International Biodiversity Management with Technological Change

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Contents

Introduction

I consider an economy where

- the conservation of land yields utility through biodiversity,
- firms improve their efficiency by in-house R&D,
- a number of countries establish a self-interested international agency for biodiversity management, and
- the countries lobby the international agency over its policy.

I compare the regulation of land use with direct subsidies for conserved land.

Institutional background

- The "international agency" called the European Commission (EC) manages biodiversity.
- Two directives regulate nature conservation in the the European Union (EU) (cf. Ostermann 1998):
  - Birds Directive 79/409/EEC on the conservation of wild birds;
  - Habitats Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora.
- These directives contain annexes with habitats and species listed as being of Community interest, and whose conservation requires the designation of sites by the Member States.

Non-governmental organizations (NGOs)

Non-governmental organizations (NGOs) play a crucial role in the highly complex political structure of the EU:

- Weber and Christophersen (2002) describe the political influence of the forest-owner associations (CEPF and BNFF) and the environmental NGOs (WWF and Fern) on the process of implementing the EU habitats directive (HD).
- They highlight the relationship between the involvement of interest groups in the political process and the acceptance of legislation among their members.

In this paper, I examine the political equilibrium in which the interest groups representing the member countries lobby the Commission over biodiversity management.

EU policy

EU policy relies heavily on regulation rather than on other mechanisms to achieve its objectives:

- Until 1987, EU environmental policy lacked a proper legal basis in the founding Treaty of Rome.
  - Environmental policies had to rely on the “implied powers” of Article 235 of the Treaty, which stipulated the use of directives and nothing else.
- With the ratification of the 1999 Amsterdam Treaty, the EU can only adopt eco-taxes and other fiscal measures with the unanimous agreement of every state (Jordan 1998).
- The founding Member States gave the EU a powerful institutional incentive to regulate wherever possible.
  - From the Commission’s perspective, regulation has the benefit of being paid for by private actors in the Member States rather than the EU itself.

The problem for study

I consider biodiversity management in three cases:

- There is no such international authority as the Commission.
- The current situation in the EU: regulation by the Commission.
- The Commission gets more authority: it can use subsidies and distribute the costs of these to the member countries.

The comparison of these cases reveals whether or not the Commission's present authority is adequate.

Literature I

MacArthur and Wilson (1967)

- show that the total number of species is an increasing function of the habitat area.

Swanson (1994), Barbier and Schulz (1997) and Endres and Radke (1999)

- consider the optimal area of habitat, comparing the benefits of its maintenance with the opportunity cost of using land in production
- analyze the effects of an external shock (e.g. a change in trade policy) on biodiversity.

Literature II

Rowthorn and Brown (1999)

- introduce exogenous technological change into the optimal habitat model
- show that on general conditions a country with a high discount rate preserves more land.

The role of technological change

- Without endogenous technological change, the optimal choice of a habitat is merely that of allocating land between conservation and production.
- With endogenous technological change, there is the following link between biodiversity and economic growth.
  - The protection of biodiversity requires transferring land from production to conservation.
    - $\Rightarrow$ Employment in production and wages fall.
    - $\Rightarrow$ Lower wages encourage labor-intensive R&D to expand, thus speeding up technological change and economic growth.

Because this link may play an important role, I introduce R&D into the optimal habitat model.

Theory for lobbying

- To consider the political economy of biodiversity management, I introduce lobbying into the the optimal habitat model. This can be examined either by
  - the *all-pay auction model* in which the lobbyist making the greater effort wins with certainty,
  - or the *menu-auction model* in which the lobbyists announce their bids contingent on the politician's actions.
- I use the menu-auction model, because it characterizes the case in which
  - the international agency's decision variables lobbied over (e.g., regulatory constraints, subsidies) are continuous
  - the interest groups obtain marginal improvements in their position by lobbying.

Countries

- An economy with a large number of countries which are placed evenly over the limit $[0, 1]$.
- All countries produce the same consumption good at the price p.
- Each country j possesses
  - one unit of labor, of which the amount l_j is devoted to production and the rest z_j to in-house R&D
  - one unit of land, of which the amount n_j is devoted to production and the rest b_j to conservation

Biodiversity

MacArthur and Wilson (1967)

- show empirically that the number of species expected to survive in an island is proportional to the area of that island.

Following Rowthorn and Brown (1999), I assume that

- in each country j, the area devoted to conservation, b_j, functions like an “islandïn the MacArthur-Wilson sense.

Thus, *biodiversity* in the economy, b, can be specified simply as the sum of conserved areas in the economy:

$$b \doteq \int_0^1 b_k dk.$$

Utility

- In each country j, there is a single revenue-maximizing agent (hereafter called country j) that controls all resources in that country.
- The utility of country j starting at time T is

$$\int_T^\infty c_j b^\delta e^{-\rho(\theta-T)} d\theta, \quad \delta > 0, \quad \rho > 0,$$

where θ is time, ρ the constant rate of time preference, c_j the consumption of country j, b biodiversity, and δ a parameter: the higher δ, the more the households appreciate biodiversity in the economy, b.

The numeraire

Because there is no money in the model that would pin down the nominal price level at any time, I can choose the monetary unit so that the consumer price $(1+\tau)p$, where p is the producer price and τ is the consumption tax, is equal to the externality effect b^{δ} in the model:

$$(1+\tau)p = b^{\delta} \quad \text{or} \quad p = b^{\delta}/(1+\tau).$$

Technology

- When country j develops a new technology, it increases its total factor productivity (TFP) by the constant $a > 1$.
  - Its TFP is then equal to a^{γ_j}, where γ_j is its technology serial number.
- Given TFP, country j is subject to the CES production function $f(l_j, n_j)$ with constant returns to scale, where l_j (n_j) is the input of labor (land):

$$y_j = a^{\gamma_j} f(l_j, n_j), \quad f_l > 0, \quad f_n > 0, \quad f_{ll} < 0, \quad f_{ln} = -f_{ll} l_j / n_j,$$
$$f_{nn} = -f_{ln} l_j / n_j = f_{ll} (l_j / n_j)^2,$$

where the subscript l (n) denotes the partial derivative with respect to l_j (n_j).

The markets

- In this one-good economy, total consumption is equal to total production:

$$\int_0^1 c_j dj = \int_0^1 y_k dk.$$

- With competitive markets, the producer real wage (rent) w_j (r_j) is determined by the marginal product of labor (land):

$$w_j = \partial y_j / \partial l_j = a^{\gamma_j} f_l(l_j, n_j), \quad r_j = \partial y_j / \partial l_j = a^{\gamma_j} f_n(l_j, n_j).$$

- The international agency
  - does not observe the level of productivity, a^{γ_j}, but
  - observes the wage w_j and the rent r_j

technology

- The improvement of technology in country j depends on labor devoted to R&D in that country, z_j.
- In a small period of time dt,
  - the probability that R&D will lead to development of a new technology with a jump from γ_j to $\gamma_j + 1$ is given by $\lambda z_j dt$,
  - the probability that R&D will remain without success is given by $1 - \lambda z_j dt$, where the constant λ is productivity in R&D.
- This defines a Poisson process χ_j with

$$d\chi_j = \begin{cases} 1 & \text{with probability } \lambda z_j dt, \\ 0 & \text{with probability } 1 - \lambda z_j dt, \end{cases}$$

where $d\chi_j$ is the increment of the process χ_j.

The measure of economic growth

- The expected growth rate of productivity a^{γ_j} is given by

$$g_j \doteq E\left[\log\, a^{\gamma_j+1} - \log\, a^{\gamma_j}\right] = (\log a)\lambda z_j,$$

where E is the expectation operator.

- Because the growth rate g_j is in fixed proportion to labor devoted to R&D, z_j, one can use z_j as the measure of economic growth.

The international agency

- The only revenue-raising tax is the tax τ on consumption expenditure $p\int_0^1 c_k dk$, where p is the consumption price and c_k consumption in country k.
- With a subsidy η to R&D expenditure $w_j z_j$ and a subsidy s to expenditure on conserved land, $r_j b_j$, the international agency's budget is

$$\tau \int_0^1 c_k dk = \int_0^1 (\eta w_j z_j + s r_j b_j) dj.$$

- The international agency decides on the minimum proportion of conserved land, $\underline{b}$, for all country j:

$$b_j \geq \underline{b} \in [0,1] \text{ for } j \in [0,1].$$

The possibility of multiple equiliria

In order to avoid multiple equilibria, I assume that the countries are biased for a low tax rate:

Assumption

If the countries face two candidates for the international agency so that both of these offer the same level of welfare for them but with a different tax rate τ, then they vote for the one with a lower tax rate τ.

Political contributions

- Country j pays political contributions R_j to the international agency.
- I assume, for simplicity, that the international agency consists of civil servants, of which a constant proportion $g_j \in [0, 1]$ inhabits country j. It is then true that

$$\int_0^1 g_k dk = 1.$$

Thus, each country j gets a constant share g_j of total contributions

$$R = \int_0^1 R_k dk.$$

Pareto optimum

- For the sake of comparison, I consider a *benevolent* international agency that claims no political contributions, $R_j = 0$ for all j, uses subsidies (s, η) to both R&D and conserved land
- This benevolent agency maximizes the expected value of the geometric average of the utility of the countries in the whole economy:

$$E \int_T^{\infty} cb^{\delta} e^{-\rho(\theta - T)} d\theta \quad \text{with} \quad \log c \doteq \int_0^1 \log c_j dj.$$

- Because the planner controls the allocation of resources completely by the subsidies (s, η), it attains the Pareto optimum (I^P, b^P).

The international agency

Assume a *self-interested* international agency that

- has no budget of its own, $s = \eta = \tau = 0$,
- controls the proportion of conserved land directly by setting $b = \underline{b}$, and
- maximizes the present value of the expected flow of the political contributions at time T,

$$E \int_T^\infty \int_0^1 R_j e^{-\rho(\theta - T)} d\theta = \frac{1}{\rho} \int_0^1 R_j dj.$$

Common agency game

In this common agency game, the regulatory constraint b is a public policy instrument. In line with Grossman and Helpman (1994), I construct a common agency game as follows:

1. The countries set their political contributions R_j conditional on the international agency's prospective policy b, taking total contributions R as given.
2. The international agency sets b and collects the contributions.
3. The countries maximize their expected utility given the contributions R_j and R.

This game is solved in reverse order: first for a country (stage 3) and then for the political equilibrium (stages 2 and 1).

Results

Proposition

Direct regulation is Pareto optimal, $(I^R, b^R) = (I^P, b^P)$.

The international agency, benevolent or self-interested, eliminates the externality due to biodiversity as a macroeconomic decision-maker.

The international agency

Assume that the self-interested international agency

- has a budget of its own
- imposes the conservation subsidy s
- cannot fully distinguish between R&D and other labor expenditures, so that the R&D subsidy η is incentive incompatible.

Without losing any generality, I can then choose $\eta = 0$.

Common agency game

In this common agency game, the subsidy s is a public policy instrument. I construct a common agency game as follows:

1. The countries set their political contributions R_j conditional on the international agency's prospective policy s, taking total contributions R as given.
2. The international agency sets s and collects the contributions.
3. The countries maximize their expected utility given the contributions R_j and R.

This game is solved in reverse order: first for a country (stage 3) and then for the political equilibrium (stages 2 and 1).

The possibility of multiple equilibria

The equilibrium conditions for the common agency game define the tax rate τ, labor devoted to production and the level of regulation, b, as a function of the subsidy s:

$$\tau(s), \quad l^S(s), \quad b^S(s).$$

Because the derivatives of these functions are mathematically ambiguous, I make the plausible assumption that the direct effect of the subsidy s dominates:

Assumption

An increase in the subsidy s to conserved land increases both the supply of conserved land, $(b^S)' > 0$, and the tax that is needed for financing the increase of the subsidy, $\tau' > 0$.

Results 1

Proposition

The equilibrium with conservation subsidies is Pareto suboptimal, $(I^S, b^S) \neq (I^P, b^P)$. Consequently, a switch from regulation to conservation subsidies decreases welfare.

This is because the international agency imposes a distorting consumption tax τ to finance the conservation subsidy s. With direct regulation, there is no distorting taxation.

Results 2

Because the equilibrium (l^S, b^S) is Pareto suboptimal, then the same welfare can be attained by two tax rates τ (with corresponding subsidies s):

- With the higher tax rate τ, the subsidy s is higher and consequently, the amount of conserved land is bigger than at Pareto optimum, $b^S > b^P$.
- With the lower tax rate τ, the subsidy s is lower and consequently, the amount of conserved land is smaller than at Pareto optimum, $b^S < b^P$.

Given Assumption, only the equilibrium with a lower tax rate, $b^S < b^P$, is feasible.

Results 3

Proposition

A switch from direct regulation into conservation subsidies decreases both the growth rate (i.e. $g^R = g^P > g^S$) and biodiversity in each country (i.e. $b^R = b^P > b^S$).

Because any inefficiency decreases the resources of the economy, there are less resources to be put into R&D and the conservation of biodiversity.
With less R&D, economic growth is slower.

Conclusions 1

Direct regulation The international agency determines the use of land throughout the whole economy, fully internalizing the externality through biodiversity.

Conservation subsidies Revenue-raising taxes cause distortions.

A shift from subsidies to direct regulation removes the distortion due to revenue-raising taxes.

$\Rightarrow$ Investment in R&D increases, promoting economic growth.

$\Rightarrow$ The transfer of labor from production to R&D decreases the demand for land in production.

$\Rightarrow$ Conserved land increases, promoting biodiversity.

Conclusions 2

- The prospect of lobbying changes the outcome of biodiversity management fundamentally.
  - A larger package of policy instruments leads to Pareto improvement with a benevolent international agency, but to Pareto worsening with a self-interested one.
- In the case of Natura 2000, regulation without a budget is the appropriate degree of authority for the Commission.
  - Greater authority narrows biodiversity and slows down economic growth.