non-cooperative game: non-signatories act as singleton, signatories maximize their joint welfare.

IEA

W^S the joint welfare of signatory countries, and by W_j^N the welfare of a non-signatory, the optimization problems are as follows:

$$\max_{e_i^S} W^S = \sum_{i \in C} W_i^S = \sum_{i \in C} \left(R(e_i) - D_i(\mathscr{E}) \right), \tag{3}$$

$$\max_{e_j^N} W_j^N = R(e_j) - D_i(\mathscr{E}), \quad j \notin C, \tag{4}$$

Solution

- Under symmetry assumption

$$e^N = \frac{\alpha - \beta + \gamma\left(\alpha\left(S-2\right) + \beta\left(2 - 2S + S^2\right)\right)}{\left(2\gamma(S-1)+1\right)\left(\gamma(N-1)+1\right) - \gamma^2 SN}$$

$$e^S = \frac{\alpha - S\beta - \gamma N e^{NS}}{\left(1 + 2\gamma(S-1)\right)}$$

Stage I - Membership game

Membership

- Open-membership: **stability check**
- Exclusive-membership: **optimal size of the treaty**

Stability of IEA

- D'Aspremont et. al (1983)

$$\text{Internal stability} \quad : \quad W_i^S(S;\mathscr{E}) \geq W_i^N(S-1;\mathscr{E}), \tag{5}$$

$$\text{External stability} \quad : \quad W_i^S(S+1;\mathscr{E}) \leq W_i^N(S;\mathscr{E}). \tag{6}$$

Numerical Illustrations

- Model parameters: M, α, β and γ.
- The most interesting parameter here is γ.

Stability of IEA

$M = 50,\ \beta = 0.015$

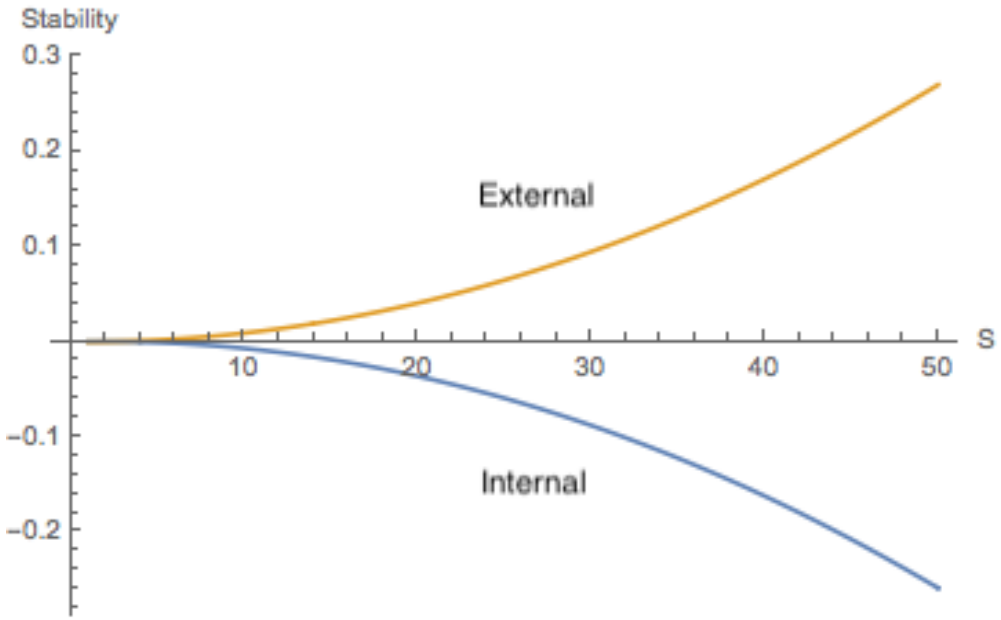

Figure: $\gamma = 0$

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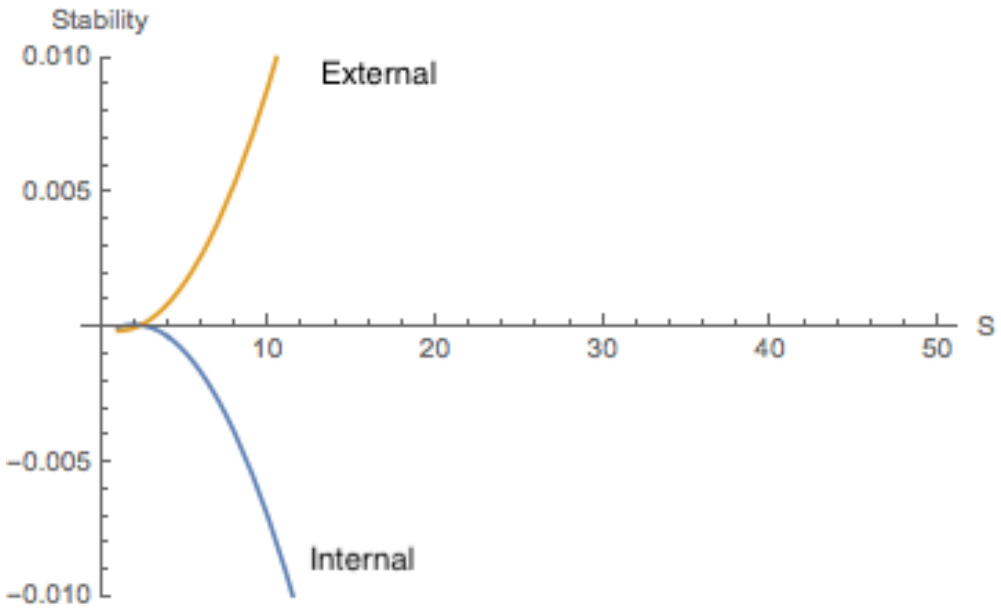

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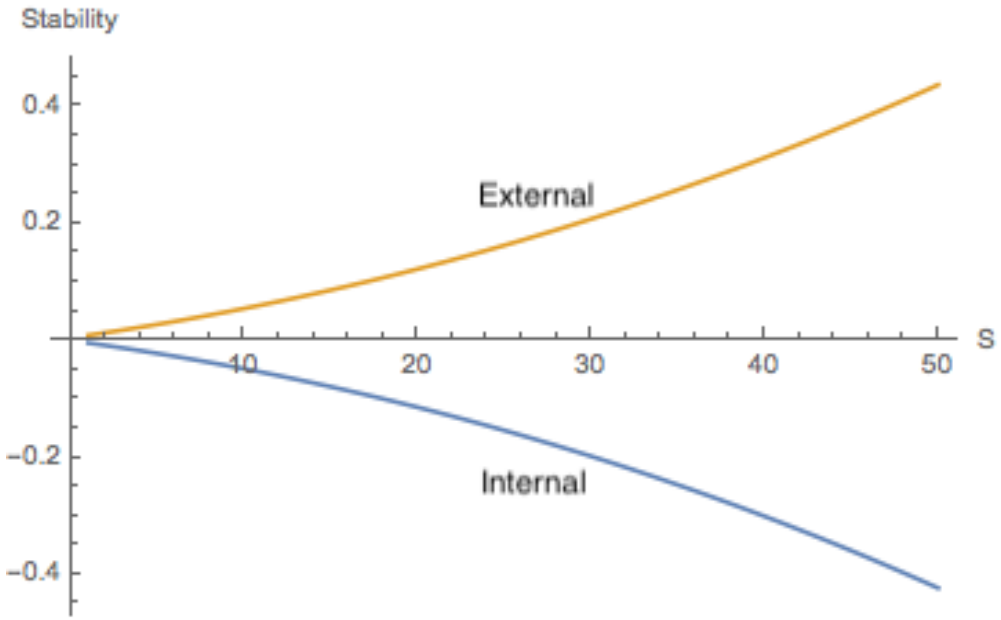

Figure: $\gamma < 0$

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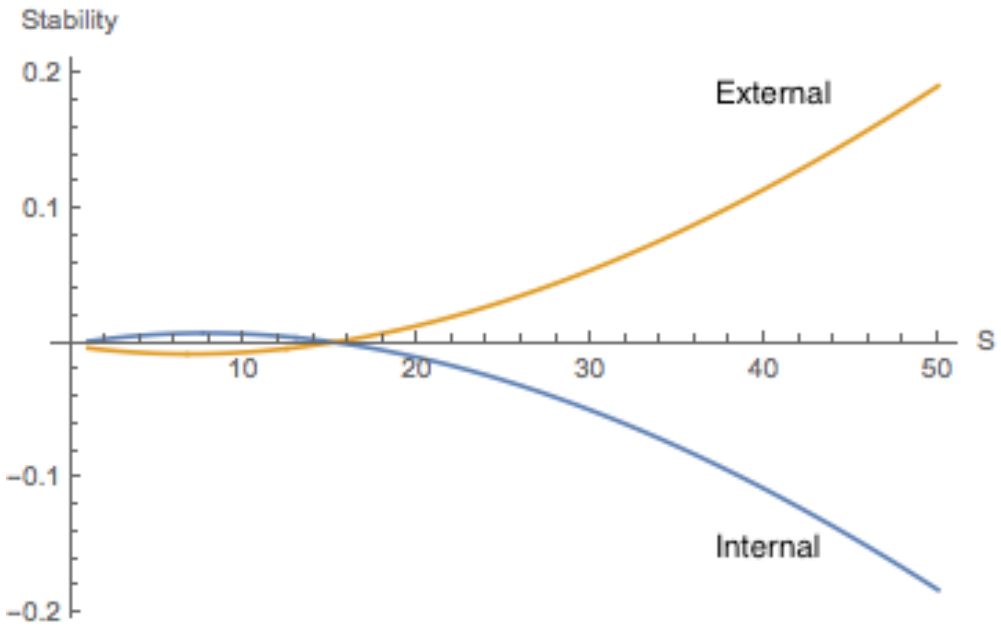

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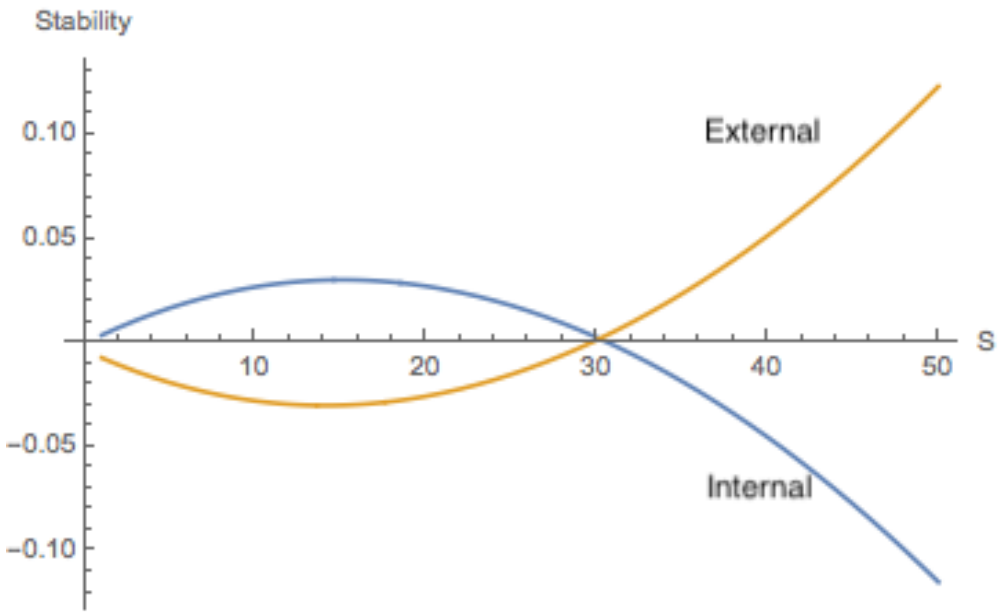

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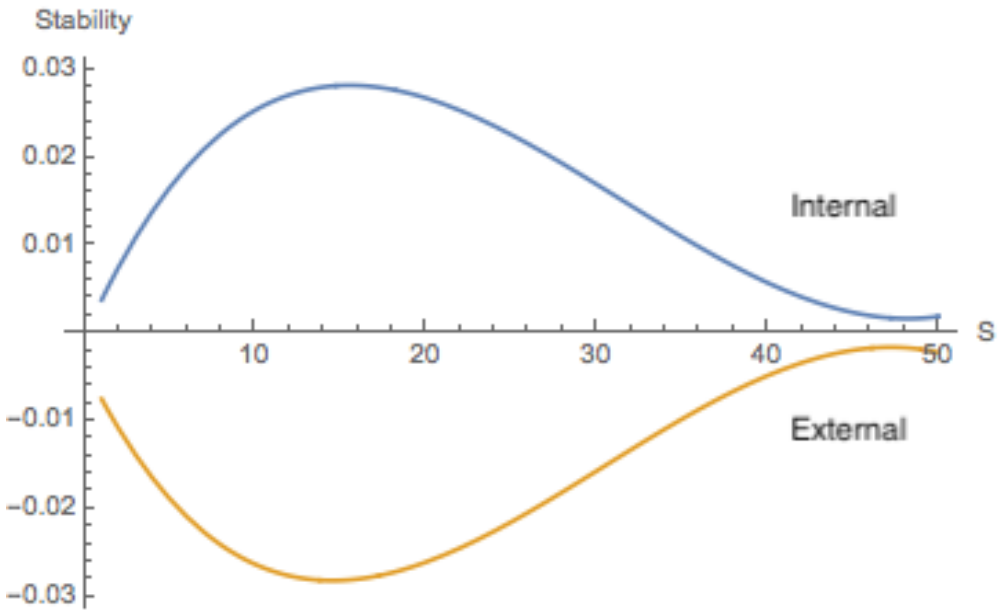


Figure: $\gamma > 0$

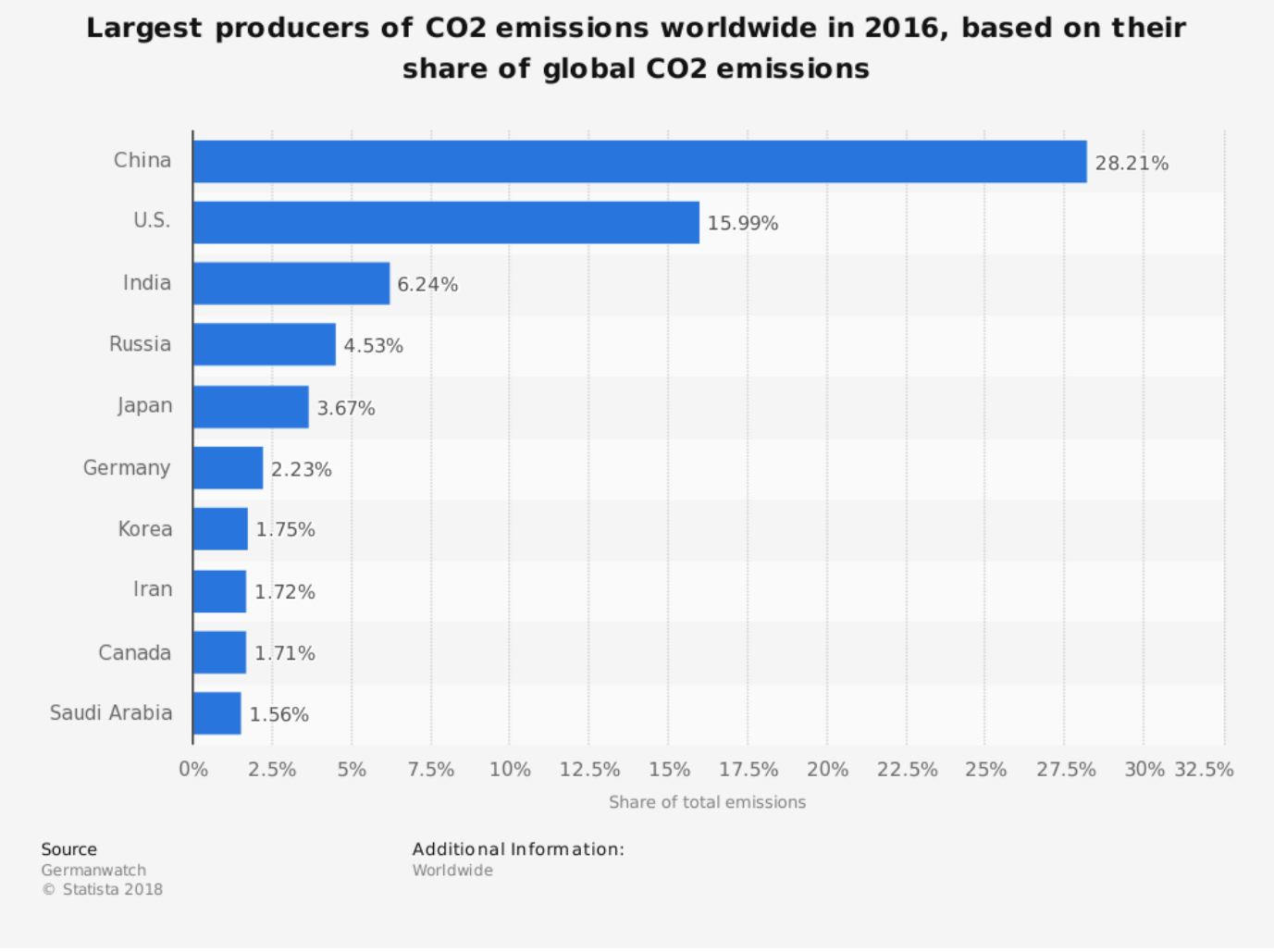
Outlook

- Heterogeneity is a fundamental fact

$$R_i(e_i) = e_i\left(\alpha - \frac{1}{2}e_i - \gamma_i \sum_{j \neq i} e_j\right)$$

- Introducing two groups

Co2 emission



Concluding remarks

- Understanding and embedding other sources of interdependencies in the discussion of IEAs is crucial.
- In many cases these could reduce the free riding incentives and make countries more willing to cooperate.

Thanks for Your Attention