Adoption Gaps of Environmental Adaptation Technologies

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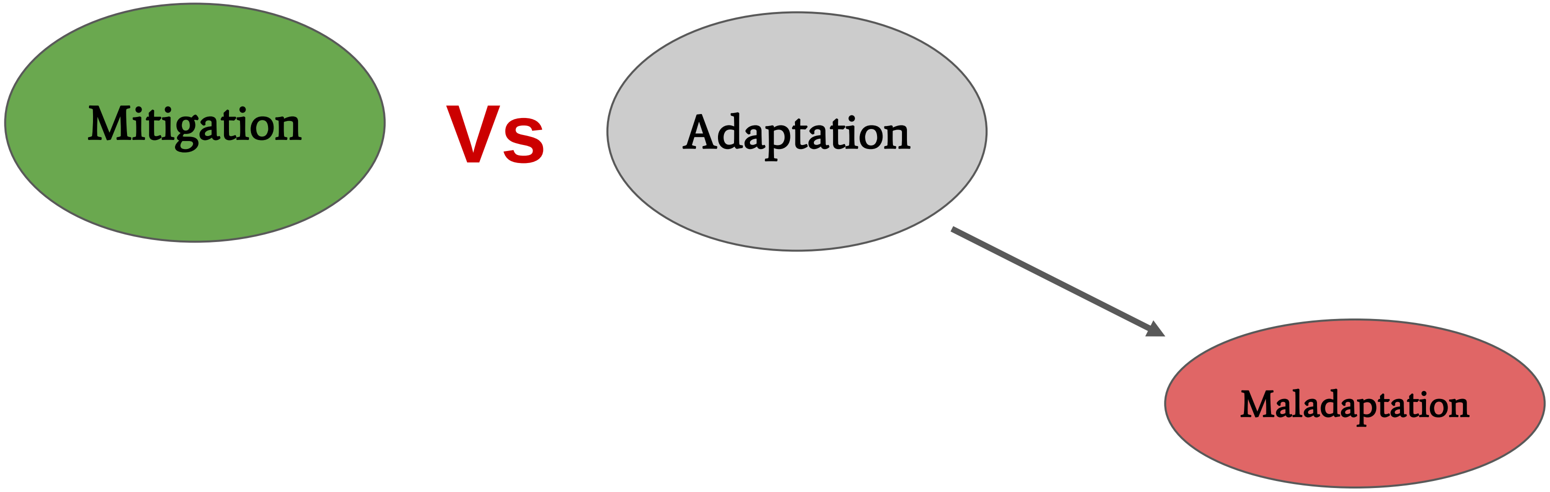
A key distinction



A key distinction

Mitigation

- **Reduces** hazards or degradation

  → Reduces harmful effects **for all**

Maladaptation

- **Increases** hazards or degradation

  → Reduces harmful effects **for self**

➢ Barnett and O'Neill (2010), IPCC (2014)

A few instances

Mitigation Vs Maladaptation

- Mitigation:
  - Water treatment plant, CCS
  - Water-saving irrigation, Home insulation
- Maladaptation:
  - Snow making, Smokestack height
  - Cooling and Heating, Pesticides overuse

(Lundgren and Kiellstrom, 2013

Tompkins, 2010

Abegg, 2008

Smith et al., 2007)

Research Question

What are the underlying dynamics of adoption gaps of mitigation and maladaptation technologies?

Adoption gap: share of adopters ≠ optimal

Too little mitigation, too much maladaptation

- Behavioural reasons
  - ➢ Myopic preferences (Warburton et al, 2018)
  - ➢ Intergenerational selfishness (Glotzbach and Baumgartner, 2012)
- Economic reasons
  - ➢ Budget and financial constraints (Blaikie, 2016; Barbier, 2010)
  - ➢ Information asymmetry (Blaikie, 2016; Barbier, 2010)
  - ➢ Lock-in (Wilson and Tisdell, 2001)
  - ➢ Externalities (Bird, 1987)

The Model

- Only one technology is available to all agents: **mitigation** or **maladaptation**
- Two countries: $j = N, S$
- Two environmental indicators: E_i^N and E_i^S
  - Autonomous components $\bar{E}^N$ and $\bar{E}^S$
  - Public effect P^N and P^S (*$P^j < 0 \rightarrow$ Maladaptation; $P^j > 0 \rightarrow$ Mitigation*)
  - Private effect p^N and p^S (*$p^N, p^S > 0$ always*)

The Model

How our environmental quality indicators look like:

$$E_{it}^{j} = \begin{cases} \overline{E}^{j} + P_t^{j} & \text{if } i \text{ chooses strategy NA} \\ \overline{E}^{j} + P_t^{j} + p^{j} & \text{if } i \text{ chooses strategy A} \end{cases}$$

Where each country ***j = N, S*** is characterised by its $\overline{E}^{j}$, P^{j}, p^{j} and ***t*** is a time index.

The Model

The public effects P^j are the externalities generated by the share x, z of adopters in countries N and S, respectively.

$$P_t^N := -(d^N \cdot x_t + f^N \cdot z_t)$$
$$P_t^S := -(f^S \cdot x_t + d^S \cdot z_t)$$

Where d^j and f^j identify the domestic and the foreign effect on P^j for each country $j = N, S$

The Model

Individual utility Π_i is constituted by the benefits derived from the local environmental indicator of country j and by the adoption cost C^D.

$$\Pi_i^j = \begin{cases} \ln(\overline{E}^j + P_t^j) & \text{if agent } i \text{ chooses strategy NA} \\ \ln(\overline{E}^j + P_t^j + p^j) - C^D & \text{if agent } i \text{ chooses strategy A} \end{cases}$$

The Model

For an agent ***i*** in country ***j***, we can now compute the differential payoff $\Delta\Pi_i$, which measures the additional benefit (or loss) in case of adoption (strategy ***A***).

$$\Delta\Pi^j(x_t, z_t) = \Pi^j_A(x_t, z_t) - \Pi^j_{NA}(x_t, z_t) = \ln \frac{\overline{E}^j + p^j + P^j_t}{\overline{E}^j + P^j_t} - C^j$$

Intuitively, if a strategy is relatively more rewarding, then it should be imitated by others:

$$\Delta\Pi^N(x_t, z_t) < 0 \Rightarrow \dot{x} < 0 \qquad \Delta\Pi^N(x_t, z_t) > 0 \Rightarrow \dot{x} > 0$$

The model

Replicator Dynamics

"The best performing strategy should diffuse faster"

"The last few take longer to change mind"

The dynamics of adoption are thus given by:

$$\dot{x} = x(1-x)\Delta\Pi_N$$

$$\dot{z} = z(1-z)\Delta\Pi_S$$

(Weibull, 1995)

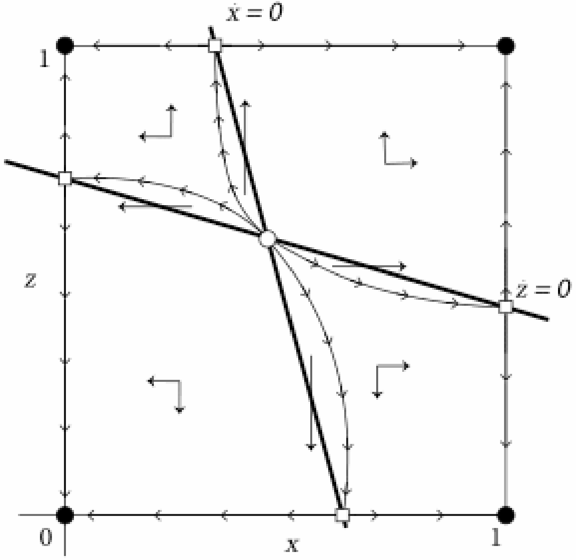
Results

We studied the adoption dynamics for our two scenarios:

- Maladaptation
  - Negative public effects (d^j and $f^j > 0 \rightarrow P^j < 0$)
- Mitigation
  - Positive public effects (d^j and $f^j < 0 \rightarrow P^j > 0$)

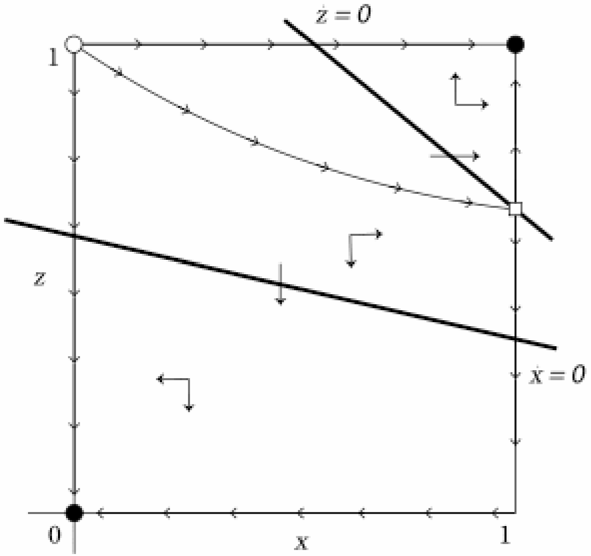
Results - Maladaptation

- Basic results: **“No middle ground”**
  - All trajectories approach a stationary state
  - Only pure population strategies are attractive



Results - Maladaptation

- Non-adoption **(x = 0, z = 0)** can be either attractive or not attractive
  - ➢ It is the social optimum even if it is not attractive (*Tragedy of the commons*)
  - ➢ Low $\frac{p^j}{e^{Cj} - 1}$ makes non-adoption attractive!



Results - Maladaptation

- Environmental dumping
  - If country ***N*** implements a green policy which reduces domestic externalities d^N but leads to the increase of f^S (PHH) the well-being consequences are unclear.
    - $d^N \downarrow \Rightarrow \Delta\Pi_N \downarrow \Rightarrow \dot{x} \downarrow$
    - $f^S \uparrow \Rightarrow \Delta\Pi_S \uparrow \Rightarrow \dot{z} \uparrow \Rightarrow f^N \cdot z \uparrow \Rightarrow \Delta\Pi_N \uparrow \Rightarrow \dot{x} \uparrow$

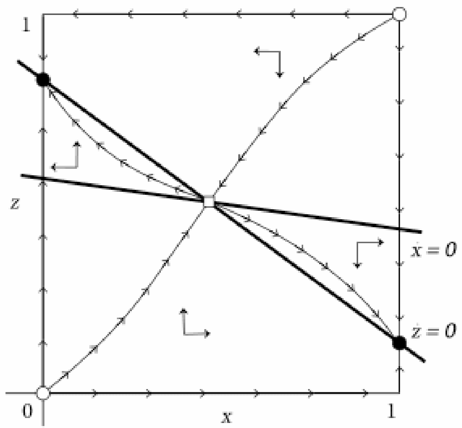
Payoff differentials:

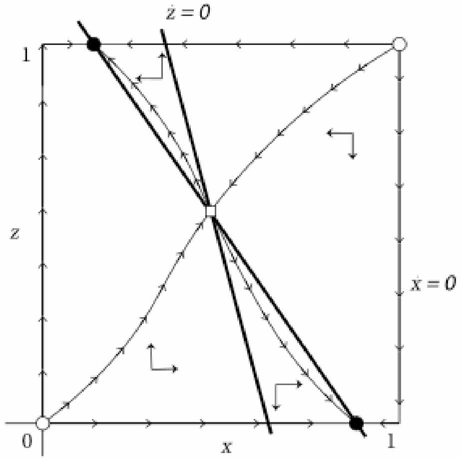
$$\Delta\Pi^N = ln\left(1 + \frac{p^N}{\overline{E}^N - d^N x - f^N z}\right) - C^N$$

$$\Delta\Pi^S = ln\left(1 + \frac{p^S}{\overline{E}^S - d^S z - f^S x}\right) - C^S$$

Results - Mitigation

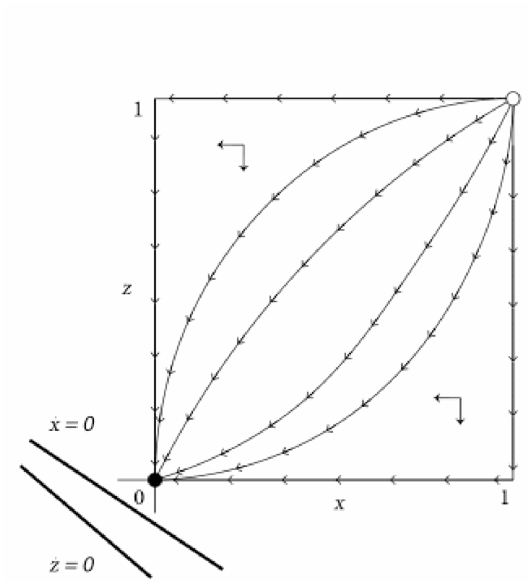
- Basic results:
  - ➢ All trajectories approach a stationary state
  - ➢ Mixed population strategies may be attractive

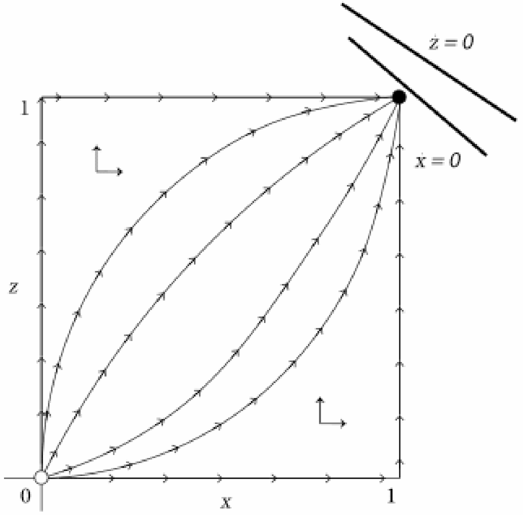




Results - Mitigation

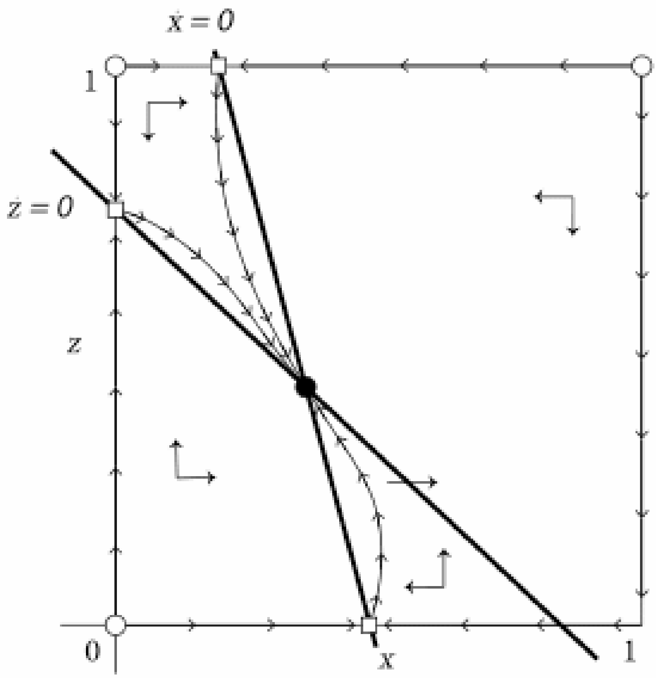
- When non-adoption or full adoption are attractive, they are global attractors





Results - Mitigation

- Full adoption **(x = 1, z = 1)** is the social optimum even when it is not attractive
- Sufficiently high efficiency leads to full adoption of mitigation technologies
- When domestic externalities are larger than foreign ones, an internal global attractor may exist



Conclusions

- ✓ A model to study the dynamics of adoption gaps in mitigation and maladaptive technologies
- ✓ Policy implications: Altering efficiency of adaptation technologies may eliminate adoption gaps
- ✓ Environmental dumping: if a domestic technology in N decreases d^N but increases f^S, well-being implications are uncertain
- ✓ Further research directions → Studying the other possible scenarios with d^j and f^j

Thank you for your attention.

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