Regulation versus Subsidies in Conservation with a Self-Interested Policy Maker

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Abstract

This article examines the following case. A set of countries produce goods from labor, government input and natural resources. Because the conservation of natural resources in any country yields utility (e.g. through biodiversity) in every country, and because there is no benevolent international government, a resident of the countries is chosen as the regulator to whom conservation policy is delegated. The countries influence the regulator by their political contributions. In this common agency setup, the following result is proven: as long as the minimum conservation standards are implemented, conservation subsidies are welfare decreasing, involving excessive conservation. This suggests that there should be no "co-financing" for designated conservation sites in the EU *NATURA 2000* project.

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1. Introduction

This article considers the case where the management of the conservation of environment must be delegated to a potentially *self-interested* regulator. The research question is then the following: Are regulatory standards sufficient, or should subsidies as well be used in conservation?

This article is motivated by the following experience. In the the *European Union (EU)*, the *European Commission (EC)* regulates the conservation of biodiversity by two directives (cf. Ostermann 1998):

- *Birds Directive* 79/409/EEC establishes a network of designated sites called *Special Protection Areas (SPAS)* for wild birds.

- *Habitats Directive* 92/43/EEC establishes a network of designated sites called *Special Areas of Conservation (SACS)* for the conservation of natural habitats and of wild fauna and flora.

These two directives contain annexes where habitats and species are listed as being of Community interest. The *NATURA 2000* network consist of both *SPAS* and *SACS* sites. A Member State is obliged to guarantee a "Favorable Conservation Status" to every NATURA 2000 site. *Non-governmental organizations (NGOs)* play a crucial role in the political structure of the EU. For instance, according to Weber and Christophersen (2002), the forest-owner associations (CEPF and BNFF) and the environmental NGOs (WWF and Fern) perform political influence on implementing the Habitats Directive.

There has been three reasons for why EU policy has traditionally relied on direct regulation rather than on financial measures:

(i) Until 1987, EU environmental policy lacked a proper legal basis. It had to rely only on the "implied powers" of Article 235 of the 1957 Rome Treaty, which stipulated the use of directives (Ledoux et al. 2000).

(ii) With the ratification of the 1999 Amsterdam Treaty, the EU could adopt eco-taxes and other fiscal measures only with the unanimous agreement of all states (Jordan 1998). This caused a threshold for ecological tax reforms and a continuing institutional inducement to rely on regulation.

(iii) Because the founding Member States vested the EU only with a little financial resources, from the viewpoint of the Commission, regulation had the benefit of being paid for by private actors in the Member States rather than the EU itself (Majone 1996).

Would it be useful to extend the authority of the Commission beyond direct regulation? There has been political pressure towards the co-financing of the regulatory sites through the budget of the Commission.

Swanson (1994), Barbier and Schulz (1997) and Endres and Radke (1999) consider the optimal area of a habitat when the variety of species yields utility, comparing the benefits of maintaining the habitat with those of using land in production. Barrett (1994), Swanson (1996), Sarr et al. (2008), Gatti et al. (2011) examine biodiversity management in a world where some countries (called the "South") are highly endowed with biodiversity, while the others (called the "North") are the primary location of the research and development industries relying upon these resources. In that case, the problem is how developing countries should be compensated for the "incremental costs"of biodiversity conservation. Because I focus on the case of the European Union (EU), I rather work with a model where every country is endowed with biodiversity that enhances welfare for the inhabitants of all countries. The problem is then how the common policy should be organized, given that the policy makers are potentially self-interested.

Winands et al. (2013) consider how the heterogeneity of countries with respect to ecosystems and wealth influences the stability of international agreements on biodiversity conservation. They model a coalition formation game and obtain following results. In the absence of inter-country transfers, heterogeneity in ecosystems and wealth reduces the size of a stable coalition, but with optimal transfers, even large coalitions can be stable. In contrast to Winands et al. (2013), I consider the case where countries lobby the regulator that manages conservation, but where any individual country can refuse from conservation at a fixed cost. The problem is then to find out the optimal set of tools for the regulator.

Palokangas (2013) examines biodiversity management by a self-interested regulator for a coalition of countries that perform R&D. He assumes in particular that the countries have the same production function, the same labor supply and the same natural resources. He shows that if the subsidies are financed by a distorting consumption tax, then the introduction of subsidies harms welfare. In this study, I examine a more relevant case where countries have different production functions, different labor supplies and different natural resources. To simplify the analysis, I assume non-distorting taxation and replace R&D by government input to production. In this setup, I show that the introduction of subsidies harms welfare, because it distorts the allocation of labor between the private and government sectors.

The remainder of this article is organized as follows. Section 2 specifies the structure of the model. Section 3 derives the Pareto optimum for the economy, as a point of reference. Section 4 considers the behavior of firms and local governments. Section 5 establishes the political equilibrium, by which the welfare considerations of environmental policy are examined in section 6. The results are summarized in section 7.

2. The economy

There is a large number M of countries $i \in [0, M]$ and a number $J_i \in \mathcal{N}$ of residents in each country i. The total mass of the residents is $J \doteq \int_0^M J_i di$.

2.1. Production

All countries $i \in [0, M]$ supply the same good, which I choose as the numeraire in the model. In country i, exogenous labor supply L_i is allocated between production l_i and public services z_i and exogenous natural resources N_i between production n_i and conservation b_i:

$$L_i = l_i + z_i, \;\; l_i \geq 0, \;\; z_i \geq 0; \quad N_i = n_i + b_i, \;\; n_i \geq 0, \;\; b_i \geq 0. \tag{1}$$

The representative firm in country i produces output y_i from labor l_i, natural resources n_i and public services z_i according to the thrice differentiable and strictly concave function

$$y_i = f^i(l_i, n_i, z_i), \quad f^i_l > 0, \quad f^i_n > 0, \quad f^i_z > 0, \quad f^i_{ll} < 0, \quad f^i_{nn} < 0, \tag{2}$$

where the subscripts l, n or z denote partial derivatives of f^i with respect to l_i, n_i or z_i, correspondingly.

2.2. Externality through natural resources

All residents in the countries $i \in [0, M]$ benefit from the conserved resources b_i of all countries $i \in [0, M]$ according to the CES index

$$B(b) \doteq \left(\frac{1}{M} \int_0^M \beta_i b_i^{1-1/\sigma} \right)^{\sigma/(\sigma-1)}, \quad \sigma \in (0,1) \cup (1, \infty), \quad \int_0^1 \beta_i di = 1, \quad (3)$$

where $b \doteq \{b_i | \, i \in [0, M]\}$ is the vector of conserved resources in all countries, β_i positive constant for $i \in [0, 1]$ and σ the constant elasticity of substitution between any pair b_i and b_k of conserved resources ($k \neq i$). The utility of conservation is an increasing and concave function x of the index B:

$$u(b) \doteq x(B), \ \ dx' > 0, \ \ x'' < 0, \ \ \frac{\partial u}{\partial b_i} = x' \frac{\partial B}{\partial b_i} = \beta_i \frac{x'(B(b))}{M} \left[\frac{B(b)}{b_i} \right]^{1/\sigma} > 0. \quad (4)$$

2.3. Utility

To eliminate aggregation problems and distributional concerns from the model, I assume that all residents $j \in [0, J]$ have the same utility function

$$U_j = I_j + u(b) \text{ for } j \in [0, J], \quad (5)$$

where I_j is the income (= consumption) of resident j and $u(b)$ the common utility of conservation [cf. (4)]. If utility U_j were a non-linear function of income I_j, then the distributional effects would excessively complicate the analysis. With the quasi-linear utility function (5) and the definitions (3) and (4), it is easy to aggregate utilities as follows.

First, the representative resident of the whole economy derives utility from aggregate consumption $c = \int_0^J I_j dj$ and conserved resources b according to [cf. (4) and (5)]

$$U(c,b) \doteq \int_0^J U_j dj = c + Ju(b) \text{ with } c = \int_0^J I_j dj \text{ and}$$
$$\frac{\partial U}{\partial b_i} = J\frac{\partial u}{\partial b_i} = \beta_i \frac{J}{M} x'(B(b)) \left[\frac{B(b)}{b_i}\right]^{1/\sigma} > 0 \text{ for } i \in [0, M]. \tag{6}$$

Because the average number of residents per country, $\frac{J}{M}$, is strictly positive, the marginal utility of conservation b_i in country i, $\frac{\partial U}{\partial b_i}$, is strictly positive.

Second, the representative resident of country $i \in [0, M]$ derives utility from conserved resources b and aggregate revenue in that country, $\int_0^{J_i} I_j dj$, according to [cf. (4) and (5)]

$$\int_0^{J_i} U_j dj = \int_0^{J_i} I_j dj + J_i u(b) \text{ with}$$
$$\frac{\partial}{\partial b_k} \int_0^{J_i} U_j dj = J_i \frac{\partial u}{\partial b_k} = \beta_k \frac{J_i}{M} x'(B(b)) \left[\frac{B(b)}{b_k}\right]^{1/\sigma} \text{ for } k \in [0, M]. \tag{7}$$

Because there is a large number M of countries, the marginal utility of conservation b_k in any country k is negligible, $\lim_{M\to\infty} \frac{\partial}{\partial b_k} \int_0^{J_k} U_j dj = 0$. Thus, the local government in country i (hereafter called *country* i) ignores its effect on the conserved resources b and maximizes total revenue in that country:

$$\int_0^{J_i} I_j dj. \tag{8}$$

2.4. The regulator

One resident $j \in [0, J]$ at a time is elected for some period as the *regulator* that runs conservation policy with the following country-specific tools. First, it sets the minimum amount m_i of natural resources (hereafter called the *regulatory standard*) that must be devoted to conservation [cf. (1)]:

$$b_i \geq m_i \text{ with } m_i \in [0, N_i] \text{ for } i \in [0, M]. \tag{9}$$

Second, the regulator can provide "co-financing" for protected sites (cf. Art. 8, Directive 92/43/EEC). This is an *ad valorem* subsidy s_i to natural resources being used for conservation over and above the regulatory standard, $b_i - m_i$. I assume that direct subsidies to the quantity b_i of a habitat are incentive incompatible, because the values of transactions are, but the transacted quantities of natural resources aren't directly observable.

Each country $i \in [0, M]$ pays political contributions R_i to the regulator. Following Grossman and Helpman (1994), I define the regulator's utility as follows. The regulator cares about its individual welfare $\int_0^M R_i di + u(b)$ [cf. (5)], where its income $\int_0^M R_i di$ consists of total contributions it receives from the countries, and about aggregate welfare U [cf. (6)]: the higher U, the more likely the incumbent regulator will be re-elected. As in Grossman and Helpman (1994), the regulator's utility W is a linear function of both its welfare as an resident, $\int_0^M R_i di + u(b)$, and aggregate welfare U [cf. (6)],

$$W = \alpha U + \int_0^M R_i di + u(b) = \alpha[c + u(b)] + \int_0^M R_i di + u(b), \quad \alpha > 0, \tag{10}$$

where α is a constant. If the utility function of the regulator, W, were non-linear in its arguments $\int_0^M R_i di + u(b)$ and U, then the distributional effects of political contributions R_i would excessively complicate the analysis.

3. Pareto optimum

To derive the Pareto optimum for the countries, let's assume that there were no regulator and that the representative household could directly maximize its utility (6) by the conserved resources $b \doteq \{b_i | \, i \in [0, M]\}$ and public services $z \doteq \{z_i | \, i \in [0, M]\}$, subject to the condition that the sum of the outputs y_i of all countries $i \in [0, M]$ [cf. (1) and (2)] is consumed:

$$c \doteq \int_0^M y_i di = \int_0^M f^i(l_i, n_i, z_i) di = \int_0^M f^i(L_i - z_i, N_i - b_i, z_i) di. \tag{11}$$

This leads to the *Pareto optimality conditions* [cf. (2) and (11)]

$$f_z^i = f_l^i \text{ for } i \in [0, M], \quad \frac{\partial U}{\partial b_i} = f_n^i \text{ for } i \in [0, M]. \tag{12}$$

Production efficiency $f_z^i = f_l^i$ says that the marginal product must be the same for both private labor l_i and government labor z_i in every country $i \in [0, M]$. *Conservation efficiency* $\frac{\partial U}{\partial b_i} = f_n^i$ says that, in each country $i \in [0, M]$, the marginal rate of substitution between consumption and natural resources must be the same in utility and production.

4. Countries

The political economy of conservation is an extensive form game with the following stages: (I) The local governments of the countries $i \in [0, M]$

influence the regulator, relating their prospective political contributions to the latter's decisions. (II) The regulator sets the regulatory standards and subsidies, and collects political contributions. (III) The local governments $i \in [0, M]$ conserve habitats b_i, produce public services z_i and finance these by local lump-sum taxes. (IV) The firms produce the good from labor and natural resources. This game is solved in reverse order: stages (IV) and (III) in subsections 4.1 and 4.2, and (II) and (I) in the next section 5.

4.1. Firms

Firms use natural resources n_i up to the level at which the rent r_i for these is equal to the marginal product of these, $r_i = f_n^i(l_i, n_i, z_i)$ [cf. (2)]. The *subsidy base* in country i, V^i, is then equal to the rent r_i times conserved resources over and above the regulatory standard, $b_i - m_i$, in that country. Noting (1) and (2), I define that base as the following function:

$$\begin{aligned} V^i(z_i, b_i, m_i) &\doteq r_i(b_i - m_i) = (b_i - m_i) f_n^i(l_i, n_i, z_i) \\ &= (b_i - m_i) f_n^i(L_i - z_i, N_i - b_i, z_i), \quad V_m^i \doteq \frac{\partial V^i}{\partial m_i} = -f_n^i < 0, \\ V_z^i \doteq \frac{\partial V^i}{\partial z_i} &= (b_i - m_i)(f_{nz}^i - f_{ln}^i), \;\; V_b^i \doteq \frac{\partial V^i}{\partial b_i} = f_n^i - (b_i - m_i) f_{nn}^i > 0. \end{aligned} \tag{13}$$

4.2. Local governments

To finance the subsidies s_i, the regulator is allowed to collect a uniform tax t from all countries. To keep taxation non-distorting, let t be the tax on given labor supply L_i. Noting (1), (2) and (13), one obtains revenue in country i, (8), as follows:

$$\int_0^{J_i} I_j dj = \pi_i(z_i, b_i, m_i, s_i, t) \doteq y_i + s_i V^i - tL_i$$
$$= f^i(L_i - z_i, N_i - b_i, z_i) + s_i V^i(z_i, b_i, m_i) - tL_i, \tag{14}$$

where y_i is output, s_i the subsidy for the subsidy base V_i [cf. (13)] and tL_i taxes. Because there is a large number of countries $i \in [0, M]$, the local government in country i (hereafter country i) ignores its effect on the tax t. Thus, country i determines its public services z_i and conserved resources b_i to maximize the utility of its residents' aggregate revenue (14) subject to the regulatory constraint (9), given the tax t. Given the definition (13), this maximization yields the equilibrium conditions (cf. the Appendix)

$$\Pi_i(m_i, s_i, t) \doteq \max_{z_i,\, b_i \geq m_i} \int_0^{J_i} I_j dj = \max_{z_i,\, b_i \geq m_i} \pi_i(z_i, b_i, m_i, s_i, t),$$
$$\frac{\partial \Pi_i}{\partial s_i} = \frac{\partial \pi_i}{\partial s_i} = V^i, \quad \frac{\partial \Pi_i}{\partial t} = \frac{\partial \pi_i}{\partial t} = -L_i, \tag{15}$$
$$s_i V_z^i(z_i, b_i, m_i) - f_l^i(L_i - z_i, N_i - b_i, z_i) + f_z^i(L_i - z_i, N_i - b_i, z_i) = 0, \tag{16}$$
$$s_i V_b^i(z_i, b_i, m_i) - f_n^i(L_i - z_i, N_i - b_i, z_i) \begin{cases} = 0 & \text{for } b_i > m_i, \\ < 0 & \text{for } b_i = m_i, \end{cases} \tag{17}$$
$$\frac{\partial \Pi_i}{\partial m_i} = s_i(V_m^i + V_b^i) - f_n^i. \tag{18}$$

From (2) and (17) it follows that the regulatory constraint (9) is binding without a subsidy (i.e. with $s_i = 0$):

$$-f_n^i < 0, \quad b_i\Big|_{s_i=0} = m_i, \quad \frac{\partial b_i}{\partial m_i}\bigg|_{s_i=0} = 1. \tag{19}$$

Because the production function (2) is thrice differentiable, the subsidy base (13) is twice differentiable and the first-order conditions (16) and (17) define diffentiable response functions for country i (cf. the Appendix):

$$z_i(m_i, s_i), \quad b_i(m_i, s_i), \quad \left.\frac{\partial b_i}{\partial s_i}\right|_{s_i=0} > 0. \tag{20}$$

In other words, a small subsidy s_i to conservation increases resources b_i devoted to conservation in any country $i \in [0, M]$.

5. The political equilibrium

To enable an equilibrium with lobbying, I assume the following: if country $i \in [0, M]$ is not involved in conservation management, then it is not subject to the regulatory constraint (9), it does not pay the tax t to the regulator, does not obtains the subsidy s_i, but it pays a constant penalty $\xi_j > 0$ to the other countries. In this *outside option*, the revenue of country i is [cf. (14)]

$$\underline{\pi}_i = \max_{z_i, b_i \geq 0, s_i = t = 0} \pi_i - \xi_i = \max_{z_i} f^i(L_i - z_i, N_i, z_i) - \xi_i = \text{constant}. \tag{21}$$

Given the definition (13) of the subsidy base and the response functions (20) of the countries $i \in [0, M]$, the regulator's budget constraint is then

$$t \int_0^M L_k dk = \int_0^M s_i V_i di = \int_0^M s_i V^i\big(z_i(m_i, s_i), b_i(m_i, s_i)\big) di, \tag{22}$$

where $t \int_0^M L_k dk$ is total tax revenue and $\int_0^M s_i V^i di$ total subsidies. The budget constraint (22) defines the tax t as a function of the regulatory standards

$m \doteq \{m_i | \, i \in [0,M]\}$ and the subsidies $s \doteq \{s_i | \, i \in [0,M]\}$ as follows:

$$t(m,s), \quad \left.\frac{\partial t}{\partial m_i}\right|_{s_k=0\,\forall k\in[0,J]} = 0, \quad \left.\frac{\partial t}{\partial s_i}\right|_{s_k=0\,\forall k\in[0,J]} = \frac{V^i}{\int_0^M L_k dk}. \tag{23}$$

Aggregate consumption c is equal to total revenues $\int_0^M \Pi_i di$. Noting (15) and (23), this condition can be written in the form

$$c = \int_0^M \Pi_i\big(m_i, s_i, t(m,s)\big) di. \tag{24}$$

Following Grossman and Helpman (1994) and Dixit et a. (1997), I assume that each country i can credibly commit itself to its contribution function $R_i(m_i, s_i)$ with any policy (m_i, s_i). With (23) and (24), the utility of the regulator (10) then becomes

$$W(m,s) \doteq \alpha \int_0^M \Pi_i\big(m_i, s_i, t(m,s)\big) + \int_0^M R_i(m_i, s_i) di + (1+\alpha) u\big(b(m,s)\big),$$

$$\text{where } b(m,s) \doteq \{b_i(m_i,s_i) | \, i \in [0,M]\}. \tag{25}$$

Because there is a large number of countries $i \in [0,M]$, country i ignores its effect on the tax rate t. It maximizes its net revenue $\Pi_i(m_i, s_i, t)$ [cf. (15)] minus political contributions R_i, given the tax rate t. The regulator maximizes its utility (25). According to Dixit et al. (1997), a subgame perfect Nash equilibrium for this game is a policy (m,s) and a set of contribution schedules $R_i(m_i, s_i)$, $i \in [0,M]$, such that the following conditions hold:

(a) Contributions R_i are non-negative but no more than the contributor's revenue Π_i.

(b) The policy (m_i, s_i) maximizes the net revenue of country i [cf. (15)]:

$$(m_i, s_i) = \arg\max_{m_i, s_i} \big[\Pi_i(m_i, s_i, t) - R_i(m_i, s_i)\big]. \tag{26}$$

(c) The policy (m, s) maximizes the utility of the regulator:

$$(m, s) = \arg\max_{m,s} W(m, s), \tag{27}$$

(d) Country i provides the regulator at least with the level of utility as in the case it offers nothing ($R_i = 0$), and the regulator responds optimally, given the contribution functions $R_j(m_j, s_j)$ of the other countries $j \neq i$.

Given (15) and (18), the equilibrium conditions (26) are equivalent to

$$\frac{\partial R_i}{\partial m_i} = \frac{\partial \Pi_i}{\partial m_i} = s_i(V_m^i + V_b^i) - f_n^i, \quad \frac{\partial R_i}{\partial s_i} = \frac{\partial \Pi_i}{\partial s_i} = V^i. \tag{28}$$

Conditions (28) say that in equilibrium the change in the contributions of country i, R_i, due to a change in any instrument m_i or s_i equals the effect of that instrument on the revenue of that country, Π_i. These contribution schedules are locally truthful. This concept can be extended to a globally truthful contribution schedule that represents the preferences of country i at all policy points as follows (cf. Dixit et al. 1997):

$$R_i = \max[\Pi_i - \underline{\pi}_i, 0], \tag{29}$$

where $\underline{\pi}_i$ is the revenue of country i in case that country does not pay contributions, $R_i = 0$, but the regulator chooses its best response, given the contribution schedules of the other countries $k \neq i$ [cf. (21)].

6. Welfare considerations

With (15), (25) and (28), the equilibrium conditions of the regulator, (27), for the regulatory standards m are equivalent to

$$\begin{aligned} 0 = \frac{\partial W}{\partial m_i} &= \alpha\bigg(\frac{\partial \Pi_i}{\partial m_i} + \int_0^M \frac{\partial \Pi_k}{\partial t}\frac{\partial t}{\partial m_i} dk\bigg) + (1+\alpha)\frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial m_i} + \frac{\partial R_i}{\partial m_i} \\ &= \alpha\bigg(\frac{\partial \Pi_i}{\partial m_i} - \frac{\partial t}{\partial m_i}\int_0^M L_k dk\bigg) + (1+\alpha)\frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial m_i} + \frac{\partial R_i}{\partial m_i} \\ &= (1+\alpha)\bigg(\frac{\partial \Pi_i}{\partial m_i} + \frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial m_i}\bigg) - \alpha\frac{\partial t}{\partial m_i}\int_0^M L_k dk \;\text{ for } i \in [0, M]. \end{aligned} \tag{30}$$

Furthermore, if the subsidies s are used, then the function (25) has the following partial derivatives [cf. (15) and (28)]:

$$\begin{aligned} \frac{\partial W}{\partial s_i} &= \alpha\bigg(\frac{\partial \Pi_i}{\partial s_i} + \int_0^M \frac{\partial \Pi_k}{\partial t}\frac{\partial t}{\partial s_i} dk\bigg) + (1+\alpha)\frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial s_i} + \frac{\partial R_i}{\partial s_i} \\ &= \alpha\bigg(\frac{\partial \Pi_i}{\partial s_i} - \frac{\partial t}{\partial s_i}\int_0^M L_k dk\bigg) + (1+\alpha)\frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial s_i} + \frac{\partial R_i}{\partial s_i} \\ &= (1+\alpha)\bigg(V^i + \frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial s_i}\bigg) - \alpha\frac{\partial t}{\partial s_i}\int_0^M L_k dk \;\text{ for } i \in [0, M]. \end{aligned} \tag{31}$$

Let's consider the initial position where there are no subsidies, $s_i = 0$ for $i \in [0, M]$. Then, with (16), (19), (23), (28) and (30), the Pareto optimality conditions (12) hold true as follows:

$$\big(f_z^i - f_l^i\big)_{s_k=0\,\forall k\in[0,J]} = 0 \;\text{ and }\; \frac{\partial W}{\partial m_i}\bigg|_{s_k=0\,\forall k\in[0,J]} = (1+\alpha)\bigg(-f_n^i + \frac{\partial U}{\partial b_i}\bigg) = 0$$
for $i \in [0, M]$.

On the other hand, from (6), (20), (23) and (31) it follows that the regulator is willing to increase subsidies s_i above zero:

$$\frac{\partial W}{\partial s_i}\bigg|_{s_k=0\,\forall k\in[0,J]} = (1+\alpha)\left(V^i + \frac{\partial U}{\partial b_i}\frac{\partial b_i}{\partial s_i}\right) - \alpha V^i = \underbrace{V^i}_{+} + \underbrace{(1+\alpha)}_{+}\underbrace{\frac{\partial U}{\partial b_i}}_{+}\underbrace{\frac{\partial b_i}{\partial s_i}}_{+} > 0 \text{ for } i \in [0, M].$$

Thus, the Pareto optimum is not a stable equilibrium with subsidies. With (16), the subsidies $s_i > 0$ violate production efficiency [cf. (12)]

$$f_l^i = f_z^i + s_i V_z^i > f_z^i \text{ for } i \in [0, M], \tag{32}$$

and because $\frac{\partial b_i}{\partial s_i}\Big|_{s_i=0} > 0$ [cf. (20)], they increase conserved resources b_i above the Pareto optimal level. These results can be summarized as follows:

Proposition. *The abolishment of subsidies leads to Pareto optimum. With subsidies, production efficiency is violated by excessive conservation.*

The subsidies distort the allocation of labor between private and public sectors [cf. (32)], violating production efficiency $f_z^i = f_l^i$ [cf. (12)].

7. Conclusions

In this article, I consider an international regulator that runs the conservation of environmental resources for a coalition of countries. Firms make goods from labor, natural resources and public services. The local governments produce public services and lobby the regulator, relating their prospective political contributions to the latter's decisions. The instruments of conservation consist of regulatory standards, and potentially of the subsidies to conserved resources over and above those standards. The main findings are the following. Lobbying for regulatory standards alone leads to Pareto efficiency. The introduction of subsidies generate excessive conservation and distort the allocation of labor between the private and government sectors.

The analysis is based on four basic assumptions: *(i)* there are public inputs to production in the countries; *(ii)* the regulator has interests of its own and it is elected from the residents of the countries, *(iii)* the individual utility is linear in consumption, and *(iv)* revenue-raising taxation is non-distorting. These assumptions can be justified as follows. *(i)* If there were no public services, then all labor would be employed in private production and the subsidies would not distort the allocation of labor between the private and public sectors. *(ii)* As a resident, the regulator shares the same preferences with the other residents. Thus, the fully benevolent regulator would not introduce conservation subsidies alongside regulatory standards. *(iii)* With a non-linear utility function, the payment of political contributions would involve distributional effects, which would excessively complicate the analysis. *(iv)* According to Palokangas (2013), distorting taxation for the payment of subsidies involves inefficiency, which strengthens the result of this article.

While a great deal of caution should be exercised when a highly stylized game-theoretical model is used to derive results on conservation policy, the following conclusion is nevertheless justified. In the EU project *NATURA 2000*, the power to set regulatory standards is appropriate. If there is any reason to believe that the policy makers in the EU have interests of their own, "co-financing" alonside regulatory standards hampers welfare.

Appendix

Country i maximizes maximizes

$$\pi_i(z_i, b_i, m_i, s_i, t) \doteq f^i(\underbrace{L_i - z_i}_{l_i}, \underbrace{N_i - b_i}_{n_i}, z_i) + s_i V^i(z_i, b_i, m_i) - tL_i \tag{33}$$

by (z_i, b_i) subject to $b_i \geq m_i$. The Lagrangean for this maximization is

$$\Lambda \doteq \pi_i + \lambda(b_i - m_i), \tag{34}$$

where the multiplier λ satisfies the Kuhn-Tucker conditions

$$\lambda \geq 0, \quad \lambda(b_i - m_i) = 0. \tag{35}$$

Noting (33) and (34), one obtains the first-order conditions

$$\frac{\partial \Lambda}{\partial z_i} = \frac{\partial \pi_i}{\partial z_i} = s_i V_z^i(z_i, b_i, m_i) - f_l^i(L_i - z_i, N_i - b_i, z_i) + f_z^i(L_i - z_i, N_i - b_i, z_i)$$

$$= 0, \tag{36}$$

$$\frac{\partial \Lambda}{\partial b_i} = \frac{\partial \pi_i}{\partial b_i} + \lambda = s_i V_b^i(z_i, b_i, m_i) - f_n^i(L_i - z_i, N_i - b_i, z_i) + \lambda = 0. \tag{37}$$

Condition (36) is equivalent to (16). Noting (33), (34), (35) and (37), one can define (15), (17) and (18):

$$\Pi_i(m_i, s_i, t_i + R_t) \doteq \max_{z_i, b_i \geq 0} \pi_i = \max_{z_i, b_i} \Lambda, \quad \frac{\partial \Pi_i}{\partial s_i} = \frac{\partial \Lambda}{\partial s_i} = \frac{\partial \pi_i}{\partial s_i} = V^i,$$

$$\frac{\partial \pi_i}{\partial b_i} = s_i V_b^i(z_i, b_i, m_i) - f_n^i(L_i - z_i, N_i - b_i, z_i) = -\lambda \begin{cases} = 0 & \text{for } b_i > m_i, \\ < 0 & \text{for } b_i = m_i, \end{cases}$$

$$\frac{\partial \Pi_i}{\partial m_i} = \frac{\partial \Lambda}{\partial m_i} = \frac{\partial \pi_i}{\partial m_i} - \lambda = s_i V_m^i - \lambda$$
$$= s_i \big[V_m^i(z_i, b_i, m_i) + V_b^i(z_i, b_i, m_i) \big] - f_n^i(L_i - z_i, N_i - b_i, z_i).$$

Finally, let's consider the case $b_i > m_i$. Then, $\lambda = 0$ holds by (35) and the second-order conditions are

$$\frac{\partial^2 \pi_i}{\partial z_i^2} < 0, \quad Q \doteq \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} > 0. \tag{38}$$

Furthermore, from (13), (36) and (37) it follows that

$$\left.\frac{\partial^2 \pi_i}{\partial b_i \partial z_i}\right|_{s_i=0} = f_{ln}^i - f_{nz}^i, \quad \left.\frac{\partial^2 \pi_i}{\partial z_i^2}\right|_{s_i=0} = f_{ll}^i - 2f_{lz}^i + f_{zz}^i, \quad \left.\frac{\partial^2 \pi_i}{\partial b_i^2}\right|_{s_i=0} = f_{nn}^i,$$
$$\frac{\partial^2 \pi_i}{\partial b_i \partial s_i} = V_b^i = f_n^i - (b_i - m_i) f_{nn}^i,$$
$$\frac{\partial^2 \pi_i}{\partial z_i \partial s_i} = V_z^i = (b_i - m_i)(f_{nz}^i - f_{ln}^i) = (m_i - b_i) \left.\frac{\partial^2 \pi_i}{\partial b_i \partial z_i}\right|_{s_i=0}.$$

Given these results, (2) and (38), one obtains

$$\left.\frac{\partial b_i}{\partial s_i}\right|_{s_i=0} = -\frac{1}{Q} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ \frac{\partial^2 \pi_i}{\partial z_i \partial s_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix} = -\frac{1}{Q} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ (m_i - b_i)\frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix}$$
$$= -\frac{1}{Q} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} + (b_i - m_i)\frac{\partial^2 \pi_i}{\partial b_i^2} + (m_i - b_i)\frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ (m_i - b_i)\frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix}$$
$$= \frac{b_i - m_i}{Q} \underbrace{\begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix}}_{Q} - \frac{1}{Q} \begin{vmatrix} \frac{\partial^2 \pi_i}{\partial b_i \partial s_i} + (b_i - m_i)\frac{\partial^2 \pi_i}{\partial b_i^2} & \frac{\partial^2 \pi_i}{\partial b_i \partial z_i} \\ 0 & \frac{\partial^2 \pi_i}{\partial z_i^2} \end{vmatrix}$$

$$
\begin{aligned}
&= b_i - m_i - \frac{1}{Q}\frac{\partial^2 \pi_i}{\partial z_i^2}\left[\frac{\partial^2 \pi_i}{\partial b_i \partial s_i} + (b_i - m_i)\frac{\partial^2 \pi_i}{\partial b_i^2}\right] \\
&= b_i - m_i - \frac{1}{Q}\frac{\partial^2 \pi_i}{\partial z_i^2}\left[f_n^i - (b_i - m_i) f_{nn}^i + (b_i - m_i) f_{nn}^i\right] \\
&= \underbrace{b_i - m_i}_{\geq 0} - \underbrace{\frac{1}{Q}}_{+}\underbrace{\frac{\partial^2 \pi_i}{\partial z_i^2}}_{-}\underbrace{f_n^i}_{+} > 0.
\end{aligned}
$$

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