Strategic Incentives for Early Movers in Sequential Climate Games

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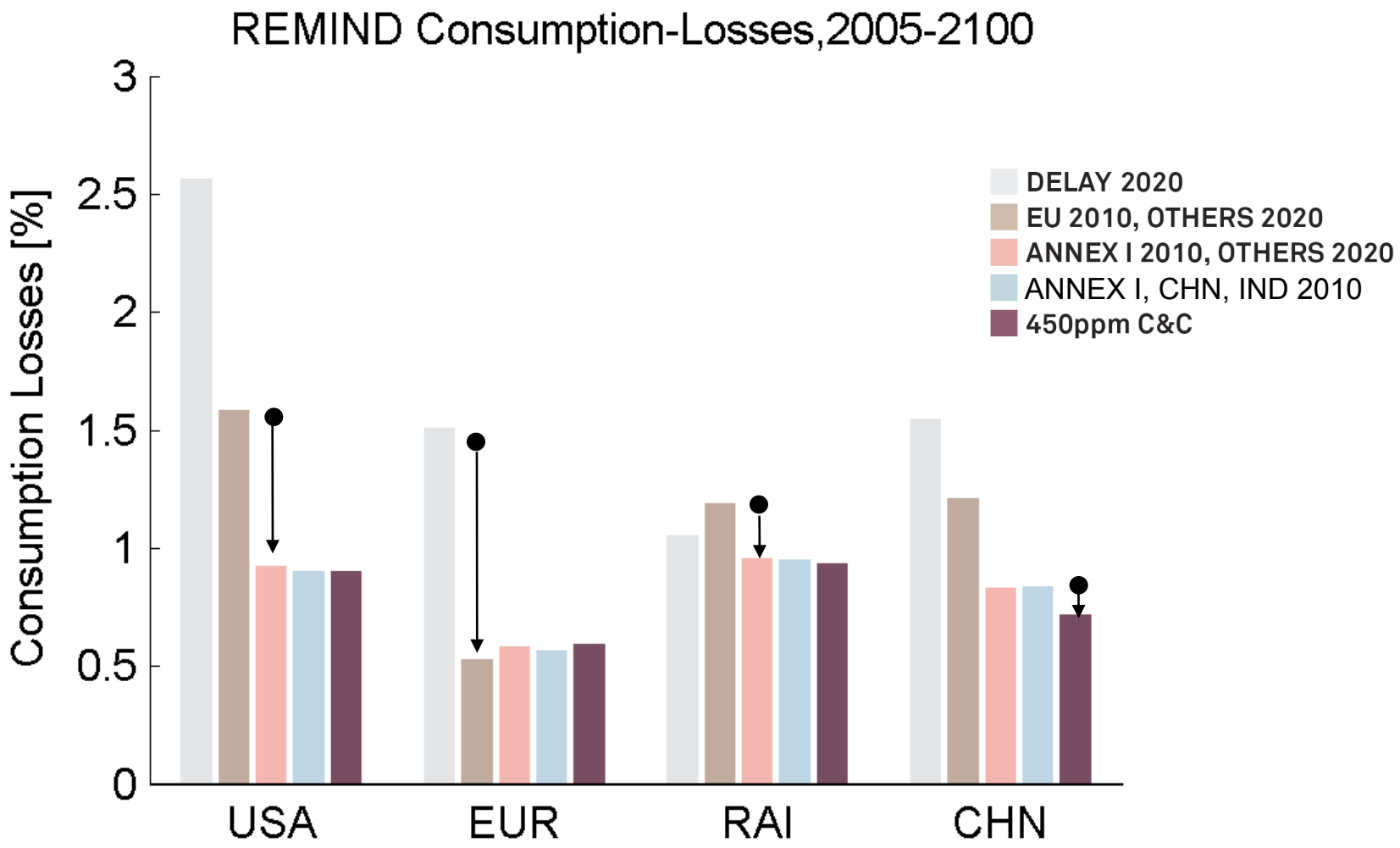
Motivation: The Value of Early Action



(Jakob et al., 2012)

Strategic Implications of Early Action

- Free-riding (e.g. Carraro and Siniscalco, 1993; Barrett, 1994)
- Improve future bargaining position by raising mitigation costs (e.g. Beccherle and Tirole, 2009; Harstad 2010)
- However, EU acts as an early mover in climate negotiations
- On the domestic level, people engage in voluntary abatement (e.g. green power)
- ⇒ Is this irrational in the strict economic sense?
- ⇒ Need to analyze strategic incentives for early movers

Model Framework

- Stackelberg setting to analyze leader-follower dynamic
- Follower makes his move, taking the leader‘s choice as given
- Leader makes choice taking into account follower‘s reaction
- International setting
  - R&D spillovers
  - LbD spillovers
  - Reduced uncertainty
- Domestic setting: green groups trying to influence regulator

International Context: R&D Spillovers

R&D Spillovers: setup

Two countries: leader (*l*) and follower (*f*) with initial wealth I^i

Utility: $u^i(c^i, \sum_i e^i), u^i_c > 0; u^i_e > 0; u^i_{cc} < 0; u^i_{ee} < 0; u^i_{ce} > 0$

Abatement costs: $\Theta^i = \Theta^i(e^i, t); \Theta^i_e > 0; \Theta^i_{ee} > 0; \Theta^i_t < 0; \Theta^i_{et} < 0$

Budget Constraint: $I^i = c^i + \Theta^i$

Leader can provide technology *t*: $\vartheta_t > 0$

R&D Spillovers: follower

Follower‘s maximization problem:

$$\max_{e^f, c^f} u^f(c^f, e^l + e^f) \text{ s.t. } I^f = c^f + \Theta^f(e^f, t).$$

Reaction funtion to leader‘s action (at optimum):

$$\frac{de^f}{de^l} = \frac{u^f_{ce}\Theta^f_e - u^f_{ee}}{u^f_{ee} - 2u^f_{ce}\Theta^f_e + u^f_{cc}(\Theta^f_e)^2 - u_c\Theta^f_{ee}}$$

$$\frac{de^f}{dt} = \frac{u^f_{ce}\Theta^f_t - u^f_{cc}\Theta^f_e\Theta^f_t + u^f_c\Theta^f_{et}}{u^f_{ee} - 2u^f_{ce}\Theta^f_e + u^f_{cc}(\Theta^f_e)^2 - u_c\Theta^f_{ee}}$$

Proposition 1: The higher the provision of public good e *by the leader, the lower will be the provision of* e *by the follower. The higher the provision of technology* t *by the leader, the higher will be the provision of* e *by the follower*

R&D Spillovers: leader

Leader‘s maximization problem:

$$\max_{e^l, c^l, t} u^l(c^l, e^l + e^f) \text{ s.t. } I^l = c^l + \Theta^l(e^l, t) + \vartheta(t).$$

First order conditions:

$$u_e^l \cdot (1 + \frac{de^f}{de^l}) - u_c^l \Theta_e^l = 0$$

$$u_e^l \cdot \frac{de^f}{dt} - u_c^l \cdot (\Theta_t^l + \vartheta_t) = 0$$

Proposition 2: Recognizing technology spillovers increases the leader’s optimal amount of technology expenditure compared to the case without spillovers. This increases the overall level of the public good e relative to the case without technology spillovers.

International Context: LbD Spillovers

LbD Spillovers: Setup

Utility and budget constraint identical to previous case

Abatement costs:

$$\Theta^l = \Theta^l(e^l);\ \Theta^l{}_{e^l} > 0$$

$$\Theta^f = \Theta^f(e^f, e^l);\ \Theta^f_{e^f} > 0;\ \Theta^f_{e^f e^f} > 0;\ \Theta^f_{e^l} < 0;\ \Theta^f_{e^l e^f} < 0$$

LbD Spillovers: follower

Follower‘s reaction funtion to leader‘s action (at optimum):

$$\frac{de^f}{de^l} = \frac{u^f_{ee} - 2u^f_{ce}\Theta^f_{e^l} + u_{cc}\Theta^f_{e^f}\Theta^f_{e^l} - u^f_c\Theta^f_{e^f e^l}}{-u^f_{ee} + 2u^f_{ce}\Theta_{e^f} - u_{cc}(\Theta^f_{e^f})^2 + u^f_c\Theta^f_{e^f e^f}}$$

Proposition 3: If the follower’s costs of providing the public good negatively depend on the leader’s provision, the former has less incentive to free-ride than in the case without learning by doing. Depending on preferences and technology, learning by doing can turn provision of e by the follower from a strategic substitute into a strategic complement to the leader’s contribution.

LbD Spillovers: leader

Leader‘s first order condition:

$$\frac{u_e^l}{u_c^l} = \frac{\Theta_e^l}{1 + \frac{de^f}{de^l}}$$

Proposition 4: If the follower’s costs of providing the public good negatively depend on the leader’s provision, the follower’s reduced incentive to free-ride raises the leader’s provision of e *as well as the overall level of* e *compared to the case without learning-by-doing.*

International Context: Reducing Uncertainty

Uncertainty: Setup

Uncertain abatement costs: $\tilde{c}^i = I^i - \tilde{\Theta}^i(e^i)$

Expected utility: $Eu^i = E[u^i(I^i - \tilde{\Theta}^i(e^i), e^i)]$

Certainty equivalent: $E[u^i(I^i - \tilde{\Theta}^i(e^i), e^i)] = u^i(I^i - (1+\sigma^i)\overline{\Theta}^i(e^i), e^i)$

$$u^i_{e\sigma} < 0 \quad u^i_{c\sigma} > 0$$

Leader‘s abatement decreases follower‘s abatement cost uncertainty: $\frac{d\sigma^f}{de^l} < 0$

Uncertainty: follower

Follower‘s reaction funtion to leader‘s action (at optimum):

$$\frac{de^f}{de^l} = \frac{u^f_{ee} - (1+\sigma^f)\overline{\Theta}^f_e u^f_{ce} + u^f_{e\sigma}\sigma^f_{e^l}}{-u^f_{ee} + 2(1+\sigma^f)\overline{\Theta}^f_e u^f_{ce} - (1+\sigma^f)^2(\overline{\Theta}^f_e)^2 u^f_{cc}}$$

Proposition 5: If the follower is risk averse and her uncertainty about the costs of providing the public good negatively depends on the leader’s provision, the former has less incentive to free-ride than in the case in which her uncertainty is independent of the leader’s action. Depending on preferences and technology, reduced uncertainty can turn provision of e by the follower from a strategic substitute into a strategic complement to the leader’s contribution.

Uncertainty: leader

Leader‘s first order condition:

$$\frac{u_e^l}{u_c^l} = \frac{(1+\sigma^l)\overline{\Theta}_e^l}{1+\frac{de^f}{de^l}}$$

Proposition 6: If the follower’s uncertainty about the costs of providing the public good negatively depends on the leader’s provision, the follower’s reduced incentive to free-ride raises the leader’s provision of e as well as the overall level of e.

Conclusions

- This study highlights three mechanisms that can (to at least some extent) countervail free-riding by late movers:
  - R&D spill-overs
  - LbD spill-overs
  - Reduced uncertainty for late movers
- In addition (in the paper): green groups‘ voluntary provision of *e* to influence regulator who sets cap (and acts as a follower)
- This somewhat alleviates the bleak prospect for the provision of the global public good of greenhouse gas mitigation