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ON LOCAL ENVIRONMENTAL PROTECTION

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On Local Environmental Protection(*)

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Abstract

We hereby propose a model to analyze the provision of environmental protection activities (United Nation 2005) with positive interregional externalities in order to verify - at least in theory - whether this kind of policy is better accomplished through centralized policymaking, which implies a coordinated solution among local representatives, or a decentralized system, whereby 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 (production externality), we can assume that different environmental policies are allowed across regions. Given this general framework, considerations favouring either institutional setting in terms of individuals' welfare seem to involve interaction among these key elements: the extent of the inter-jurisdictional spillovers, the size of local jurisdictions and the regional preferences for environmental protection policy.

JEL classification: *H71, H73, H23, Q58*

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

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1. Introduction

A part of the literature on fiscal federalism over the years has dealt with environmental policy as a specific case of the supply of public goods. In particular, according to the literature on environmental federalism (Kraft and Scheberle 1998; Oates and Portney 2001; Oates 2002; Kunce and Shogren 2005; Dalmazzone 2006; Breton *et al.* 2007), an important role for decentralized governments in the setting of environmental standards and the design of regulatory programs 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).

More generally, environmental policymaking typically takes place in the context of a system with several levels of government. This raises the important issue of the appropriate role of the various governments in the setting of environmental standards, the design of regulatory measures to attain the standards and the monitoring and enforcement of these measures. Indeed, it is commonplace for environmental measures to take the form of centrally determined standards, with the responsibility for implementation lying in the hands of state or provincial governments.

Thus, environmental policy is often a joint activity in which the exact division of responsibilities varies substantially among 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 on the part of some that Europe-wide standards for environmental quality are needed (Oates 2002). The key question of the debate remains as to which approach is more suitable between moving toward 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 greater role in this kind of policy.[1] 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.[2] In Australia, the approach adopted in addressing environmental issues - in particular that of water supply - has been one of cooperation whereby the policies developed under the "umbrella of cooperation" are monitored by the National Competition Council[3] and reflect the centralist interpretation of the Constitution in the assignment of environmental powers sustained by the High Court of Australia (Petchey 2007). Furthermore, the United Nations' Development Program suggests, for example, facing the risks and costs of climate change by assigning to national government the role of setting general standards of environmental protection in order to reduce air pollution.

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[1] The debate over environmental federalism has been intensified recently not only in the United States but also in the European Union where the main question concerns the controversy over the independent role of the member countries in environmental policymaking and more centralized measures that "harmonize" policies in Europe (Schwab 2006).

[2] Cf. Environmental Protection Agency: *Clean Air Act* and *Clean Water Act.*

[3] It is a national body with the power (effectively used) to levy financial penalties for non-compliance.

However, it also recognizes 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. A case in point is Brazil, where the conservation of its huge endowment of natural resources is not only a domestic issue, even though the responsibility for the preservation of the Amazonian forests falls mainly on state and local governments (Cavalcanti 2007). Recent trends toward a greater decentralization of environmental policy have also occurred in Canada where, although some coordination would be necessary, this would result in significant costs which would slow down the political-making process (Valiante 2007). In particular, the implementation of environmental policies occurs primarily through traditional regulatory instruments at the provincial level.[4]

In general, the complexity of ecological systems implies that decisions concerning a specific natural resource generally affect more than one ecological component, although the impact is often slow and difficult to predict. Environmental policymaking, in turn, 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 and Portney 2001), yet largely ignored in conventional environmental economics.

In this vein, the aim of this paper is basically to shed some light on how multi-level governance can plan and implement environmental action which would affect the assignment of powers and the design of environmental institutions, while at the same time recognizing the need for policies aimed not only at controlling pollution and conserving a few particular species but also protecting the integrity of ecological systems and functions at local and regional levels. In detail, we will check whether environmental protection activities are better accomplished within a country - at least theoretically - through centralized policymaking which implies, in our model, a coordinated solution among local representatives, or a decentralized system where 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)", where 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",[5] according to

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

[5] 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).

the standard definition derived from statistical standards developed by international organizations such as IMF, OECD, etc. (United Nation *et al.* 2005).

Moreover, we assume that environmental policy is an "active" government activity which has a cost. Indeed, a common feature of both scenarios is the presence of positive externalities related to the provision of environmental outcome across local jurisdictions. In reference to this, we treat positive externalities in a different way as usual,[6] that is as a mechanism contributing to lowering the cost of environmental protection activities in each region (production externality). In other words, the unitary cost of environmental provision is assumed to negatively depend on the level of externalities linked to the environmental policy implemented in all regions. In such a way, each region - most likely neighboring - is assumed to be able to exploit such externalities in order to finance its own environmental policy at a lower cost. This assumption is also quite common in practice. Indeed, the level of environmental quality in jurisdiction *j* depends on environmental quality in other regions *k*. Several examples could be provided: the cost of prevention of landslide risk for region *j* can be reduced if the other (neighboring) regions adopt a policy against this kind of risk; likewise, the cost of waste disposal can be reduced if others implement policies for disposal. 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.

Given this framework, one thing is clear: an efficient environmental protection outcome will not generally take the form of uniform national standards, but is likely to imply different levels of environmental quality across jurisdictions. On the basis of this line of reasoning, we can also assume that in both cases - cooperative and non-cooperative decision-making processes - different environmental policies can be implemented across regions. Indeed, it is rather unclear - from a theoretical point of view - 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 a central government in a federal system.[7]

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 in which member states influence the Union's policy formation in the Council (the official institution where they can defend their interests) as well as at many other levels in the policy process (Dalmazzone 2006). When mechanisms of this sort are at work, they probably create wide margins for central policies to

[6] The standard literature (Gilbert and Picard 1996; Conley and Dix 1999; Dur and Staal 2008) in this field models positive spillovers deriving from externalities in the consumption of public goods (consumption externalities).

[7] 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.

reflect local variations across jurisdictions. The institutional devices by which a governance system can build up the capacity for higher levels of government to tailor their policies to suit local heterogeneity are a subject that deserves further attention. The key point remains that an environmental policy which has to prevent the cost of environmental degradation (i.e. to anticipate and mitigate the cost of climate change) has to be decided at the local level. Thus, an environmental policy that is appropriate in one region is unlikely to be appropriate in other regions. Federal or central regulation is rarely sensitive to these differences; on the other hand, it often implies a single uniform policy in all regions. 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 the grounds of efficiency - to provide the same menu of public services in each community (Tiebout 1956, Oates 1972). In this vein, we allow state and local governments to decide how much to spend on education, when refuse has to be collected, and so on (Schwab 2006). This logic would lead to the conclusion that state and local governments may be in a better position than the federal (or central) government to choose also the correct level of environmental quality for their constituencies. Yet, this may conflict with the general presumption that uniform standards should be satisfied within the national territory. To solve this problem, we assume that a minimum standard level of environmental protection is provided by local jurisdictions when they autonomously implement environmental policy and also when they cooperate to design this kind of intervention.

Allowing each community, region, and state to design and implement its own distinctive blend of policies and plans that best promises to support environmental protection (Kraft and Scheberle 1998) also implies a system of differentiated taxes that would depend on the location of the source and the people affected. Such differentiated tax rates are determined and imposed separately by each local authority under decentralization and jointly by all regions under centralization which represents a case of regional cooperation. Other things equal, the research question remains to compare - in welfare terms - the outcome under a cooperative decision-making institution 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, provincial, or local governments would typically ignore the benefits that such activities provide to residents in other places. However, we have to recognize that decentralization can provide a valuable dimension in policy innovation by offering the opportunity for experimentation with differing approaches to environmental management (Oates 1999). Moreover, the Dinan *et al.* study (1999) on the setting of uniform national standards for drinking water in the United States indicates the potentially

significant magnitude of welfare losses arising from this uniformity.[8] Hence, for environmental matters of strictly local interest (treated as local public goods) a decentralized system of setting ambient standards seems to be appropriate. Indeed, the "one size fits all" approach[9] 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 regional preferences for environmental protection activity. The issue of size,[10] for example, is relevant since it allows a range of different public policies under decentralization and centralization. Oates and Schwab (1988) argue that "'small homogeneous jurisdictions'" decentralized choices are likely to be socially optimal because each local government sets environmental standards to equate marginal benefits with the incremental costs. Kanbur *et al.* (1995) take into account the dimension of the country and show that small countries will reduce their environmental standards to be able 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 affirm that without these foremost optimal instruments, distortions persist in both fiscal and environmental choices. More generally, the efficient levels of concentration of air pollutants in Los Angeles are surely very different from those in Buffalo; likewise for Paris and Venice (Oates 2002).

From this point of view, the role of size in strategic tax and spending design may be important. Disparity in size may be, for example, a source of inefficiency itself, exacerbating the loss that each region suffers as a consequence of non-cooperative behaviour. Increasing differences in population size across regions would lead towards the cooperative solution. Intuitively, a high variability in size leads to a high variability in costs to provide the public good. Thus, to avoid disparities in costs among regions, the cooperative system seems to be the best. This result is mainly due to the cross subsidization effect, which implies an implicit transfer across different regions in line with the Boadway and Hobson's model (1993). Yet with the introduction of spillovers, it emerges that from a positive viewpoint coordination of environmental protection should not be necessarily pursued by all

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

[9] 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. Institutions providing these services should then be tailored to specific local contexts (Barca 2009).

[10] In reference to the meaning of size, it can be measured in terms of land or population (King 1984), and also considering the public budget of government. We define size in terms of population, as in most of the literature of fiscal federalism (Buchanan 1965; Oates 1972).

regions, but it depends on their relative size. In particular, the net gain between the potential benefit of free-riding behaviour and the effect of internalizing spillovers among different jurisdictions should be taken into account, as it is likely to differ for large and small local units. Indeed, non-cooperation becomes more attractive at high spillover levels for small regions (and those with high preferences for environmental policy), which have a larger incentive to free-ride on each other's policies and production costs. At the same time, large regions (and those with low preferences for the environmental public good) gain more through coordination instead of remaining autonomous and acting as a free-rider, *ceteris paribus*.

The remainder of the paper is organized as follows. Section 2 outlines the general framework of the model. Section 3 derives conditions under which a cooperative or a non-cooperative institutional system is the most appropriate and efficient to implement environmental protection activities. Finally, Section 4 offers some concluding remarks.

2. The model: hypotheses and assumptions

2.1 The welfare function

We propose a multiple-regions model where the economy is divided into J geographically distinct regions indexed by $j = 1,...,J$, each populated by a different number of individuals ($i = 1,....,N_j$), who are heterogeneous and immobile.[11] The total population of the country is represented by N (with $N = \sum_{j=1}^{J} N_j$). The utility function of the representative inhabitant - the median-voter - 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", which represents the set of environmental protection activities provided by each local authority.[12] In other words, the kind of public action subject to decision concerns environmental protection aimed at reducing environmental

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

[12] 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 government. This can be intended as a uniform environmental protection standard with "merit good" content. The mechanism works when regions autonomously implement environmental policy and when they also cooperate to design this kind of intervention.

damage in order to increase individual welfare. The parameter θ_j (satisfying $0 \leq \theta_j \leq 1$) is the environmental protection preference of the median-voter in jurisdiction j. It indicates, to some extent, the "green preference" of each local community.

In a non-cooperative regional system, each policy maker maximizes the local welfare function corresponding to the median-voter's utility[13] in order to implement the socially-accepted environmental policy under a decentralized system:

(2) $$W_j = U_j = x_j + \theta_j \ln E_j$$

Likewise, under a cooperative regional system - centralization - a government representing all districts decides different levels of environmental protection in each region, thus maximizing the aggregate welfare function given by the sum of the median-voter's utilities of each community:

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

2.2 The budget constraint and cost function

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

(3) $$x_j + t_j E_j = 1$$

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

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 budget constraint is as follows:

(3.a) $$x_j + tE_j = 1$$

[13] As individual preferences are *single-peaked* and *unidimensional*, the median-voter's theorem holds and it can be applied to determine the level of environmental policy.

The unitary cost of environmental policy (α_j) is assumed to be different across regions. It is a function of the amount of environmental outcomes provided in all regions. It means that the cost in a region depends on the environmental policy adopted in the others (i.e., the cost of waste disposal can be reduced if other regions implement similar policies; the cost of preventing landslides in region *j* can be reduced if others adopt 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 ($0 \leq \gamma \leq 1$) negatively affects the cost of environmental policy. For simplicity, such externalities are supposed to be symmetric and equal for all the regions.[14] Indeed, the parameter γ is a measure of the average spillover effects deriving from the overall environmental policy. Since the total size of the economy is fixed (N), the overall effect of externalities - which is over the whole national territory - on costs for environmental protection should not depend on the number of regions in which the territory is divided. Equation (4) captures this aspect, where F is the same fixed cost. We consider that the cost associated with environmental policy mainly concerns enforcement procedures and precautionary actions.

As explained before, we treat external spillovers as a mechanism allowing the reduction in production costs of environmental policy in each - mostly neighboring - local jurisdiction (externality production). The intuition is the following. 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, local government collects taxes on its residents. In detail, the sum of all contributions collected within each region ($t_j E_j N_j$), in the case of the non-cooperative solution (decentralization), is assumed to be equal to the total cost of environmental protection in that region ($\alpha_j E_j$):

$$t_j E_j N_j = \alpha_j E_j \tag{5}$$

[14] 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.

The idea is that 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.

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

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

In short, equations (5) and (5.a) represent the government budget constraint, respectively under a non-cooperative and cooperative system. In both cases, in order to be re-elected, the policy maker should provide the amount of environmental protection required by the median-voter in each region, whatever the level of taxation.[15] Thus: $E_j = \frac{\theta_j}{t_j}$ under an uncoordinated system; $E_j = \frac{\theta_j}{t}$ under a coordinated system.

2.3 Tax setting

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

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

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 median-voter's environmental quality level into equation (5.a), results in the following:

[15] For further details on this assumption, see Fiorillo and Sacchi (2011).

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

3. Environmental protection under different institutional settings

3.1 The choice of regions

The median-voter's utility increases with the level of environmental protection provided by local governments. In this section, we make considerations as to which regions vote for cooperation and which do not. Thus, in each region the median-voter would vote for the institutional system which guarantees the highest amount of environmental policy; the actual institutional system depends on how the vote of regions are weighted. In reference to this, we compare environmental outcomes given tax solutions obtained in the previous steps, respectively in equations (6) and (6.a):

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

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

Equations (7) and (7.a) describe environmental policy implemented respectively under a non-cooperative and a cooperative institutional setting, where "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 of the median-voters, 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: $\omega_j = \frac{M\hat{N}}{\theta_j N_j - F}$ which 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 indexes can be considered: $\Omega = \frac{J}{\sum_{j=1}^{J} \left(\frac{1}{\omega_j} \right)}$ and $\Gamma = \left(\prod_{j=1}^{J} \omega_j \right)^{\frac{1}{J}}$, which are the harmonic and geometric mean of the gross mark-up, respectively.

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

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

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

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 vein, we can introduce two indicators of heterogeneity in order to easily compare environmental policy under coordinated and non-coordinated institutional systems. 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 solution is mainly determined by these two indexes 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 institutional setting, which provides a larger level of environmental protection ($E_j^{NC} > E_j^C$), if the following is verified:

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

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 the following:

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 of regional size grows, contributing to increasing the $H\omega$ indicator, *ceteris paribus*. Following this rule, a coordinated 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, whereby smaller jurisdictions suffer higher costs and mark-up. Hence, to avoid disparities in costs among 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.

Concerning 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 verifying equation (9); an indirect one concerning the increase of mark-up heterogeneity ($H\omega\uparrow$), which contributes to a non-verification of equation (9). According to the traditional theory of fiscal

federalism (Tiebout 1956; Buchanan 1965; Oates 1972), we can 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 (such as decentralization).

Observing the left hand side, we have the following:

Proposition 2: *The cooperative solution is preferred by smaller regions and 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. This means that 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 coordinated policymaking where implicit transfers across regions (from larger to smaller) can take place. Likewise, when the median-voter's environmental preference is higher than the average ($\ln\frac{\theta_j}{M}$ is high), the conventional two effects occur. As explained before, we assume that the direct effect is stronger than the indirect one, hence favouring cooperation. Indeed, regions with higher preferences for environmental protection are likely to be cross subsidized by those with lower preferences. ■

Moreover, the following emerges from the examination of externalities:

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 term is positive* ($HM-H\omega>0$).
- **b)** *When the right hand term is negative* ($HM-H\omega<0$), *there exists a threshold for externalities: below the threshold, regions would not prefer cooperation and 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 may emerge that 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-coordinated system, large municipalities can 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 is mostly true 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:*

- **a)** *Citizens always prefer the cooperative solution when the right hand term is negative* ($HM - H\omega < 0$).
- **b)** *When the right hand term is positive* ($HM - H\omega > 0$), *there exists a threshold for externalities: below the threshold, regions would prefer cooperation and 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 - as in Kanbur and Keen's (1993) - and can also offset the benefits of internalizing externalities. The intuition behind this result is as follows. Small regions and those with high preferences for environmental protection would prefer the cooperative solution as they try to charge other regions for some production cost. Generally speaking, this may reflect why such municipalities would prefer monetary transfers from the State, rather than autonomously deciding their policy. When positive spillovers increase, these regions may start to find a non-coordinated 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 ($HM - H\omega > 0$).

In short, we may conclude that regional preferences, the extent of spillovers and the size of local jurisdictions determine whether a coordinated or non-coordinated institutional setting for environmental policy is more suitable. In addition, our propositions suggest that cases of under-provision of environmental protection may occur. Indeed, when the emerging institutional setting is that not preferred by some regions (i.e., small or large, those with low preferences or with high preferences), this implies, by definition, that environmental policy is under-provided. In detail, this kind of under-protection is not due to the fact that we do not consider positive inter-regional

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. This is the case where the resulting dynamic instability - in the absence of countervailing forces - could set a competitive "race to the bottom" strategy (Oates and Schwab 1988; Wellish 1995; Wilson 1996; Oates and Portney 2001; Oates 2002; Kunce and Shogren, 2005) leading to inefficiently low levels of environmental protection.

In our case, under-provision of environmental quality is mainly due to the fact that some regions are forced after voting to have an institutional setting they do not prefer. Indeed, it depends on the fact that the effects and convenience of cross subsidization may be different considering local size. In particular, smaller regions may not have enough resources to autonomously finance environmental policy for their community; the opposite situation could take place for larger ones. Hence, a cooperative institutional 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-coordinated system should not be voted only without externalities, but also with high spillovers. Actually, this system would be voted by small regions and those with higher preferences for environmental protection, where the free-riding gains outweigh the benefits of internalizing spillovers.

3.2 The level of overall environmental protection

Finally, we analyze under which conditions the highest level of environmental protection could be obtained. In other words, we propose a normative approach suggesting which institutional setting should be adopted in order to provide and guarantee - in aggregate terms – a more pervasive environmental policy within the national territory. In this vein, we compare the total outcomes for environmental policy obtained in the previous part of the analysis summing up[16] the output levels of all regions. The overall environmental protection in a non-coordinated system is:

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

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

Under a coordinated system it is:

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

Comparing equations (10) and (10.a), we have the following:

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. ■

Thus, in order to provide the highest level of environmental protection, a State - where 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 institutional setting which could guarantee a greater environmental output to all citizens.

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

4. Concluding remarks

In conventional environmental economics (as in the welfare economics literature from which it descends), governments are depicted as carrying the responsibility for much of the desired environmental protection. That literature tends to ignore that fact that environmental policymaking does not originate from a single unitary authority but 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 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 have demonstrated that the relative performance of "centralized" and "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 the preferences of citizens, the costs of production and other local conditions; this would allow the attainment of a higher social welfare compared to the provision of a uniform standard of environmental protection across all jurisdictions.

In the case of environmental governance, in several countries, a tendency has been observed for the policies of the central government not to be imposed by a command system but to be implemented unevenly and flexibly through a process of negotiation (Breton and Salmon 2007). Without assuming policy uniformity also under a cooperative legislature (as in Oates and Schwab 1996; Oates 2002; Oates and Portney 2001; Lockwood 2002; Besley and Coate 2003), we can identify the following factors which interact to determine 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, where the net benefit of each item is basically different for large and small communities.

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 cost of environmental provision in each region. This means that positive spillover effects do not derive from externalities in the consumption of environmental policy (consumption externalities) rather from cost-reducing spillover effects in the implementation of environmental policy in different jurisdictions (production externalities).

Given this general framework, the main results of the paper are that increasing differences in population size across regions would basically lead towards the cooperative solution; while, increasing heterogeneity in preferences mostly to the non-cooperative scenario. To some extent, this finding is quite consistent with the traditional theory of fiscal federalism according to which "the welfare gain from the decentralized provision of particular local public good becomes greater as the diversity of individual demands within the country as a whole increases" (Oates 1972). Indeed, a central point in favour of decentralized standard setting to maximize social welfare is that heterogeneous preferences across jurisdictions over environmental and health standards must be respected.

Yet, considering spillover effects and the different size of local jurisdictions allow for a better qualification of these results. In addition, environmental economists have substantially ignored inter-

jurisdictional externalities as a motive behind the assignment of powers over the environment.[17] In reference to this, our findings suggest that the familiar presumption that a coordinated institutional setting is preferable only with higher spillovers is not confirmed since it can be chosen also for a low degree of spillovers. 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. At the same time, large jurisdictions and those with low preferences for environmental protection policy would prefer non-cooperation only without any external spillovers to exploit; while, when spillovers increase, they start to internalize spillovers through cooperation mechanisms hence gaining more from internalization than from free-riding.

Finally, the model could be also developed in order to consider different kinds of externalities, such as technological ones, allowing no symmetric effects of spillover as we have already assumed in this paper. Moreover, an empirical investigation on the behaviour of regions with different sizes in facing different spillovers could be the issue for further research.

[17] 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 Breton and Scott (1978) and Inman and Rubinfeld (1997).

Appendix

Proof of Proposition 3

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

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

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

This proves the case b).

Hence, Proposition 3 is proved. ■

Proof of Proposition 4

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

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

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

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 that 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. ■

References

- Barca, F. (2009). An Agenda for a Reformed Cohesion policy. A Place-Based Approach to Meeting European Union Challenges and Expectations. *Independent Report prepared at the request of Commissioner for Regional Policy.*
- Besley, T., Coate, S. (2003). Centralized versus Decentralized Provision of Local Public Goods: a Political Economy Approach, *Journal of Public Economics* **87**, 2611-2637.
- Boadway, R., Hobson, P. (1993). *Intergovernmental Fiscal Relations in Canada*, Canadian Tax Foundation.
- Breton, A., Scott, A. (1978). *The Economic Constitution of Federal States.* University of Toronto Press, Toronto.
- Breton, A., Brosio, G., Dalmazzone, S., Garrone, G. (2007). *Environmental Governance and Decentralisation.* Edward Elgar, Cheltenham.
- Breton, A., Salmon, P. (2007). France: Forces shaping centralization and decentralization in environmental policymaking. In *Environmental Governance and Decentralisation.* A. Breton, G. Brosio, S. Dalmazzone and G. Garrone (eds.) Edward Elgar, Cheltenham, 457-494.
- Buchanan, J.M. (1965). An Economic Theory of Club. *Economica* ***32***(125), 1-14.
- Cavalcanti, C. (2007). Economic growth and environmental protection in Brazil: An unfavourable trade-off. In *Environmental Governance and Decentralisation.* A. Breton, G. Brosio, S. Dalmazzone and G. Garrone (eds.) Edward Elgar, Cheltenham, 49-76.
- Conley, J., Dix, M. (1999). Optimal and Equilibrium Membership in Clubs in the Presence of Spillovers, *Journal of Urban Economics* **46**, 215-229.
- Dalmazzone, S. (2006). Decentralization and the environment. In *Handbook of Fiscal Federalism.* E. Ahmad and G. Brosio (eds.) Edward Elgar, Cheltenham, 459-477.
- Dinan, T., Cropper, M., Portney, P. (1999). Environmental federalism: Welfare losses from uniform national drinking water standards. In *Environmental and Public Economics: Essays in Honor of Wallace E. Oates.* A. Panagariya, P. Portney and R.M. Schwab (eds.) Edward Elgar, Cheltenham, 13-31.
- Dur, R., Staal, K. (2008). Local Public Good Provision, Municipal Consolidation, and National Transfers, *Regional Science and Urban Economics* **38**, 160-173.
- Fiorillo, F., Sacchi, A. (2011). Free-riding or Internalizing? An Opportunistic View on Decentralization versus Centralization. *CESifo Working Paper* n. 3328.
- Gilbert, G., Picard, P. (1996). Incentives and Optimal Size of Local Jurisdictions, *European Economic Review* **40**, 19-41.
- Inman, R.P., Rubinfeld D.L. (1997). The political economy of federalism. In *Perspectives on Public Choice, A Handbook.* D.C. Mueller (ed.) Cambridge University Press, New York, 73-105.

- Kanbur, R., Keen, M. (1993). Jeux sans Frontières: Tax Competition and Tax Coordination when Countries Differ in Size, *American Economic Review* **83**(4), 877-892.
- Kanbur, R., Keen, M., van Wijnbergen, S. (1995). Industrial competitiveness, environmental regulation and direct foreign investment. In *The Economics of Sustainable Development.* I. Goldin and L.A. Winters (eds.) Cambridge University Press, New York, 289-302.
- King, D. (1984). *Fiscal Tiers: The Economics of Multi-level Government.* London: Allen and Unwin.
- Kraft, M.E., Scheberle, D. (1998). Environmental Federalism at Decade's End: New Approaches and Strategies. *Publius: The Journal of Federalism* **28**(1), 131-146.
- Kunce, M., Shogren, J.F. (2005). On interjurisdictional competition and environmental federalism. *Journal of Environmental Economics and Management* **50**(1), 212-224.
- Lockwood, B. (2002). Distributive Politics and the Cost of Centralization. *Review of Economic Studies* **69**(2), 313-337.
- Lockwood, B. (2006). The Political Economy of Decentralization. In *Handbook of Fiscal Federalism.* E. Ahmad and G. Brosio (eds.) Edward Elgar, Cheltenham, 33-60.
- Markusen, J.R, Wigle, R.M. (1989). Nash Equilibrium Tariffs for the United States and Canada: the Roles of Country Size, Scale Economies, and Capital Mobility. *Journal of Political Economy* **97**(2), 368-386.
- Oates, W.E. (1972). *Fiscal Federalism.* Harcourt Brace, New York.
- Oates, W.E. (1999). An essay on fiscal federalism. *Journal of Economic Literature* **37**(3), 1120-49.
- Oates, W.E. (2002). A reconsideration of environmental federalism. In *Recent Advances in Environmental Economics.* J.A. List and A. de Zeeuw (eds.) Edward Elgar, Cheltenham, 1-32.
- Oates, W.E., Portney, P.R. (2001). The political economy of environmental policy. *Discussion Paper 01-55 Resources for the Future*, http://www.rff.org.
- Oates, W.E., Schwab, R. (1988). Economic Competition among Jurisdictions: Efficiency-Enhancing or Distortion-Inducing? *Journal of Public Economics* **35**, 333–354.
- Oates, W.E., Schwab R. (1996). The theory of regulatory federalism: the case of environmental management. In *The Economics of Environmental Regulation.* W.E. Oates (ed.) Edward Elgar, Cheltenham, 319-331.
- Petchey, J.D. (2007). Australia: Preserving biodiversity and managing water resources. In *Environmental Governance and Decentralisation.* A. Breton, G. Brosio, S. Dalmazzone and G. Garrone (eds.) Edward Elgar, Cheltenham, 17-48.
- Revesz, R.L. (1996). Federalism and Interstate Environmental Externalities. *University of Pennsylvania Law Review* **144**(6), 2341-2416.
- Schwab, R. (2006). Environmental Federalism. In *The RFF reader in Environmental and Resource Policy.* W.E. Oates (ed.) RFF Press Book, Washington, 109-114.
- Seabright, P. (1996). Accountability and Decentralization: an Incomplete Contracts Model. *European Economic Review* **40**(1), 61– 90.

- Tiebout, C. (1956). A Pure Theory of Local Expenditures. *Journal of Political Economy* **64**(5), 416–424.
- United Nations (1997). *Glossary of Environment Statistics*, Studies in Methods, Series F, n. 67, United Nations, New York.
- United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank (2005). *Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003*, Studies in Methods, Series F, n. 61, rev.1, Glossary, United Nations, New York.
- Valiante, M. (2007). Interdependence and coordination in the Canadian environmental policy process. In *Environmental Governance and Decentralisation.* A. Breton, G. Brosio, S. Dalmazzone and G. Garrone (eds.) Edward Elgar, Cheltenham, 77-110.
- Wellish, D. (1995). Locational choices of firms and decentralized environmental policy with various instruments. *Journal of Urban Economics* **37**, 290–310.
- Wilson, J.D. (1996). Capital mobility and environmental standards: Is there a theoretical basis for a race to the bottom? In *Fair Trade and Harmonization: Prerequisites for Free Trade?* J. Bhagwati and R. Hudec (eds.) MIT Press, Cambridge, 393-427.