Environmental regulation, trade integration and cooperation

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Climate warming is a major issue of international politics

- *"Given the nature and magnitude of the challenge, national action alone is insufficient. No nation can address this challenge on its own. No region can insulate itself from these climate changes. That is why we need to confront climate change within a global framework, one that guarantees the highest level of international cooperation."*

  Ban Ki-Moon, Secretary General of the United Nations
  24 September, 2007

- There is a strong and recurrent opposition between countries about the definition of precise commitments of greenhouse gases emissions reductions

How important is international cooperation on global environmental matters?

- What are the ecological and economic impacts of the dispersion of pollution-control efforts?
- How does cooperation on environmental issues between trade partners affect the welfare impact of trade liberalization?

Different frameworks used to study interdependencies between the environment and the economic activity

- Perfect competition
  - Markusen (1975): countries may want to substitute environmental taxes for trade policy to improve their terms-of-trade
- Oligopoly
  There are incentives for a strategic use of environmental policies, which can result in ecological dumping (cooperative regulation stricter than unilateral policy)
  - to shift rents toward domestic firms (Rauscher (1994))
  - to attract capital (Hoel (1997))

Different frameworks used to study interdependencies between the environment and the economic activity

- Monopolistic competition
  - Pflüger (2001): there is a trade-off between more economic activity and less local pollution, which does not necessarily lead to ecological dumping
  - Haupt (2006): non cooperative environmental standards can be too tough when pollution is local, because they reduce the number of varieties produced
  - Gurztgen and Rauscher (2000): there is a leakage effect (an undesirable outcome of a national environmental policy on foreign pollution) specific to monopolistic competition, which occurs through a modification of market structure

Contributions

- To a basic model of the new trade theory (Helpman and Krugman (1985)) we add:
  - pollution: emissions are released during the production of every varieties of a differentiated product
  - environmental policy: governments can impose production process standards to polluting firms (like in Haupt (2006))
- Contributions:
  - consideration of pollution as a global externality
  - introduction of trade costs
  - explicit study of the strategic game between countries on environmental standards
  - interaction between environmental and trade policies

Results

- The market-structure leakage effect can undermine the effectiveness of a national environment-friendly policy
- The non cooperative equilibrium is characterized by suboptimal environmental regulation
- Trade liberalization is welfare improving only if countries cooperate on environmental matters

We consider two developed countries (home and foreign) identical in size, tastes and technologies.

- The home representative consumer's utility function (U):

$$U = lnC - \eta E \qquad \eta > 0$$

  - C: consumption of goods ($U_C > 0$ and $U_{CC} < 0$)
  - E: global environmental damage (the world-wide amount of polluting emissions) ($U_E < 0$ and $U_{EE} = 0$)
  - η: the marginal disutility of pollution

1rst stage of demands determination

- The consumption index:

$$C = H^{1-\mu} D^{\mu} \qquad 0 < \mu < 1$$

  - H: consumption of a homogeneous good
  - D: consumption of a basket of all existing varieties of a differentiated product

- The budget constraint:

$$w = H + PD$$

  - w: wage rate in the home country
  - P: price index of the basket of varieties of the differentiated good
  - the homogeneous good's world price is one

- Individual demands:

$$H = (1 - \mu)\, w \qquad \text{and} \qquad D = \frac{\mu w}{P}$$

2nd stage of demands determination

- The differentiated good index:

$$D = \left[n d_h^{\frac{\sigma-1}{\sigma}} + n^* d_f^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

  - n: number of varieties produced by home (n^*: by foreign)
  - d_h: home consumption of each home variety (d_f: foreign variety)
  - $\sigma > 1$: constant elasticity of substitution

- The corresponding price index:

$$P = \left[n p^{1-\sigma} + n^* (\tau p^*)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

  - p: production price of varieties produced by home (p^*: by foreign)
  - $\tau > 1$: iceberg transport costs

- Individual demands:

$$d_h = \mu w p^{-\sigma} P^{\sigma-1} \qquad \text{and} \qquad d_f = \mu w (\tau p^*)^{-\sigma} P^{\sigma-1}$$

The homogeneous good

- Only one factor of production: labor
  - mobile within countries
  - internationally immobile
- The homogeneous good:
  - perfect competition
  - one unit of labor per unit of good
  - production in both countries after free trade
    $\Rightarrow$ unique world price $= 1$
    $\Rightarrow$ $w = w^* = 1$

The differentiated good

- The total cost expressed in labor terms, l, associated to the production of q units of a home variety:

$$l = f + vq$$

  - f: fixed cost of production
  - v: variable cost of production

- Two equilibrium conditions in monopolistic competition:
  - production price: $p = \frac{\sigma}{\sigma - 1} v$
  - output: $q = (\sigma - 1) \frac{f}{v}$

The environmental policy

- Command-and-control policy: definition of the emission rate (the amount of pollutants released per unit of output)
- Complying with environmental standards is costly for firms; the regulation can affect alternately:
  - the fixed cost of production:
    $f = 1 + f_{env}$ and $f^* = 1 + f^*_{env}$
  - the variable cost of production:
    $v = 1 + v_{env}$ and $v^* = 1 + v^*_{env}$

The fixed-cost case

- R&D expenses to set-up and design a cleaner production process
- The abatement function: $\tau_{e_f} = f^{\alpha}$ with $\alpha < 0$
  The more environment-friendly the country, the lower the emission rate, the higher the fixed cost of production
- Equilibrium conditions become:
  - production price:
    $p = p^* = p_f = \frac{\sigma}{\sigma - 1}$
  - outputs:
    $q_f = (\sigma - 1) f$ and $q_f^* = (\sigma - 1) f^*$

The variable-cost case

- Expenses devoted to pollution-control activities all along and at the end of the production line
- The abatement function: $\tau_{e_v} = v^{\beta}$ with $\beta < 0$
  The more environment-friendly the country, the lower the emission rate, the higher the variable cost of production
- Equilibrium conditions become:
  - production prices:
    $p_v = \frac{\sigma}{\sigma-1} v$ and $p_v^* = \frac{\sigma}{\sigma-1} v^*$
  - outputs:
    $q_v = (\sigma - 1)\frac{1}{v}$ and $q_v^* = (\sigma - 1)\frac{1}{v^*}$

The market equilibrium

The equilibrium numbers of varieties produced in each region solve market clearing conditions: for each variety, output must be equal to the sum of all individual consumptions:

$$\begin{cases} q = Ld_h + L^*\tau d_h^* \\ q^* = L\tau d_f + L^* d_f^* \end{cases}$$

- We assume identical country size ($L = L^*$)
- Iceberg transport costs represent an indirect demand (quantities lost in the transit have to be taken into account)

The fixed-cost case - The market equilibrium

The equilibrium numbers of varieties are:

$$n_{\mathrm{f}} = \frac{\mu L}{\sigma}\frac{\left(1+\phi^2\right)f^* - 2\phi f}{(f^* - \phi f)(f - \phi f^*)} \qquad \text{and} \qquad n_{\mathrm{f}}^* = \frac{\mu L}{\sigma}\frac{\left(1+\phi^2\right)f - 2\phi f^*}{(f^* - \phi f)(f - \phi f^*)}$$

with $\phi = \tau^{1-\sigma}$ the freeness of trade

- When the regions are perfectly integrated ($\phi = 1$) firms can't face a negative differential of environmental policy
- Having both the numbers of home and foreign firms non negative impose the following condition:
  $\frac{2\phi}{1+\phi^2} \leq F \leq \frac{1+\phi^2}{2\phi}$ and $F = f/f^*$

The fixed-cost case - The environmental damage

The amount of worldwide polluting emissions is:

$$E_{\mathrm{f}} = n_{\mathrm{f}}\tau_{e_{\mathrm{f}}}q_{\mathrm{f}} + n_{\mathrm{f}}^{*}\tau_{e_{\mathrm{f}}}^{*}q_{\mathrm{f}}^{*} = (\sigma-1)\left(n_{\mathrm{f}}+n_{\mathrm{f}}^{*}\right)$$

$$= (\sigma-1)\frac{\mu L}{\sigma}\frac{(1-\phi)^{2}\left(f+f^{*}\right)}{\left(f^{*}-\phi f\right)\left(f-\phi f^{*}\right)}$$

- We set $\alpha = -1$: emissions per firm are simply equal to $\sigma - 1$, whatever their size
- Upgrading national environmental standard:
  - lowers the number of firms in the country
  - increases their size
  - increases the number of foreign firms

$\Rightarrow$ Firm reallocation induces a leakage effect which can undermine the effectiveness of a national environmental policy

The variable-cost case - The market equilibrium

The equilibrium numbers of varieties are:

$$n_{\mathrm{v}} = \frac{\mu L}{\sigma} \frac{\left(1+\phi^2\right)v^{1-\sigma} - 2\phi v^{*1-\sigma}}{(v^{*1-\sigma} - \phi v^{1-\sigma})(v^{1-\sigma} - \phi v^{*1-\sigma})} v^{*1-\sigma}$$

and $$n^*_{\mathrm{v}} = \frac{\mu L}{\sigma} \frac{\left(1+\phi^2\right)v^{*1-\sigma} - 2\phi v^{1-\sigma}}{(v^{*1-\sigma} - \phi v^{1-\sigma})(v^{1-\sigma} - \phi v^{*1-\sigma})} v^{1-\sigma}$$

We can make similar observations to the previous scenario:

- Firms which have to face the toughest national environmental policy are not able to cope with international competition without protection
- Having both the numbers of home and foreign firms non negative impose the following condition:

$$\left(\frac{2\phi}{1+\phi^2}\right)^{\frac{1}{\sigma-1}} \leq V \leq \left(\frac{1+\phi^2}{2\phi}\right)^{\frac{1}{\sigma-1}} \qquad \text{and} \qquad V = v/v^*$$

The variable-cost case - The environmental damage

The environmental damage is:

$$E_{\mathrm{v}} = n_{\mathrm{v}} \tau_{e_{\mathrm{v}}} q_{\mathrm{v}} + n^*_{\mathrm{v}} \tau^*_{e_{\mathrm{v}}} q^*_{\mathrm{v}} = (\sigma - 1)\left(n_{\mathrm{v}}/v^2 + n^*_{\mathrm{v}}/v^{*2}\right)$$

- To be able to compare the results, we assume $\beta = -1$
- A tougher national environmental policy:
  - decreases domestic firms' output
  - decreases domestic firms' emission rate
  - modifies the repartition of firms between the two countries to the benefit of the foreign country

$\Rightarrow$ There are leakage effects through a modification of the market structure; the overall effect is ambiguous

Two policy scenarios

The endogenous choice of environmental standards rests on consumers' welfare. Two political options are considered:

- Cooperation: a supranational authority is in charge of the design of an international agreement on environmental standards ($\Rightarrow$ cooperative equilibrium)
- Unilateralism: governments simultaneously choose their own standard, considering the foreign policy as given ($\Rightarrow$ Nash equilibrium)

- Optimal environmental policies maximize the worldwide representative consumer's utility:

$$f_{coop} = \frac{2\eta L(\sigma-1)^2}{\sigma} \qquad \text{and} \qquad v_{coop} = \left[\frac{4\eta L(\sigma-1)}{\sigma}\right]^{\frac{1}{2}}$$

- Then we have:

$$U_{\mathrm{f_{coop}}} = ln\left[c\left(\frac{\sigma(1+\phi)}{2\eta(\sigma-1)^2}\right)^{\frac{\mu}{\sigma-1}}\right] - \frac{\mu}{\sigma-1}$$

$$\text{and} \qquad U_{\mathrm{v_{coop}}} = ln\left[c\left(L\left(1+\phi\right)\right)^{\frac{\mu}{\sigma-1}}\left(\frac{\sigma}{4\eta L(\sigma-1)}\right)^{\frac{\mu}{2}}\right] - \frac{\mu}{2}$$

- Trade liberalization:
  - does not influence the environmental standard
  - does not aggravate the global environmental damage
  - benefits to consumers since imported varieties become cheaper

$\Rightarrow$ Liberalization is welfare improving

- Governments do not cooperate and simultaneously choose their standard as the one which maximizes the domestic representative consumer's utility:

$$f_{nash} = \frac{\eta L(\sigma-1)^2(1-\phi)}{\sigma} \quad \text{and} \quad v_{nash} = \left[\frac{2\eta L(\sigma-1)(1-\phi)}{\sigma}\right]^{\frac{1}{2}}$$

- Then we have:

$$U_{\mathrm{f_{nash}}} = ln\left[c\left(\frac{\sigma(1+\phi)}{\eta(\sigma-1)^2(1-\phi)}\right)^{\frac{\mu}{\sigma-1}}\right] - \frac{2\mu}{(\sigma-1)(1-\phi)}$$

$$\text{and} \quad U_{\mathrm{V_{nash}}} = ln\left[c\left(L\left(1+\phi\right)\right)^{\frac{\mu}{\sigma-1}}\left(\frac{\sigma}{2\eta L(\sigma-1)(1-\phi)}\right)^{\frac{\mu}{2}}\right] - \frac{\mu}{1-\phi}$$

- Trade liberalization:
  - softens the environmental protection (strategic use of environmental policy)
  - aggravates the global environmental damage
  - benefits to consumers:
    - fixed-cost case: a greater number of varieties to be consumed
    - variable-cost case: a lower production price
    - in both cases: imported varieties become cheaper
  - what is the strength of consumption gains relative to poorer environmental quality?
    - fixed-cost case: utility unambiguously decreases
    - variable-cost case: utility decreases, except for small levels of competition and openness

$\Rightarrow$ Liberalization is welfare depressing (in most cases)

The comparison of equilibria

- Environmental policies:
  $\frac{f_{coop}}{f_{nash}} = \frac{2}{1-\phi} > 1$ and $\frac{v_{coop}}{v_{nash}} = \left(\frac{2}{1-\phi}\right)^{\frac{1}{2}} > 1$
  Individual actions create incentives to relax national environmental policies to help the domestic industry to face foreign competitors; the strategic use of environmental regulations generates a race to lower standards
- Utilities:
  $U_{f_{coop}} - U_{f_{nash}} = \frac{\mu}{\sigma-1}\left[\frac{1+\phi}{1-\phi} - ln\left(\frac{2}{1-\phi}\right)\right] > 0$
  and $U_{v_{coop}} - U_{v_{nash}} = \frac{\mu}{2}\left[\frac{1+\phi}{1-\phi} - ln\left(\frac{2}{1-\phi}\right)\right] > 0$
  To the extend that we deal with global pollution, it is quite logical to find that the answer must also be global

The impacts of trade liberalization

- Environmental policies:
  $\frac{\delta(f_{coop}/f_{nash})}{\delta\phi} > 0$ and $\frac{\delta(v_{coop}/v_{nash})}{\delta\phi} > 0$
  Growing competitive concerns as liberalization goes on increases the gap between cooperative and Nash equilibrium
- Utilities:
  $\frac{\delta\left(U_{f_{coop}} - U_{f_{nash}}\right)}{\delta\phi} > 0$ and $\frac{\delta\left(U_{v_{coop}} - U_{v_{nash}}\right)}{\delta\phi} > 0$
  As a consequence, we find that the more integrated the regions, the larger the gap between utilities

Summary of results

- In a country, rising environmental standards improves the environmental quality at the expense of the economic activity; the reallocation of firms abroad creates a leakage effect which can eventually undermine national pollution-control efforts
- Due to strategic considerations, the non cooperative equilibrium is characterized by suboptimal environmental regulation; the welfare cost of non cooperation increases with trade liberalization
- Trade liberalization is welfare improving only when countries do cooperate on environmental matters