

Economic Growth of Insiders and Outsiders of a Climate Agreement: A Theoretical Model

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Paris Accord (sealed Dec., 12th, 2015 – in force Nov. 6th, 2016)

- June, 1st, 2017: Donald Trump exits from the Paris Accord.
- July, 8th, 2017: Recep Tayyip Erdoğan follows.
- (others: the Holy See)

PRO: free-rider arguments, industrial policy

CON: technological spillovers

Question 1: What are the long-term growth effects?

Question 2: How are the green strategies of the insiders affected?

Modeling framework:

- growth model with spillovers
- directed technical change à la Acemoglu (2003)

1 Two modeling strategies

2 The structure of the model

3 Economic growth of insiders and outsiders

4 Green targets instead of given environmental policies

5 Extensions and further research

1 Two modeling strategies

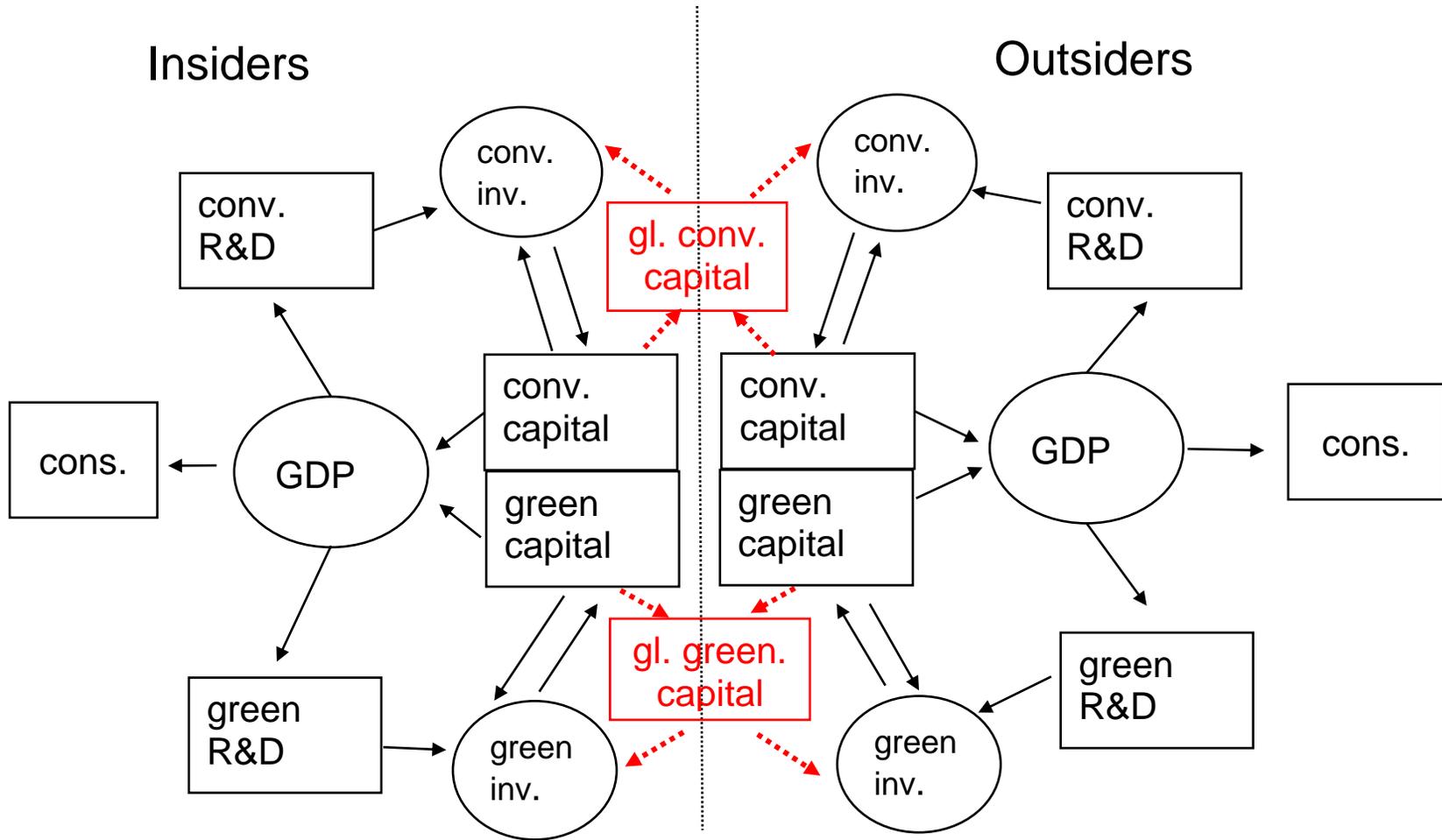
Model I: Jones (1995), directed technological change with conventional and green capital and R&D (Rauscher, 2010)

Model II: Romer (1986), learning by doing, with aggregate capital and "greenness"

Model I:

based on Jones (1995) and Rauscher (2010), related to Acemoglu et al. (2012)

Structure of the model:



Complexity

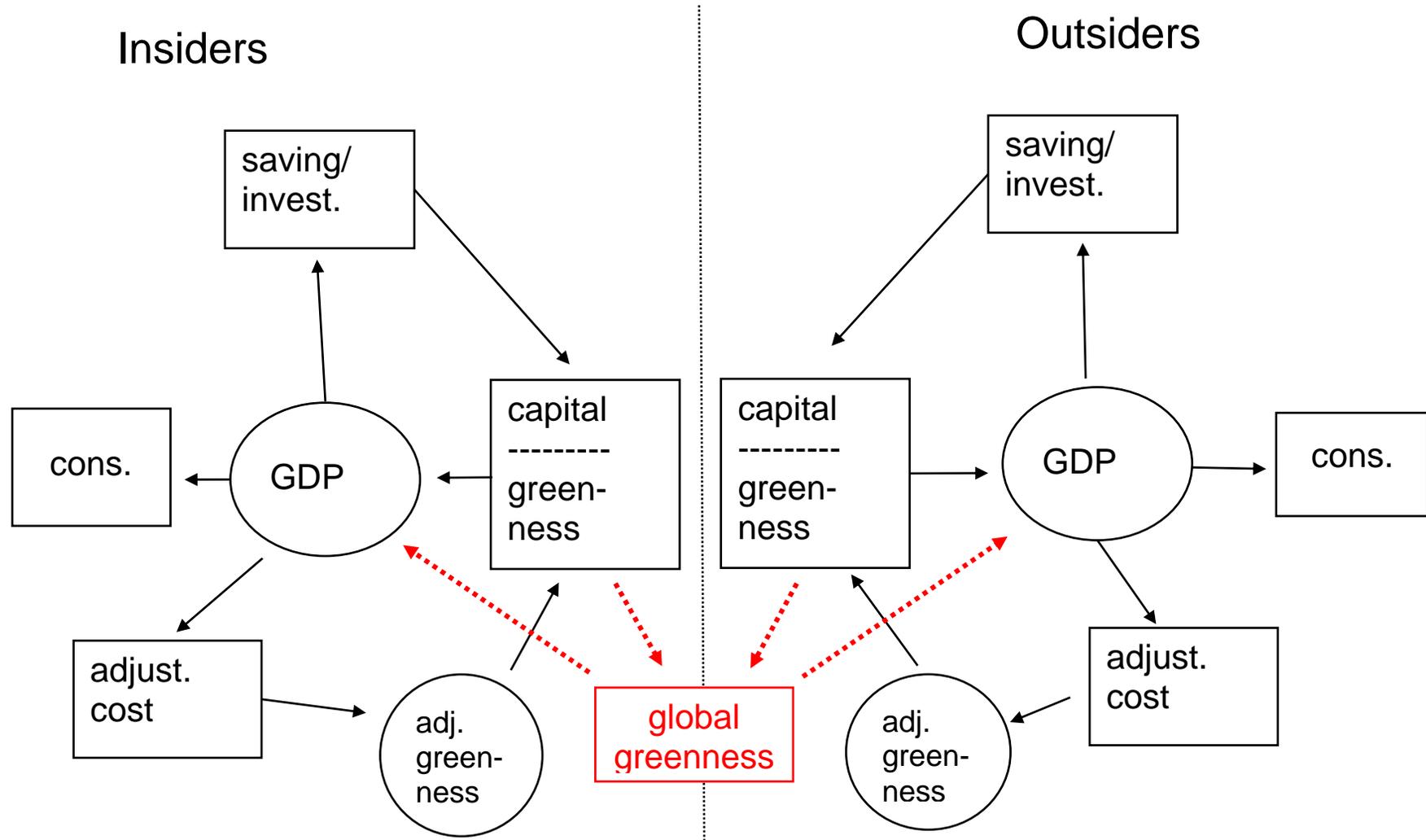
- four state variables (green and conv. capital, insiders and outsider)
- four controls (green and conv. R&D, insiders and outsiders)
- four global spillovers (green/conv. capital → g./c. investment, insiders and outsiders)
- six production activities
 - green investment (three inputs: R&D, own and global capital)
 - conv. investment (three inputs: R&D, own and global capital)
 - GDP (two inputs: green and conv. capital)

Six to eight policy instruments

- taxes/subsidies on conventional capital
- subsidies on green (and potentially conventional) investment

Model II

based on Romer (1986)



Less complexity

- four state variables (capital and greenness, insiders and outsiders)
- four controls (capital investment. and adjustment of greenness, insiders and outsiders)
- two global spillovers (greenness → production, insiders and outsiders)
- four production activities
 - greenness (one input: adjustment of greenness)
 - GDP (two inputs: own capital, greenness, global greenness spillover)
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Two policy instruments

- taxes/subsidies on adjusting greenness (equiv. to emission taxes/subsidies),
insiders and outsiders

2. The structure of the model in detail

Purely positive analysis

a continuum of countries with measure 1

inhabited by consumer-producer-investor households

- m insiders of the IEA
- $(1 - m)$ outsiders of the IEA (*)
- equal in all respects – except environmental policies

maximize $\int_0^{\infty} \ln C e^{-\rho t} dt$

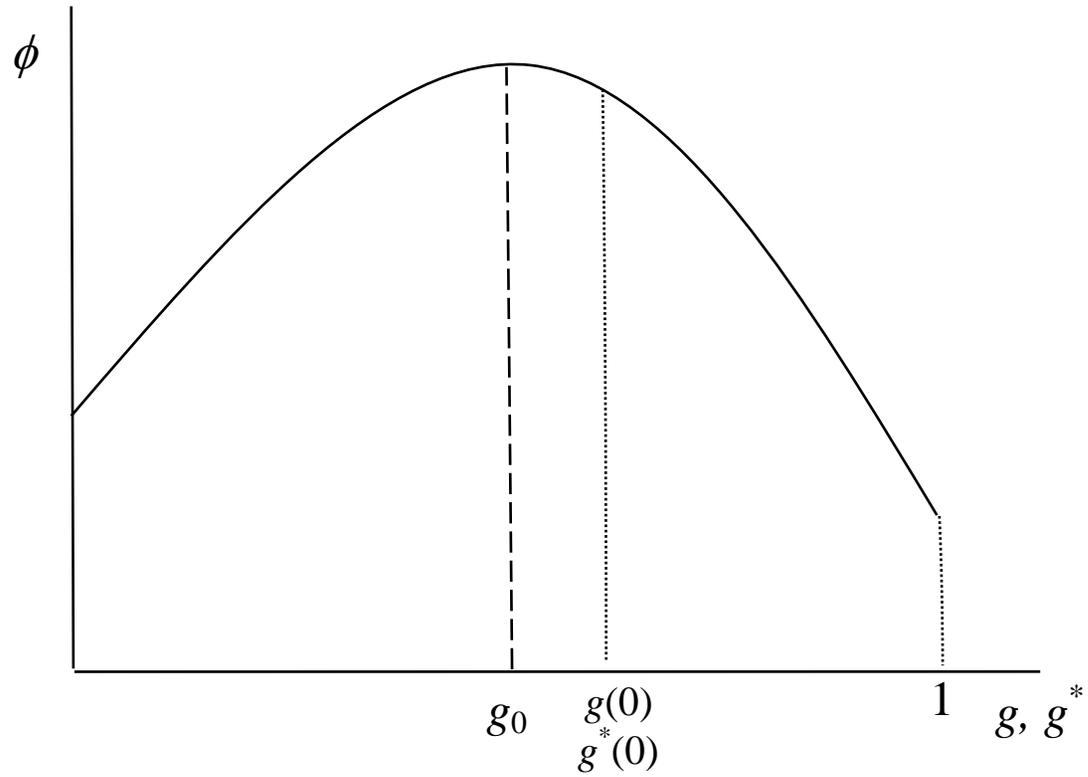
Output depends on

- "greenness" of technology, $g(t)$, $0 \leq g(t) \leq 1$
- capital, $K(t)$
- knowledge spillover $S(t) = s(t) K(t)$

$s(t)$ is a similarity index comparing technologies $0 \leq s(t) \leq 1$

production $\phi(g) F(K, S)$ CRS such that $f(s) \equiv F(1, s) = \frac{F(K, S)}{K}$

The $\phi(\cdot)$ function



Moreover, we argue that insiders are at least as green as outsiders

$$g \geq g^*$$

knowledge spillovers

- $s(g, g^*, m) \in [0,1]$
- $s_g < 0, s_{g^*} > 0, s_m > 0$ and $s(g, g, m) = 1, s(g, g^*, 1) = 1$.

Examples:

$$s(g, g^*, m) = 1 + (1 - m)(g^* - g), \quad (1)$$

$$s^*(g, g^*, m) = 1 + m(g^* - g). \quad (1^*)$$

Adjusting greenness is costly $z(\dot{g})$

- $z''(\cdot) > 0$ and $z(0) = 0$
- total cost: $z(\dot{g})K$.

Policy instruments (GIVEN)

- constant subsidy on green investments $\sigma > 0, \sigma^* \leq 0$
- constant emission tax on on-green capital $\theta > \theta^* \geq 0$
(emissions proportional to non-green capital $(1 - g)K$)

Budget constraint of a representative insider country:

$$\dot{K} = \phi(g)F(K, S) - C - z(\dot{g})K + \sigma \dot{g}K - \theta(1 - g)K + \Theta,$$

with $\Theta(t)$ as a lump-sum transfer or tax

$g(0)$ and $K(0)$ are historically given.

maximum principle

Present-value Hamiltonian

$$H = \ln C + \gamma \dot{g} + \kappa(\phi(g)F(K, S) - C - z(\dot{g})K + \sigma \dot{g}K - \theta(1 - g)K + \Theta)$$

Ramsey's rule

$$\hat{C} = \phi(g)F_K(K, sK) + \sigma \dot{g} - z(\dot{g}) - \theta(1 - g) - \rho, \quad (3)$$

Problem:

four differential equations $(\hat{C}, \dot{K}, \dot{g}, \ddot{g})$ for each country group

Steady state $\dot{\gamma} = 0$

$$z'(\dot{g}) = \sigma + \frac{\phi'(g)f(s) + \theta}{\rho} \quad (4)$$

In the very long run $\dot{g} = 0$ and $z' = 0$

$$\sigma + \frac{\theta}{\rho} = -\frac{\phi'(g)f(s)}{\rho}.^1 \quad (5)$$

ecological equivalence of environmental taxes and subsidies in the very long run

but not with respect to growth:

$$\hat{C} = \phi(g) \left(f(s) - sf'(s) \right) - (1 - g)\theta - \rho. \quad (6)$$

¹ If $\sigma + \frac{\theta}{\rho} > -\frac{\phi'(1)f(s)}{\rho}$, then $g = 1$.

3. Economic growth of insiders and outsiders

Corresponding results for the outsiders

short-run growth:

$$\hat{C}^* = (g^*)F_{K^*}(K^*, s^*K^*) + \sigma^* \dot{g}^* - z(\dot{g}^*) - (1 - g^*)\theta^* - \rho \quad (3^*)$$

long run growth and greenness:

$$\hat{C}^* = \phi(g^*) \left(f(s^*) - s^* f'(s^*) \right) - (1 - g^*)\theta^* - \rho \quad (6^*)$$

$$\sigma^* + \frac{\theta^*}{\rho} = - \frac{\phi'(g^*)f(s^*)}{\rho}, \quad (5^*)$$

At $t = 0$, insiders growth faster than outsiders if

$$\sigma \dot{g} - z(\dot{g}) - (1 - g(0))(\theta - \theta^*) > \sigma^* \dot{g}^* - z(\dot{g}^*).$$

What do we learn from this? NOTHING

Effects of policy changes on long-run greenness

$$\frac{dg}{d\theta^*} = \frac{1}{\rho} \frac{dg}{d\sigma^*} = \Delta^{-1}(1 - m)\phi'f'$$

$$\frac{dg^*}{d\theta^*} = \frac{1}{\rho} \frac{dg^*}{d\sigma^*} = \Delta^{-1}(\phi''f - (1 - m)\phi'f')$$

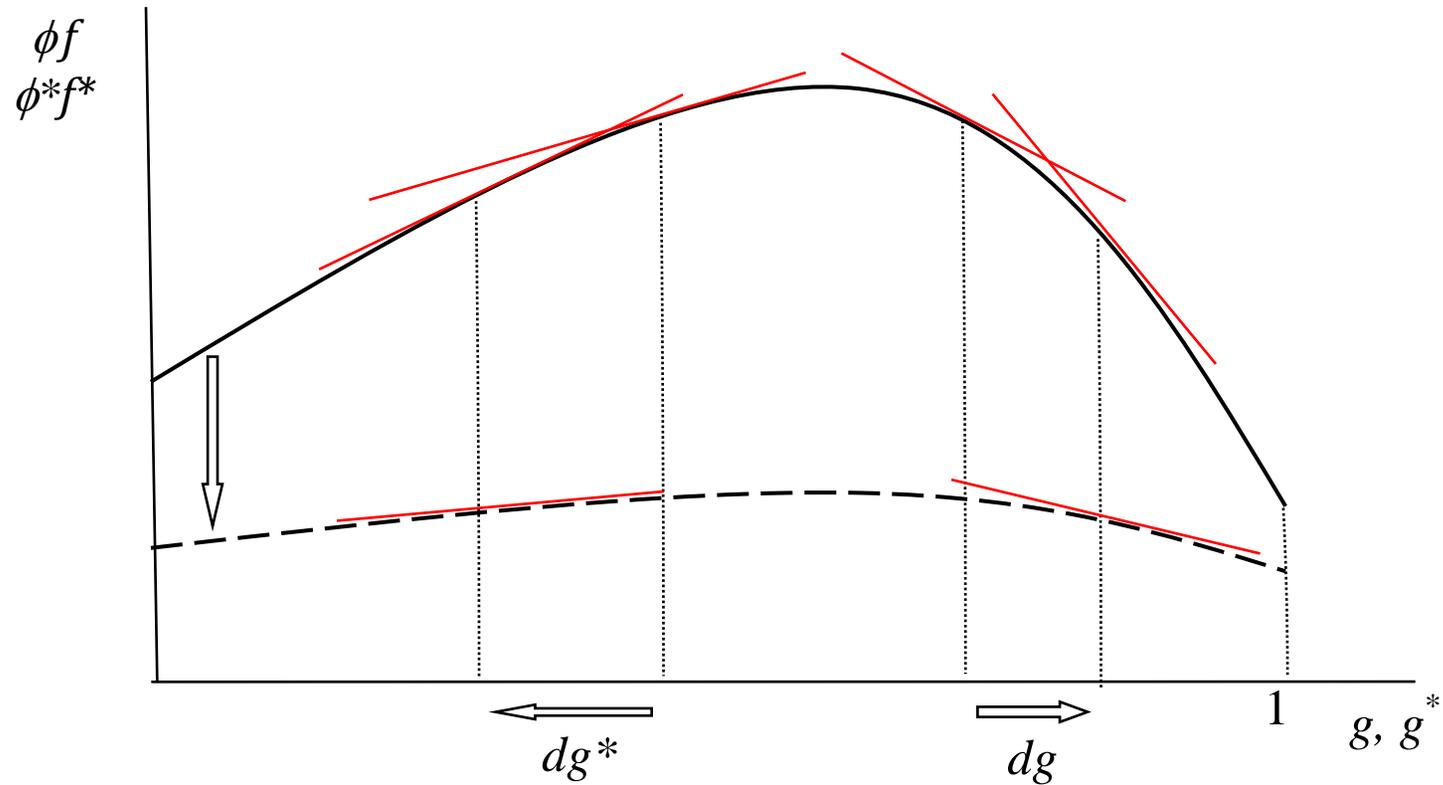
with $\Delta = \phi''\phi^*''ff^* + m\phi''\phi^*''ff^{*'} - (1 - m)\phi'\phi^*''f'f^* \geq 0$.

Proposition 1

The marginal impacts of outsiders' taxes and subsidies on long-run greenness are ambiguous.

Underlying intuition, effect of a change in g or g^*

- move on the ϕf curve
- shift of the ϕf curve



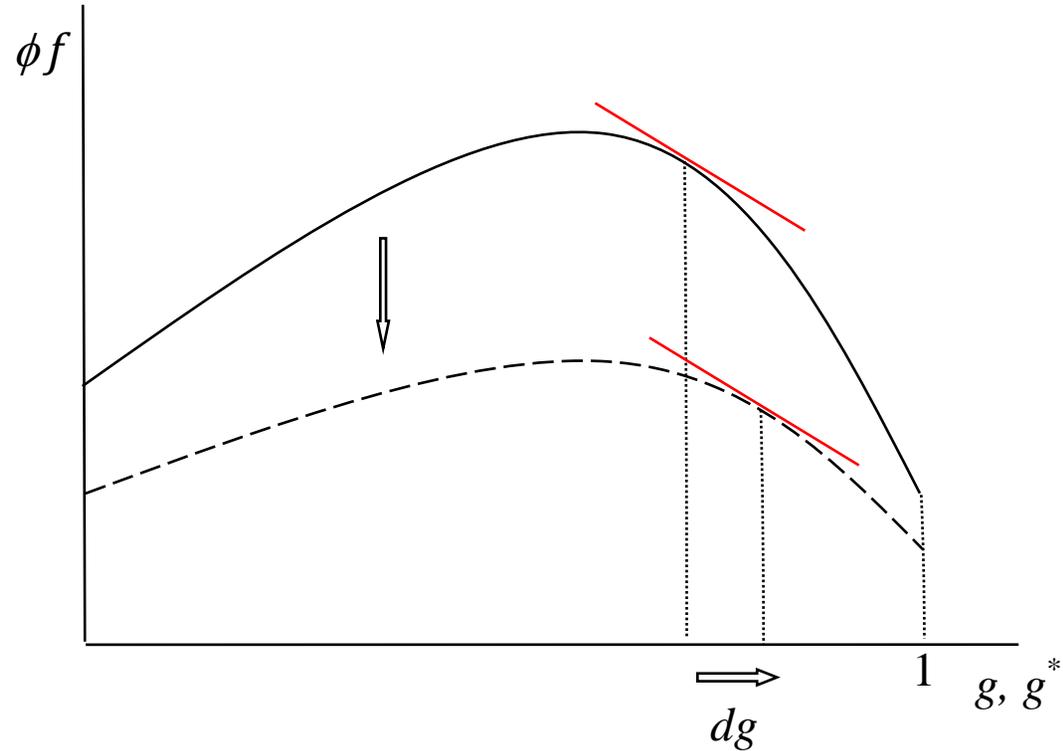
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Proposition 2 (outsiders' policies)

If f^ and f are sufficiently small, a reduction in green subsidies and in emission taxes induces an reduction in own greenness.*

The impact of the reduction in taxes and subsidies on the insiders' greenness is positive.

Intuition



Totally differentiating (6) and (6*) yields

$$d\hat{C} = [\phi' F_K + (1 - m)s\phi f'' + \theta]dg - (1 - m)s\phi f'' dg^* - s\phi f''(g - g^*)dm$$

This implies:

Proposition 3

Insiders' growth benefits from own group size and from the rest of the world's greenness and is harmed by own greenness, unless the tax effect is so large that it dominates the other two effects.

Outsiders' growth benefits from own greenness and is harmed by insiders' greenness and group size.

Benchmark: equal growth rates in all countries.

$$\left. \frac{dg}{dm} \right|_{\hat{c}=\hat{c}^*} = \frac{(s\phi f'' + s^*\phi^* f^{*''})(g - g^*)}{\phi' F_K + (1 - m)s\phi f'' - ms^*\phi^* f^{*''}}, \quad (8a)$$

$$\left. \frac{dg}{dg^*} \right|_{\hat{c}=\hat{c}^*} = \frac{\phi^* F_{K^*} - ms^*\phi^* f^{*''} + (1 - m)s\phi f''}{\phi' F_K + (1 - m)s\phi f'' - ms^*\phi^* f^{*''}}, \quad (8b)$$

Assume that the $\phi(\cdot)$ function is symmetric around $g_0 = 0.5$

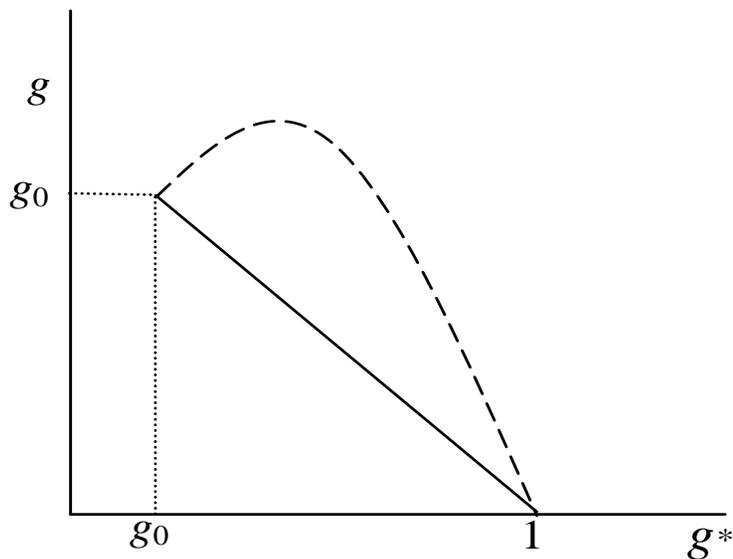


Figure 2: Equal growth-lines for $m = 0.5$ and $m > 0.5$

4 Green targets instead of given environmental policies

Insiders' target

$$g(t) \geq \bar{g} > g_0 \quad \text{for } t \geq T >$$

Strategies

- given path
- cost-minimising path

Result:

Achieving the target becomes more costly in terms of consumption loss along the given path.

Long-run effects

$$\sigma + \frac{\theta}{\rho} = -\frac{\phi'(g)f(s)}{\rho} \quad (5')$$

$$\sigma^* + \frac{\theta^*}{\rho} = -\frac{\phi'(g^*)f(s^*)}{\rho} \quad (5'^*)$$

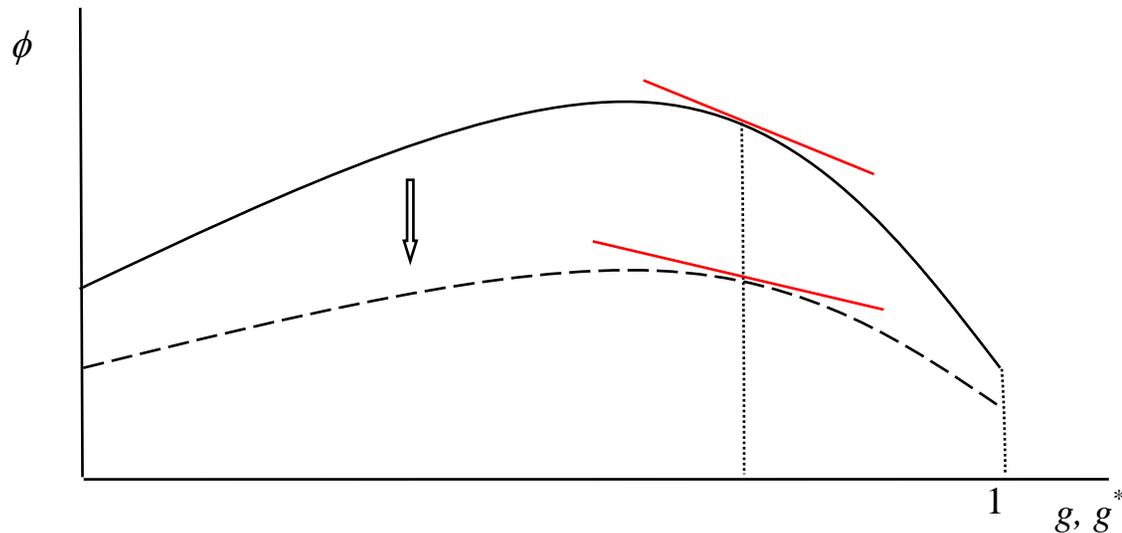
Comparative statics of the equilibrium (both groups using the same instrument):

$$\frac{dg^*}{d\theta^*} = \frac{1}{\rho} \frac{dg^*}{d\sigma^*} = \frac{(1-m)\phi'f'}{\phi^{*''}f^* + m\phi^{*'}f^{*'}} \begin{matrix} \geq \\ < \end{matrix} 0$$

$$\frac{d\sigma}{d\sigma^*} = \frac{d\theta}{d\theta^*} = \frac{-1}{\phi^{*''}f^* + m\phi^{*'}f^{*'}} \begin{matrix} \geq \\ < \end{matrix} 0$$

Proposition 4

If externalities are not too large, lower taxes and subsidies in the outsider countries reduce their greenness and reduce the taxes and subsidies necessary to achieve the insider's green target.



5. Extensions and areas of future research

Adjustment dynamics and stability

Trade (diversity is good)

- FDI
- Fossil fuels
- Final goods

Consider type-I model

Empirical importance of spillovers

Welfare economics and optimal climate policy