

Environmental Regulations, International Trade and Strategic Behavior

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Trade and the Environment

- **Impact of trade liberalization on the environment**
- **international competitiveness and environmental regulation**
- **international environmental agreements, free riding and trade**
- **trade in hazardous substances**
- **Strategic environmental policy**
 - **Eco-dumping or Race-to-the-bottom**

Eco-dumping: Relaxing environmental standards in order to generate competitive advantage over the trading partners

Earlier Studies:

- Conrad (1993),
- Rauscher (1994),
- Kennedy (1994),
- Barrett (1994),
- Ulph (1996).

Strategic Behavior by Governments

- Type of regulation instrument (tax or standards)
- Market type
- Type of pollution (local or tranboundary)

Strategic Behavior by Producers (R&D Investment)

Ulph (1996) shows in a 2x2x1 model

- Allowing producers to act strategically always reduces the incentives for governments to relax their environmental policies
- Allowing governments to act strategically always increases the incentives for producers to act strategically
- Welfare is lower when both act strategically

In this paper, we will study

- explicit and extensive welfare analysis of the strategic behavior among producers and governments
- Equilibrium of the strategic game (in the sense of Nash) for both sequential and simultaneous moves

MODEL

- Two countries (symmetric)
- One producer in each producing a homogeneous good, the production of which generates pollution.
- Competition in a third-country market.
- The inverse demand function: $p = A - x - y$, where p is the price, x is the domestic production, y is the foreign production and A is a positive constant.
- Revenue function for the home country producer is given by $R(x, y) = x(A - x - y)$.
- Total cost function is $\varphi \frac{x^2}{4} + \frac{1}{\varphi}$; φ represents the technology parameter, and $\frac{1}{\varphi}$ the cost of R&D.
- Cost minimizing level of R&D: $\varphi = \frac{2}{x}$; (Efficient Total cost = x)
- Any other R&D level indicates a *strategic behavior* by the producers

MODEL (cont.)

Pollution:

- Local
- Home-country Emission level: $e = x - a$ (it is being assumed that one unit of output generates one unit of emission).
- Producers choose the level of abatement, a .
- The cost of abatement is equal to $\frac{a^2}{2}$.
- The welfare cost of pollution is $\frac{de^2}{2}$, $d > 0$

Profits:

- Domestic firm's profits:
$$\pi_D = (A - x - y) x - x - 0.5(x - e)^2$$
- Foreign firm's profits:
$$\pi_F = (A - x - y) y - y - 0.5(y - \varepsilon)^2$$

Welfare

- Welfare of the domestic country:

$$W_D(e) = (A - x - y) x - x - 0.5(x - e)^2 - 0.5de^2$$

- Welfare of the foreign country:

$$W_F(\varepsilon) = (A - x - y) y - y - 0.5(y - \varepsilon)^2 - 0.5d\varepsilon^2$$

Welfare Analysis of Behaviours of Governments and Producers

- **Symmetric Cases:**
 - 1) neither the governments nor the producers are acting strategically in both countries (NS—NS),
 - 2) only governments are acting strategically (GS—GS),
 - 3) only producers are acting strategically (PS—PS),
 - 4) both governments and producers are acting strategically (Both—Both)
 - **Non- Symmetric Cases:**
 - 5) domestic government and producer are acting non-strategically (NS), and only the foreign government is acting strategically (GS) --- (NS versus GS)
 - 6) non-strategic behavior in the domestic country (NS), and only the foreign producer is acting strategically (PS)--- (NS versus PS)
- Similarly
- 7) NS versus Both,
 - 8) GS versus PS,
 - 9) GS versus Both,
 - 10) PS versus Both .

There will be six more cases: the reciprocals of the cases 5 to 10.

Three stages of the game:

- In the first stage, governments choose the emission levels, e and ε , domestic and foreign respectively.
- Then the producers take the emission levels as given, and choose their R&D level, φ and ψ , domestic and foreign respectively.
- At the final stage the producers choose their output levels (x and y) using the emission levels set by the governments, and the R&D levels set in the second stage

Case: Both Governments and Producers Act Strategically

Domestic Government:

$$\max_e W(e) = (A - x - y)x - \varphi x^2 / 2 - 1 / \varphi - 0.5(x - e)^2 - 0.5de^2$$

First order conditions:

$$e(1 + d) = x \left(1 - \frac{\partial y}{\partial e} - \frac{\partial y}{\partial \psi} \frac{\partial \psi}{\partial e} \right)$$

Domestic Producer :

$$\max_{\varphi} (A - x - y)x - \varphi x^2 / 4 - 1 / \varphi - 0.5(x - e)^2$$

First order conditions:

$$1 / \varphi^2 = x^2 / 4 + x \frac{\partial y}{\partial \varphi}$$

Due to symmetry one can easily derive Foreign counterparts of above equations.

Case: Only Domestic Government and Foreign Producer are Acting Strategically (GS versus PS)

Domestic Government:

$$\max_e W(e) = (A - x - y)x - x - 0.5(x - e)^2 - 0.5de^2$$

First order conditions:

$$e(1 + d) = x \left(1 - \frac{\partial y}{\partial e} - \frac{\partial y}{\partial \psi} \frac{\partial \psi}{\partial e} \right)$$

Domestic Producer :

$$\max_x (A - x - y)x - x - 0.5(x - e)^2$$

First order conditions:

$$x = (A - 1 + e - y) / 3$$

Foreign Government:

$$\max_{\varepsilon} W(\varepsilon) = (A - x - y)y - y - 0.5(y - \varepsilon)^2 - 0.5d\varepsilon^2$$

First order conditions:

$$\varepsilon = \frac{y}{1 + d}.$$

Foreign Producer :

$$\max_{\psi} (A - x - y)y - \psi y^2 / 4 - 1/\psi - 0.5(y - \varepsilon)^2$$

First order conditions:

$$\frac{1}{\psi^2} = \frac{y^2}{4} + y \frac{\partial x}{\partial \psi}$$

NASH EQUILIBRIUM

- **Simultaneous Move Game:**

Welfare Levels:

		Foreign Country							
		NS		GS only		PS only		BOTH	
Domestic Country	NS	8,505	8,505	8,532	8,593	8,149	8,297	7,968	8,337
	GS only	8,593	8,532	8,252	8,252	8,177	8,103	8,017	8,143
	PS only	8,297	8,149	8,103	8,177	8,423	8,423	8.014	8.231
	BOTH	8,337	7,968	8,143	8,017	8.231	8.014	8.070	8.070

Producers' Profits.

		Foreign Producer							
		NS		GS only		PS only		BOTH	
Domestic Producer	NS	9,315	9,315	9,311	9,611	8,964	9,153	8,765	9,452
	GS only	9,611	9,311	9,330	9,330	9,262	8,944	9,082	9,231
	PS only	9,153	8,964	8,944	9,262	9,248	9,248	8.839	9.324
	BOTH	9,452	8,765	9,231	9,082	9.324	8.839	9.136	9.136

NASH EQUILIBRIUM (cont)

- Sequential Move Game:

Welfare Levels:

		Foreign Country							
		NS		GS only		PS only		BOTH	
Domestic Country	NS	8,505	8,505	8,532	8,593	8,149	8,297	7,968	8,337
	GS only	8,593	8,532	8,252	8,252	8,177	8,103	8,017	8,143
	PS only	8,297	8,149	8,103	8,177	8,423	8,423	8,014	8,231
	BOTH	8,337	7,968	8,143	8,017	8,231	8,014	8,070	8,070

Producers' Profits

		Foreign Producer			
		NS		PS only	
Domestic Producer	GS only	9,611	9,311	9,262	8,944
	Both	9,452	8,765	9,324	8,839

Emission Levels.

	NS		GS only		PS only		BOTH	
NS	1,285	1,285	1,269	1,444	1,276	1,308	1,262	1,493
GS only	1,444	1,269	1,472	1,472	1,473	1,296	1,459	1,475
PS only	1,308	1,276	1,296	1,473	1,297	1,297	1,284	1,478
BOTH	1,493	1,262	1,475	1,459	1,478	1,284	1,459	1,459

Conclusions

- There is a unique Nash equilibrium in the simultaneous-move game:
 - Both producers and governments behave strategically.
 - Both countries end up with a lower welfare and higher emission level than the case in which none behaves strategically.
- In the sequential-move game, two equilibria exist, but one dominates the other in terms of both the welfare and emission levels:
 - First-moving (leader) government acts strategically, the follower government will not act strategically, and none of the producers will behave strategically.
 - The first-moving country gets higher welfare than the follower country. Similarly, producer in the first-moving country gets higher profits than the producer of the follower country. Furthermore, as expected, emission level is higher in the first-moving country because of the strategic behavior
- The highest welfare levels correspond to the cases in which only one government acts strategically
- Allowing governments to act strategically does not increase the incentives for producers to act strategically as opposed to earlier findings.