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On Local Environmental Protection

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Abstract. We propose a theoretical model to analyze the provision of environmental protection activities with positive interregional externalities in order to verify whether this kind of policy is better accomplished through centralized policymaking, which implies a coordinated solution among local representatives, or by a decentralized system, where local authorities independently finance and implement their environmental protection policy. The research question concerns the identification of criteria on how to allocate powers and functions to environmental management at different tiers of government. Moreover, modelling interregional externalities as a mechanism contributing to lowering the cost of financing environmental policy in each region allows different environmental policies across regions. Given this framework, considerations favouring either institutional setting in terms of individuals' welfare seem to involve the interaction among these key elements: the extent of the inter-jurisdictional spillovers, the size of local jurisdictions, and the intensity of regional preferences for environmental policy.

Keywords: *Cooperation; Environmental federalism; Environmental protection activities; Externalities; Local government size.*

1 Introduction

A part of the literature on fiscal federalism has dealt with environmental policy as a specific case of public goods supply. In particular, according to the literature on environmental federalism (Kraft and Scheberle 1998; Oates 2002; Kunce and Shogren 2005; Dalmazzone 2006; Breton *et al.* 2007), an important role for decentralized governments in setting environmental standards, designing regulatory programs, and monitoring and enforcing such measures can be properly played under certain circumstances. Indeed, for environmental problems that are highly localized, economics suggests that it makes more sense to set standards for environmental quality that reflect local conditions rather than uniform national standards (Schwab 2006). It is commonplace for environmental measures to take the form of centrally (federally) determined standards, with the responsibility for implementation lying in the hands of provincial (state) authorities.

More generally, environmental policymaking does not emanate from a single unitary authority, but is rather the outcome of a multi-layered structure mainly designed by history to deal with the large number of different and sometimes conflicting demands that citizens place on their governments (Breton *et al.* 2007). Several questions posed by the assignment of powers over the environment have been considered in environmental federalism literature (Oates 2002), yet largely ignored in conventional environmental economics.

In this perspective, the aim of this paper is basically to shed some light on how multi-level governance can plan and implement environmental action that would affect the assignment of powers and the design of environmental institutions, recognizing, at the same time, the need for policies aimed not only at controlling pollution and conserving a few particular species, but also at protecting the integrity of ecological systems and functions at local and regional levels. In detail, we theoretically

investigate whether environmental protection activities within a country are better accomplished through centralized policymaking that implies, in our model, a coordinated solution among local representatives, or by a decentralized system wherein local authorities independently finance and implement their environmental policy.

We consider environmental protection activities as "those where the primary purpose is the protection of the environment; that is, the avoidance of the negative effects on the environment caused by economic activities. The activities are generally classified according to the classification of environmental protection activities (CEPA 2000)", whereby environmental protection refers "to any activity to maintain or restore the quality of environmental media through preventing the emission of pollutants or reducing the presence of polluting substances in environmental media"[1] (United Nation *et al*. 2005).

We assume that environmental policy is an "active" government intervention having a cost. Moreover, a common feature of both scenarios is the presence of positive externalities related to the provision of environmental outcome across local jurisdictions. In detail, we treat positive externalities as a mechanism contributing to lowering the cost of environmental protection activities in each region and not as consumption externalities. This assumption is also quite common in practice: the level of environmental quality in jurisdiction *j* usually depends on environmental quality in other regions *k* (e.g., the cost of prevention of landslide risk for one region can be reduced if some others - mostly neighboring - adopt a policy against this kind of risk; the cost of waste disposal can be reduced if others implement similar policies). Thus, it makes sense to assume that positive interregional externalities may be the source of beneficial effects, involving reduced costs to guarantee the same environmental quality, especially in a setting of decentralized policymaking. More importantly, the role of inter-jurisdictional externalities as a reason for the assignment of responsibilities and power over the environment to different tiers of government is not very explored by environmental economists.[2]

Given this framework, one thing is clear: an efficient environmental protection outcome would not generally take the form of uniform national standards, but it is likely to imply different levels of environmental quality across jurisdictions. On this reasoning, we also assume that in both cases - cooperative and non-cooperative decision-making processes - different environmental policies can be implemented across regions. It is also rather unclear from a theoretical viewpoint, why a government entrusted with providing environmental protection in a centralized system cannot differentiate the levels according to the heterogeneous tastes and needs in each district. This assumption seems to be unsatisfactory also on the empirical front. Indeed, there are many examples of goods provided unequally by the central/national government in a federal system.[3]

The *modus operandi* of EU directives to the European member States, for example, is not one of top-down imposition of uniform standards, but a complex decision-making system wherein member States influence the Union's policy formation in the Council as well as at other levels of the policy process (Dalmazzone 2006). When such mechanisms are at work, they probably create wide margins for central policies to reflect local variations across jurisdictions. The key point remains that an environmental policy that has to prevent the cost of environmental degradation (i.e. to anticipate and mitigate the cost of climate change) has to be decided at a local level. Thus, an environmental policy

[1] It may consist of: (a) changes in characteristics of goods and services; (b) changes in consumption patterns; (c) changes in production techniques; (d) treatment or disposal of residuals in separate environmental protection facilities; (e) recycling; (f) prevention of degradation of the landscape and ecosystems (United Nations 1997).

[2] One reason may be that many inter-jurisdictional externalities can be dealt with coordination – a theme which has received attention in the literature on decentralization for example by Inman and Rubinfeld (1997).

[3] The case of federal highway spending in the United States illustrates this well: a significant fraction of funds in the *Federal Highway Aid Program* are earmarked by legislators for specific projects in their districts. This approach of "no policy uniformity" is also adopted by the recent stream of fiscal federalism literature - namely the *Second Generation Theory* (Lockwood 2002, 2006; Besley and Coate 2003) - and it can also be extended to the environmental protection issue.

that is appropriate in one region is unlikely to be appropriate in others. Federal or central regulation is rarely sensitive to these differences. Revesz (1996), for example, shows that in the arena of air quality management, federal measures in the United States have not been very effective in addressing the issue of interstate externalities.

To some extent, this approach should sound familiar to the more general issue of fiscal federalism according to which it would make little sense - on efficiency grounds - to provide the same menu of public services in each community (Oates 1972, 1999; Schwab 2006). Thus, local governments (or states) may be in a better position than the central (or federal) government to choose also the correct level of environmental quality for their constituencies.

Allowing each community, region, and state to design and implement its own distinctive blend of policies and plans that best promise to support environmental protection (Kraft and Scheberle 1998) also implies a system of differentiated taxes that would depend on the location of resources. Such differentiated tax rates are levied separately by each local authority under decentralization and jointly by all regions under centralization (i.e. the case of regional cooperation). Other things equal, the research question remains to compare, in utility terms, the outcome under a cooperative decision-making process with that of a decentralized system that allows each jurisdiction to select its own preferred environmental policy.

In general, a purely decentralized system would be expected to provide too little in the way of research and development environmental activities given that individual state or local government would typically ignore externalities. However, the study by Dinan *et al.* (1999) on the setting of uniform national standards for drinking water in the US highlights the potentially significant magnitude of welfare losses arising from this uniformity.[4] Hence, for environmental matters of strictly local interest (treated as local public goods) a decentralized system of setting environmental standards seems to be more appropriate. Indeed, the "one size fits all" approach[5] can result in large welfare losses compared with a system in which individual jurisdictions introduce standards that are the best suited to their circumstances (Oates 2002).

Nevertheless, it may be difficult to reach a general conclusion for these two prevalent categories of cases. A better approach might be to determine the particular circumstances that favour one of the two alternatives over the other. Such considerations may involve the extent of the inter-jurisdictional positive spillovers, the size of local jurisdictions, and the strength of regional preferences for environmental activities.

The issue of size, for example, is relevant since it allows a range of different public policies under decentralization and centralization. Oates and Schwab (1988) argue that decentralized choices of "small homogeneous jurisdictions" are likely to be socially optimal because each local government sets environmental standards to equate marginal benefits with incremental costs. Kanbur *et al.* (1995) take into account the dimension of a country and show that small countries will reduce their environmental standards to attract foreign investors. More recently, Kunce and Shogren (2005) have highlighted the difficulty of "small" jurisdictions to use efficient tax instruments (i.e. a "firm tax") with the effect of Pigovian remedies to realign the overprotection equilibrium with social efficiency and they have affirmed that without these foremost optimal instruments, distortions persist in both fiscal and environmental choices.

Our results suggest that the role of size in strategic tax and environmental policy design is crucial. Disparity in size may be a source of inefficiency itself, exacerbating the loss that each region suffers as

[4] This is a case where the costs of per capita treatment vary so dramatically across jurisdictions that uniform standards come at a very high welfare cost compared with the efficient pattern of local treatment.

[5] In general, economic institutions need to be designed and shaped, on the basis of general principles, to suit the local context and to embody local knowledge. Indeed, the effectiveness of strictly local services (i.e. water supply, waste disposal, local transport) as well as of more general services (such as education, health care, law and order) strongly depends on their being adapted to places.

a consequence of the non-cooperative behaviour. Hence, increasing differences in population size across regions would lead towards the cooperative solution. Moreover, when introducing spillover effects, it emerges that coordination of environmental protection should not be necessarily pursued by all regions, but it depends on their relative size. In particular, non-cooperation becomes more attractive at high spillover levels for small regions (and those with high preferences for environmental policy), having a stronger incentive to free-ride on each other's policies and production costs.

The remainder of the paper is organized as follows. Section 2 describes some international experience on environmental policymaking. Section 3 outlines the general framework of the model. Section 4 derives conditions under which a cooperative or a non-cooperative institutional system is the most appropriate to implement environmental protection activities (positive analysis), while Section 5 provides some normative suggestions. Finally, Section 6 offers some concluding remarks.

2 Who is the "environmental policy-maker"? Some international experience

Environmental policy is often a joint activity wherein the exact division of responsibilities varies substantially across countries. In the European Union, for example, there is a continuing conflict between a basic commitment to decentralized policymaking - in force of the principle of subsidiarity - and the sense of some others affirming that Europe-wide standards and "harmonization" for environmental quality are needed (Oates 2002; Schwab 2006). The key question of the debate concerns which approach is more suitable between moving towards a greater centralization with more responsibility given for promoting environmental policy to the central (or federal) government or encouraging further decentralization and allowing state and local governments a major role in this kind of policy. Likewise, in the United States there are uniform national standards for high air quality - decided upon by the federal government - but state-specific standards for water quality. In Australia, the approach adopted in addressing environmental issues - e.g., for water supply - has been one of cooperation according to which the policies developed under the "umbrella of cooperation" are monitored by the National Competition Council and reflect the centralist interpretation of the Constitution in the assignment of environmental powers sustained by the High Court of Australia (Petchey 2007).

In turn, the United Nations' Development Program suggests facing the risks and costs of climate change by assigning to national governments the role of setting general standards of environmental protection in order to reduce air pollution. At the same time, the UNDP 4th Global Program 2009-2011 and the Strategic Plan 2008-2013 stress, however, the role of local actors as an essential counterpoint and complement to UNDP's work at national and international levels. In particular, they recognize that local governments have a significant role to play in order to face the adaptation and mitigation costs of climate change or, in general, to decide on how to recover environmental quality. Generally speaking, this local role is crucial for the so-called Environmental Protection Activities (EPA).

A case in point is Brazil, wherein the conservation of its huge endowment of natural resources is not only a domestic issue, even though the task of preserving the Amazonian forests falls mainly on state and local governments (Cavalcanti 2007). Indeed, the federal Parliament adopts a participative approach according to which the responsibility for implementing environmental policy is basically of sub-federal tiers of government. Recent trends towards a greater decentralization of environmental policy have also occurred in Canada wherein although some forms of coordination would be necessary this would result in significant costs that would slow down the political-making process (Valiante 2007). In particular, the implementation of environmental policies occurs primarily through traditional

regulatory instruments at a provincial level.[6]

Hence, actual assignments of environmental powers do vary significantly across countries. However, a recent common trend of national and federal governments seems to be the allocation of environmental tasks also to sub-central governments.

3 The model: hypotheses and assumptions

3.1 The welfare function

We propose a multiple-regions model wherein the economy is divided into J geographically jurisdictions indexed by $j = 1,..., J$, each populated by a different number of individuals (N_j), who are immobile.[7] The total population of the country is represented by N ($N = \sum_{j=1}^{J} N_j$). The utility function of the representative inhabitant in region j is:

$$U_j = x_j + \theta_j \ln E_j \tag{1}$$

where x_j is the private good and E_j is the "local public good" that represents the set of environmental protection activities provided by each local authority,[8] aimed at reducing environmental damage in order to increase individual welfare. The parameter θ_j (satisfying $0 \le \theta_j \le 1$) is the environmental protection preference of the representative individual in jurisdiction j; it indicates, to some extent, the "green preference" of each local community.

Under a non-cooperative regional system, each policy-maker maximizes the local welfare function corresponding to the representative individual's utility:[9]

$$W_j = U_j = x_j + \theta_j \ln E_j \tag{2}$$

Likewise, under a cooperative system a government representing all districts decides different levels of environmental protection in each region, thus maximizing the aggregate utility function given by the sum of the representative individual's utilities of each community:

$$W = \sum_{j=1}^{J} W_j = \sum_{j=1}^{J} \left(x_j + \theta_j \ln E_j \right) \tag{2.a}$$

3.2 The budget constraint and the cost function

Under an uncoordinated system, the budget constraint of the representative individual is:

$$x_j + t_j E_j = 1 \tag{3}$$

[6] Moreover, the command-and-control approach is gradually being supplemented by information-based schemes, economic instruments and voluntary initiatives.

[7] We ignore issues of mobility in this analysis. While such considerations are normally important, incorporating them is sufficiently difficult that they are best left for a separate paper.

[8] The level of E_j is greater than 0 $(E_j > 0)$ as we assume there exists a minimum level of environmental output provided by each local government.

[9] Analogous results are obtained by assuming preferences heterogeneity. In that case, the representative individual corresponds to the median-voter, as preferences are *single-peaked* and *one-dimensional*.

where the private good is the numerary, while t_j represents the contribution paid by each citizen to finance environmental provision. Hence, environmental policy is financed by a uniform head tax (t_jE_j) on local residents.

Under a coordinated system, a government representing all districts decides different levels of environmental protection in each region and sets a uniform head tax on all citizens (tE_j). Thus, the representative individual's budget constraint is:

$$x_j + tE_j = 1 \tag{3.a}$$

In both equations (3) and (3.a), we assume equal individual income in each region.

The unitary cost of environmental policy (α_j) is assumed to differ across regions. It is a function of the amount of environmental outcomes provided in all jurisdictions as the cost in a region is likely to depend on the environmental policy adopted in the others (i.e. the cost of preventing landslides in region *j* can be reduced if others implement analogous policies). We assume that it negatively depends on the average environmental protection:

$$\alpha_j = \left(\prod_{k=1}^{J} E_k\right)^{-\frac{\gamma}{J}} + \frac{F}{E_j} \tag{4}$$

The degree of inter-jurisdictional spillovers ($0 \le \gamma \le 1$) negatively affects the cost of environmental policy. For simplicity, the effects of such externalities are supposed to be symmetric and equal for all regions.[10] Indeed, the parameter γ is a measure of the average spillover effects deriving from the total environmental policy. Since the total size of the economy is fixed (N), the overall effect of externalities - which covers the national territory wholly - on costs for environmental protection should not depend on the number of regions wherein the territory is divided. Equation (4) captures this aspect, wherein F/E_j is the unitary fixed cost.[11]

External spillovers are treated as a mechanism allowing the reduction in production costs of environmental policy in each - mostly neighboring - local jurisdiction (i.e. externality production). The intuition is that when positive externalities are large (γ is high), the production cost is lower as each policy-maker can exploit these beneficial effects by paying less for providing environmental protection to the local community; on the contrary, when positive externalities are small (γ is low), the opposite situation takes place.

In order to finance environmental policy in jurisdiction j, the local government collects taxes on its residents. The sum of all contributions within each region ($t_jE_jN_j$) is assumed to be equal to the total cost of environmental protection in that region (α_jE_j), in the case of the non-cooperative solution:

$$t_jE_jN_j = \alpha_jE_j \tag{5}$$

Benevolent politicians adopt a "full recovery costs" strategy, setting taxation levels equal to the cost of providing environmental policy, without any additional gains for themselves.

[10] This means that externalities are two-way: the policy adopted in region *j* reduces the cost of environmental policy in region *k*, and vice versa, in a symmetric way. This assumption allows simplifying algebra without changing the qualitative results.

[11] Fixed costs are sustained in order to implement enforcement procedures and precautionary actions or, for example, to explore the environmental conditions of the territory.

Something different occurs in the case of the cooperative solution. Indeed, politicians - still benevolent - of all regions are assumed to cooperate and choose to do not differentiate inhabitants in terms of taxation ($t_j = t$). Hence, they set a unique tax - centralized funding (see Lockwood 2002) - to cover environmental production costs in all jurisdictions:

$$t\sum_{j=1}^{J} E_j N_j = \sum_{j=1}^{J} \alpha_j E_j \tag{5.a}$$

In short, equations (5) and (5.a) represent the government budget constraints, respectively under a non-cooperative and a cooperative system. In both cases, the policy-maker should provide the amount of environmental protection required in each region, whatever the level of taxation. Thus: $E_j = \frac{\theta_j}{t_j}$ under an uncoordinated system; $E_j = \frac{\theta_j}{t}$ under a coordinated system.

3.3 Tax setting

With a non-cooperative solution, each region covers its costs to provide environmental policy with own revenue. By substituting environmental protection preferred by region j into equation (5), we derive the level of taxation set by the local policy-maker:

$$t_j = \left(\frac{\theta_j}{\theta_j N_j - F}\right)\left[\prod_{k=1}^{J}\left(\theta_k N_k - F\right)\right]^{-\frac{\gamma}{J(1-\gamma)}} \tag{6}$$

The tax solution negatively depends on the degree of externalities (γ).

With a cooperative solution, all regions together cover the cost of providing environmental protection with the sum of their tax revenues. In this case, local jurisdictions could themselves cross subsidize environmental protection. Substituting the environmental outcome into equation (5.a) yields the following:

$$t = \left[\frac{\sum_{k=1}^{J}\theta_k}{\sum_{k=1}^{J}\left(\theta_k N_k - F\right)}\right]^{\frac{1}{1-\gamma}} \left(\prod_{k=1}^{J}\theta_k\right)^{-\frac{\gamma}{J(1-\gamma)}} \tag{6.a}$$

4 Environmental protection under different institutional settings: the positive analysis

4.1 The choice of regions

The individual utility increases with the level of environmental protection provided by local governments. Given this fact, we make considerations on which regions vote for cooperation. In detail, in each jurisdiction the representative individual would vote for the institutional system that

guarantees the highest amount of environmental policy.[12]

In reference to this, we compare the two environmental outcomes given tax solutions obtained in the previous steps:

$$E_j^{NC} = \frac{\theta_j N_j - F}{\left[\prod_{k=1}^{J}\left(\theta_k N_k - F\right)\right]^{-\frac{\gamma}{J(1-\gamma)}}} \tag{7}$$

$$E_j^{C} = \frac{\theta_j}{\left[\frac{\sum_{k=1}^{J}\theta_k}{\sum_{k=1}^{J}\left(\theta_k N_k - F\right)}\right]^{\frac{1}{1-\gamma}}\left(\prod_{k=1}^{J}\theta_k\right)^{-\frac{\gamma}{J(1-\gamma)}}} \tag{7.a}$$

Equations (7) and (7.a) describe environmental policy implemented respectively under a non-cooperative and a cooperative institutional setting, whereby "policy uniformity" is never assumed and a different amount of environmental protection in each local community is allowed also when regions cooperate.

Let us define $M = \frac{\sum_{j=1}^{J}\theta_j}{J}$ and $\Theta = \left(\prod_{j=1}^{J}\theta_j\right)^{\frac{1}{J}}$ as the arithmetic and geometric mean of the regional preferences based on each representative individual, respectively. Moreover, assuming $\hat{N} = \frac{\sum_{j=1}^{J}N_j}{J}$ as the average population size of regions, we finally introduce a new parameter: $\omega_j = \frac{M\hat{N}}{\theta_j N_j - F}$ that represents the gross mark-up on variable costs in region j ($\theta_j N_j - F$) necessary to finance environmental protection equal to the average spending on this kind of policy in all regions ($M\hat{N}$). The idea is that a high average spending and high fixed costs would imply a higher mark-up, while with a higher expenditure in region j ($\theta_j N_j$) - determined by high values of θ_j and N_j - a lower mark-up would be required. Starting from ω_j, two indices can be built: $\Omega = \frac{J}{\sum_{j=1}^{J}\left(\frac{1}{\omega_j}\right)}$ and $\Gamma = \left(\prod_{j=1}^{J}\omega_j\right)^{\frac{1}{J}}$, that are the harmonic and geometric mean of the gross mark-up, respectively.

[12] The actual institutional system, which will be effectively set, depends on how the votes of regions are weighted. More precisely, it depends on the voting rule to aggregate preferences at a national level. Our analysis tells only which institutional setting citizens would prefer.

After some algebra, equations (7) and (7.a) can be finally re-written as follows:

$$E_j^{NC} = \frac{M\hat{N}}{\omega_j}\left(\frac{M\hat{N}}{\Gamma}\right)^{\frac{\gamma}{1-\gamma}} \tag{8}$$

$$E_j^{C} = \frac{\theta_j \hat{N}}{\Omega}\left(\frac{\Theta\hat{N}}{\Omega}\right)^{\frac{\gamma}{1-\gamma}} \tag{8.a}$$

Both environmental provisions directly depend on summary measures of regional preferences (M for E_j^{NC} and Θ for E_j^{C}, respectively) and inversely on those of the gross mark-up (Γ for E_j^{NC} and Ω for E_j^{C}, respectively).

In this perspective, we can introduce two indicators of heterogeneity in order to easily compare environmental policy obtained under a cooperative institutional system with that under a non-cooperative scenario. The former concerns preference heterogeneity, $\frac{M}{\Theta}$, which increases with the variance in preferences; the latter describes the heterogeneity in mark-up, $\frac{\Gamma}{\Omega}$, which increases with the variance in preferences and variability of local size (N_j). Hence, the choice between the cooperative and non-cooperative solutions is mainly determined by these two indices of heterogeneity, given different values of externalities (γ).

Considering the logarithmic form of equations (8) and (8.a), region j would prefer the non-cooperative setting, which provides a higher level of environmental protection ($E_j^{NC} > E_j^{C}$), if the following holds:

$$\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] < HM - H\omega \tag{9}$$

where $HM = \ln\left(\frac{M}{\Theta}\right) > 0$ and $H\omega = \ln\left(\frac{\Gamma}{\Omega}\right) > 0$.

Starting from the right-hand term, we have:

Proposition 1: *Increasing differences in population size across regions would lead towards the cooperative solution; while, with increasing heterogeneity of preferences, regions prefer the non-cooperative system.*

Proof: The proof is straightforward. ■

Equation (9) is likely to be false when the variability in regional size grows, contributing to increase the $H\omega$ indicator, *ceteris paribus*. Following this rule, a cooperative institutional system is preferred when regions are quite different in size. Intuitively, high variability in size leads to high variability in costs to implement environmental policy, where smaller jurisdictions suffer both higher costs and

mark-up. Hence, to avoid disparities in costs across regions, the cooperative system appears to be the best solution. In this case, cross subsidization occurs from larger to smaller regions and its effect is obviously different considering local population size.

As for preferences heterogeneity, it is also easy to show that an increasing variability in preferences has two effects: a direct one, implying an increase of the HM index, which contributes to verify equation (9); an indirect one, concerning the increase of mark-up heterogeneity ($H\omega\uparrow$), which contributes to do not verify equation (9). According to the traditional theory of fiscal federalism (Oates 1972, 1999), we basically assume that the direct effect prevails over the indirect one, therefore establishing that a higher degree of preferences heterogeneity is likely to favour a non-cooperative system (e.g., decentralization).

Observing the left-hand-side, we have:

Proposition 2: *The cooperative solution is preferred by smaller regions and by those with higher preferences for environmental protection.*

Proof: Equation (9) is likely to be false - citizens of region j do not prefer the non-cooperative institutional setting - when regions are quite small as their relative mark-up ($\ln\frac{\omega_j}{\Omega}$) is high. Indeed, smaller regions have to pay higher per capita costs, so they prefer a cooperative policymaking wherein implicit transfers across regions (i.e. from larger to smaller) could take place. Likewise, regions with environmental preference higher than the average ($\ln\frac{\theta_j}{M}$ is high) are likely to be cross subsidized by those with lower preferences, so they would prefer cooperation. ■

Moreover, looking at the externalities we have:

Proposition 3: *When regions have low preferences for environmental protection and they are large, their mark-up is lower than the average and we have:* $\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)<0$. *Then:*

- **a)** *Citizens always prefer the non-cooperative solution when the right-hand-side term is positive* ($HM-H\omega>0$).
- **b)** *When the right-hand-side term is negative* ($HM-H\omega<0$), *there exists a threshold for externalities: below the threshold, regions would not prefer cooperation; beyond the threshold, they would prefer cooperation.*

Proof: see the Appendix. ■

With large jurisdictions and those with low preferences for environmental policy, the standard result emerges, so the non-cooperative solution would be better in the case of high heterogeneity of preferences within the whole territory and with low externalities. For these regions, the effect of cross subsidization is negative as they have to pay implicit transfers to those with higher environmental preferences under a cooperative institutional setting. On the other hand, under a non-cooperative system, large municipalities can, for example, autonomously finance their environmental policy, even without any external spillovers to exploit. When spillovers increase, those regions start to internalize externalities instead of remaining autonomous as gains from internalization outweigh the advantages of free-riding. This mostly holds when disparities in size are very high ($HM-H\omega<0$).

Proposition 4: *When regions have high preferences for environmental protection and they are small, their mark-up is higher than the average and we have:* ($\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)>0$). *Consequently:*

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a) *Citizens always prefer the cooperative solution when the right-hand-side term is negative (HM – Hω<0).*

b) *When the right-hand-side term is positive ($HM - H\omega > 0$), there exists a threshold for externalities: below the threshold, regions would prefer cooperation; beyond that threshold, they would not cooperate.*

Proof: see the Appendix. ■

To summarize, the advantages of free-riding may be asymmetric for regions differing in preferences and size (Kanbur and Keen 1993) and they can also offset the benefits of internalizing externalities. The intuition behind this result is that small regions and those with high preferences for environmental protection would prefer the cooperative solution as they try to charge others for their production costs. Generally speaking, this may reflect the reason why such municipalities would prefer monetary transfers from the State instead of autonomously deciding their policy.

When positive spillovers increase, these regions may start to find a non-cooperative system more suitable as they can exploit, as a free-rider, beneficial externalities deriving from environmental protection provided by other regions. Moreover, the free-riding behaviour can be convenient when preferences heterogeneity is high ($HM - H\omega > 0$).

We may conclude that the relative position of a region, both with respect to the average preference and mark-up (linked to its population size), and the extent of spillovers determine whether a cooperative or a non-cooperative setting for environmental policy is more or less suitable.

Our propositions also suggest that cases of under-provision of environmental protection may occur. Indeed, when the emerging institutional setting is that not preferred by some regions, this implies that environmental policy is under-provided by definition. This kind of under-spending is not due to the fact that we do not consider positive interregional spillovers, as in the traditional literature; nor to inter-jurisdictional competition by which local governments lowered their environmental standards in order to hold down the costs of compliance for existing and prospective firms (Wellish 1995; Wilson 1996). In our case, such under-provision is, in fact, mainly driven by the condition that some regions are forced, after voting, to have an institutional setting they do not prefer; it depends on the fact that the effects and convenience of cross subsidization may be different considering local size. Hence, a cooperative system can generally bring benefits for someone who needs financial help, but it may also imply a waste of resources for someone else who should pay more than in the case of a non-cooperative setting.

Even when introducing the impact of externalities, the key insight of our findings is the different size of regions, which may determine an asymmetry among regions' responses to the best institutional solution necessary to implement environmental policy. Hence, from a positive viewpoint, a non-cooperative system should be voted not only without externalities, but also with high spillovers. Actually, this system would be voted whereby the free-riding gains outweigh the benefits of internalizing spillovers.

5 The level of overall environmental protection: some normative prescriptions

The choice of the institutional setting in each region deriving from the voting process guarantees the highest environmental provision in utility terms. However, this does not imply that it corresponds to the highest level of overall environmental protection within the national territory. Then, we propose a normative approach analyzing which institutional setting should be adopted in order to provide - in aggregate terms - a more "pervasive" environmental policy as a whole. In this perspective, we compare the total outcomes for environmental policy obtained in the previous part of the analysis

summing the output levels of all regions.[13] The overall environmental protection under a non-cooperative system is:

$$\sum_{j=1}^{J} E_j^{NC} = M\hat{N}\left(\frac{M\hat{N}}{\Gamma}\right)^{\frac{\gamma}{1-\gamma}} \sum_{j=1}^{J} \frac{1}{\omega_j} \tag{10}$$

Under a cooperative system it is:

$$\sum_{j=1}^{J} E_j^{C} = \frac{\hat{N}}{\Omega}\left(\frac{\Theta\hat{N}}{\Omega}\right)^{\frac{\gamma}{1-\gamma}} \sum_{j=1}^{J} \theta_j \tag{10.a}$$

Comparing equation (10) with (10.a), we have:

Proposition 5: *The level of overall environmental protection is higher with a non-cooperative regime if* $\frac{M}{\Gamma} > \frac{\Theta}{\Omega}$, *thus if* $HM > H\omega$.

Proof: see the Appendix. ■

In order to provide the highest level of environmental protection, a State - wherein heterogeneity in preferences is higher than heterogeneity in size - should adopt a non-cooperative institutional setting. On the contrary, disparity in size higher than variability in preferences would require a cooperative system that could guarantee a wider environmental output to everyone. Given these results, some reflections may be drawn.

On the one hand, as within a country cultural values are likely to be quite homogenous, heterogeneity in regional preferences for a public good such as environmental protection can be assumed being lower than heterogeneity in regional size. This means that a cooperative system would be better in order to provide a higher level of environmental policy. On the other hand, as cultural differences across national communities are likely to be wider, thus preferences heterogeneity across countries suggests that forms of cooperation in environmental policymaking could not be the optimal solution.

6 Concluding remarks

In conventional environmental economics, governments are depicted as carrying the responsibility for much of the desired environmental protection. This literature tends to ignore the fact that environmental policymaking does not originate from a single unitary authority but it is the outcome of a multi-layered structure designed to deal with the large number of differing and conflicting demands that citizens place on their governments. In this perspective, decentralization seems to be a way of dealing effectively with a large number of objectives, increasing flexibility in policymaking, and permitting the use of a broader range of policy instruments (Dalmazzone 2006).

However, this solution may not be the best for all regions, especially given their size. Indeed, we prove that the relative performance of centralized *versus* decentralized provisions - corresponding, respectively, to cooperative and non-cooperative solutions in our model - of environmental protection activity depends upon the extent of spillovers, differences in tastes for environmental policy, and disparities in regional size. In other words, the outcome of environmental policy can be tailored to

[13] We obtain the same result defining the overall protection as the product of the output level of all regions.

citizens' preferences, to the costs of production and other local conditions; this would allow the attainment of a higher social welfare compared with the provision of a uniform standard of environmental protection across all jurisdictions.

We can identify the following factors at work determining the choice between the two solutions: a) the free-riding gains exploiting positive externalities; b) the gains of internalizing externalities; c) the degree of preferences heterogeneity; d) cross subsidization across different regions; whereby the net benefit of each item is basically different for large and small communities, suggesting asymmetric vocations for environmental federalism. Indeed, key features of the paper have been the focus on the size of local jurisdictions - which can be relevant for the scale effect in the financing mechanism of non-rival public goods, such as environmental policy - and modelling interregional externalities as a mechanism contributing to lowering the production costs of environmental provision in each region.

One result of this study is that increasing differences in population size across regions would basically lead towards the cooperative solution; while increasing heterogeneity of preferences mostly leads towards the non-cooperative scenario. To some extent, this finding is quite consistent with the traditional theory of fiscal federalism (Oates,1972).

Moreover, considering inter-jurisdictional externalities and different sizes of local jurisdictions allow for a better qualification of these results. Indeed, our findings suggest that the "familiar" presumption of preferring a non-cooperative institutional setting only with low degrees of spillovers is not confirmed, as it can be chosen also for high values of them. For small regions and those with higher preferences for environmental quality, for example, the free-riding gains outweigh the benefits of internalizing spillovers, favouring non-cooperation when beneficial spillovers increase.

7 Appendix

Proof of Proposition 3

$$\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] < HM - H\omega \tag{9}$$

- The proof of case a) is straightforward.
- In the case b), the left-hand-side is increasing in γ and:

$$\lim_{\gamma\to 0}\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] = -\infty$$

$$\lim_{\gamma\to 1}\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] = 0$$

This proves the case b).

Hence, Proposition 3 is proved. ■

Proof of Proposition 4

$$\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] < HM - H\omega \tag{9}$$

- The proof of case a) is straightforward.
- In the case b), the left-hand-side is decreasing in γ and:

$$\lim_{\gamma\to 0}\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] = +\infty$$

$$\lim_{\gamma\to 1}\frac{1-\gamma}{\gamma}\left[\ln\left(\frac{\theta_j}{M}\right)+\ln\left(\frac{\omega_j}{\Omega}\right)\right] = 0$$

This proves the case b).

Hence, Proposition 4 is proved. ■

Proof of Proposition 5

Substituting $\frac{1}{J}\sum_{j=1}^{J}\frac{1}{\omega_j}=\frac{1}{\Omega}$ in equation (10) and $\frac{1}{J}\sum_{j=1}^{J}\theta_j = M$ in equation (10.a), we have that $\sum_{j=1}^{J}E_j^{NC} > \sum_{j=1}^{J}E_j^{C}$ if $\frac{M}{\Gamma} > \frac{\Theta}{\Omega}$.

Hence, Proposition 5 is proved. ■

8 References

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