Coordination of Local Pollution Control in a Federal System

By
Per Andersen & Tim Jeppesen
Department of Economics Odense University
Denmark

Presented at the World Congress of Environmental and Resource Economists
Venice, Italy, June 25-27, 1998

Corresponding author:
Tim Jeppesen, Department of Economics
Odense University, Campusvej 55, DK 5230 Odense M,
Denmark, fax +4566158790, tij@busieco.ou.dk
Abstract
This paper examines local pollution control in a federal system where the central and the local authorities are imperfectly informed. The central and the local authority have the same goals but different information. The local authority may be better informed about the local demand for changes in environmental policy, whereas the central authority may be better informed about many scientific aspects related to changes in environmental quality. The paper shows how the central authority can introduce a grant-in-aid system that induces the local authority to take central authority information into account and combine it with local information. The grant-in-aid system is flexible so that the local authority is induced to use a weighted combination of local and central information. In one extreme, the central authority is highly uncertain of the environmental and health effects of a specific pollutant. In this case, the tax subsidy scheme may be designed to allow local information to play an essential role in the environmental policy. In the other extreme, the central authority is quite certain that a specific pollutant must not exceed a certain limit. In this case, the tax subsidy scheme is designed to allow local information little influence on the environmental policy.

1 Introduction
Analysis of the appropriate division of functions among levels of government goes back to Musgrave’s (1959) treatment of the public sector. The various layers of the public sector deal with matters of (supra)national, regional and local concern. Each layer of government has fiscal and regulatory responsibilities for its own geographical jurisdiction. This federal structure of the public sector opens up for large array of important issues, including the proper allocation of fiscal functions among the different levels of government, assignment of specific instruments to the various levels, and the vertical assignment of regulatory responsibilities (Oates 1994). An economic approach to the assignment of environmental regulatory responsibilities involves a balancing of control costs against damages. Following the standard models, if costs and benefits are localized and specific to their geography, environmental policies should be tailored to the particular circumstances of localities. A local environmental problem should be regulated by a local authority. If pollution is transboundary, more centralized measures are required (see e.g. Baumol & Oates 1988, Cropper & Oates 1992). This result assumes complete information. This paper examines local pollution control in a federal system where the central and the local authorities are incompletely informed. In our analysis, both the central and the local authorities possess information which should be used in the determination of environmental policies. Consequently, a wholly decentralized approach is inappropriate, and we examine how the central authority can induce the local authority to take central information into account.

The United States and the European Union have different experiences with the development of the institutional arrangements for pollution control. The US has exhibited an oscillation of environmental regulatory responsibilities between the states and the federal government (Vig and Kraft 1990). In the 1960s the federal government's role was limited to management of public lands. Air and water pollution were considered local issues. This changed dramatically in the
beginning of the 1970s, when rising public concern about the environment triggered the development of federal institutions such as the EPA and the Council on Environmental Quality and of federal environmental policy programmes, such as the Clean Air and Water acts. In the 1980s the Reagan presidency had a very different environmental policy agenda. 'Environmental deregulation' was part of a large policy change intended to reduce the scope of federal regulation and shift responsibilities to the states. Between 1981 and 1983 the EPA's budgets were cut by more than 50%, the number of employees fell significantly, and the states were delegated enforcement responsibilities for a large amount of the emission standards (List & Gerking 1996).

The institutional arrangements for pollution control in the EU have evolved quite differently than in the US. Until the signing of the Single European Act (SEA) in 1987, environmental policy had no formal treaty basis. Environmental directives were nevertheless passed, based either on trade interests or restricted to general framework provisions. The driving force behind the SEA was to complete the single market in 1992. However, the SEA also brought the formal introduction of a legal base for environmental policy. The legal base has been strengthened and enlarged with the amendments of the 1993 Maastricht Treaty and the Amsterdam Treaty in 1997. The amendments have changed the decision-making procedure from unanimity to qualified majority, and the powers of the European Parliament have been increased from just being a consulting institution exercising veto powers in some situations. The EU has thus built up substantial powers previously located exclusively in the domain of the Member States. However, Liefferink (1996) shows that the increased EU competences did not necessarily pre-empt or replace national environmental policy. For countries such as the Netherlands and Germany, the EU established an additional level of governance. Only in the Mediterranean countries were environmental policy responsibilities limited by the increased EU responsibilities. Furthermore, it should be noted that the distribution of environmental policy responsibilities has been debated since the introduction of environmental policy in the SEA. The principle of subsidiarity was included in Article 130r of the SEA, i.e. before it was adopted as a general principle in the Maastricht Treaty.

Even though the two systems are quite different, a common feature is that central and local authorities have ‘shared responsibilities’. This means that the central authority set environmental policy goals and leaves it to the local authorities to implement the environmental policies necessary for obtaining the goals. Examples of shared responsibility are the Clean Water Act in the US and the extensive use of directives in the environmental policy in the EU. The Clean Water Act requires local authorities (the states) to develop and implement plans for reducing non-point source pollution to achieve the federally specific goals (see e.g. Freeman 1990 and Portney 1990). A directive is an instrument which allows the objective in terms of minimum quality (e.g., of drinking water) to be set at the Community level while leaving it to the Member States to decide the means to reach the objectives (see, e.g. COM (93) 680 final, and COM (94) 612 final).

This paper develops a simple model that captures the interaction between a central authority and a local authority in the regulation of local pollution problems. In our model, the local authority has the competence to determine the local environmental quality based on its private information. However, the central authority possesses private information which ideally should be transmitted to the local authority. In order to do this, the central authority is in a position to implement a grant-in-aid system which induces the local authority to take into account central information. In this way, the central and local authorities have shared responsibilities in the sense that they both possess relevant information and both have an interest in the formulation of environmental policies.
The local authority may be better informed about, say, the local demand for changes in environmental policy, whereas the central authority may be better informed about scientific aspects related to changes in environmental quality. We will argue here that the central authority can construct a grant-in-aid system that induces the local authority to choose their decision variables in such a way that the welfare function of the central authority is also maximized. The flexible grant-in-aid system induces the local authority to use a weighted combination of local and central information. At one extreme, the central authority is highly uncertain of the environmental and health effects of a specific pollutant. In this case, the grant-in-aid system is designed to allow local information to play an essential role in the environmental policy. This leaves much room for the local authority to regulate the environment. At the other extreme, the central authority is quite certain that a specific pollutant must not exceed a certain limit. Here the grant-in-aid system is designed to allow local information little influence on the environmental policy, leaving little room for the local authority to regulate the environment.

This paper is structured as follows. Section Two provides an overview of theoretical approaches to the analysis of the distribution of environmental policy responsibilities in a federal system. Our model is presented in Section Three, and in Section Four we determine the optimal mix of central and local information. The concluding remarks are presented in Section Five.

2 Theoretical Approaches to Environmental Policy in a Federal System

On first sight, basic economic reasoning seems to offer a straightforward solution to the problem of distributing environmental regulative responsibilities between a central and a local authority: Standards should vary among states according to the local circumstances. A standard should be set where marginal abatement costs equal marginal benefits. If the costs and benefits are regional or local they are likely to vary between states, a condition which clearly calls for a decentralized approach to environmental regulation. In the case of transboundary pollutants, however, a decentralized approach is inappropriate. In this case, each state will consider only the impact of pollution on the residents of the state where it is emitted. Thus, the decentralized provision of public goods generating spillovers into neighbouring states is inefficient and justifies central government intervention (Oates 1972, Baumol & Oates 1988, Cropper & Oates 1992). However, this basic economic reasoning ignores migration responses to unilateral actions to control pollution, and that the central and the local authority possess asymmetric information. If factor mobility and asymmetric information is included in the analysis, the derived results will differ from the basic economic reasoning.

2.1 Factor Mobility
If labour is mobile, a decentralized provision of public goods may be socially efficient. Myers (1990) shows that decentralized governments provide efficient levels of a local public goods if consumers are perfectly mobile and governments can make interregional income transfers. There is no role for a central authority because it is in the local authorities’ self-interest to make the
transfers in order to obtain a preferred local population.\footnote{This result is also obtained in the case of imperfect mobility. Mansoorian & Myers (1993) introduce imperfect labour mobility by assuming that people derive utility from living in their native country. Their result however, is dependent upon the absence of spill-overs.} Wellisch (1994) demonstrates that Myers’ result also holds when local governments provide goods that generates spillovers. In Wellisch (1994), two regions generates transboundary pollution. Labour is perfect mobile. As with Myers (1990), perfect mobile labour (e.g. a fully integrated labour market) serves as a disciplinary mechanism inducing implicit cooperation between local authorities and thus improves the quality of the environment. The fact that labour reacts to differences in environmental policy forces local authorities to take into account the welfare of non-residents due to the presence of transboundary pollution. Thus, local decision-making internalizes the externalities from transboundary pollution, and the decentralized outcome is socially efficient. Silva (1997) uses a model quite similar to Wellisch (1994), except that it is only one of the regions that generates a transboundary pollutant (upstream-downstream pollution). Silva also derives the result that the decentralized outcome is efficient in the case of transboundary pollution. In contrast to Wellisch (1994), this is obtained even if it is not possible for the local authorities to make interregional income transfers. This is due to the fact that the upstream region’s abatement enables the downstream region to lower its abatement. In this way the abatement expenditure of the upstream region takes the role of explicit income transfers.

If capital is mobile, regions might engage in a destructive interjurisdictional competition in order to attract new business investment. Such competition may take the form of lowering environmental taxes with low environmental quality as a likely result. Thus, in addition to transboundary pollution, tax competition may provide another argument for central government intervention. Oates and Schwab (1988) and (1989) have constructed a set of models based on perfect competition. Here local officials trade off tax revenues and environmental quality for local jobs and income. In their basic model, local choices under simple-majority rule will be socially optimal. It is in the interest of the local authority to select a zero tax on capital and set a standard such that the cost of improved environmental quality at the margin equals the locals’ willingness-to-pay. This result is also obtained if the interests of future generations are taken into account. Local officials choose an efficient environmental policy because both present and future environmental policy is capitalized into property values. However, models based on imperfect competition and increasing returns to scale derive a different result. Markusen, Morey & Olewiler (1995), Hoel (1994), Rauscher (1994), (1995), and Motta & Thisse (1993) all show that a decentralized outcome in general will not be socially efficient. However, it is not clear whether the rate of the environmental tax will be higher or lower than the socially optimal tax rate. The environmental tax may be higher than the socially optimal tax because we have the ‘Not-In-My-Back-Yard’ (NIMBY) case, where it is rational for a local authority to raise the environmental tax in order to drive the polluting industries out of its jurisdiction. The environmental tax may also be lower than the socially optimal tax because it could be rational for a local authority to lower the environmental tax in order to attract new business investment.

Hence, the general presumption that local (transboundary) pollution problems should be solved locally (centrally) does not seem to be very robust. If capital is mobile, a local authority does not necessarily solve local environmental problems efficiently. If labour is mobile, transboundary
pollution problems may be solved efficiently by local authorities.

2.2 Asymmetric Information
The approaches with labour and capital mobility do not say much about information. Presumably, perfect and symmetric information is assumed. List (1997), Klibanoff & Poitevin (1996), Klibanoff & Morduch (1995), Rob (1989), and Farrell (1987) all deal with aspects of externalities and asymmetric information. Labour and capital are assumed to be immobile. Klibanoff & Morduch (1995) studied the efficiency of decentralization in the case of externalities. Centralization is not considered. They adopt a mechanism design approach and emphasise the crucial role of individual-rationality and incentive-compatibility constraints. Local information is superior to central information, and the autonomy of individual localities is respected. Klibanoff and Morduch show that coordination through Coasian bargaining can raise social welfare only when external effects are relatively large. When external effects are relatively small, coordination cannot yield improvements at all. Autonomy and private information can make it very difficult to internalize externalities and may result in substantial losses in social efficiency. Thus, the argument that small externalities lead to small inefficiencies while large externalities give rise to large inefficiencies is not necessarily true. Individual-rationality constraints mean that agents cannot have a central project imposed upon them. In order to study both centralization and decentralization, Klibanoff & Poitevin (1996) ignore individual-rationality constraints. They consider the decision over a project which affects the welfare of two agents. In the centralized setting, the agents have no rights over the project (agents have no participation constraints). In the decentralized setting, the central authority has no means of imposing a project size (agents have participation constraints). The result is that it is not necessarily true that large externalities justify centralization. A decentralized approach may be justified if the distribution of benefits is differently distributed between regions and the variance of the externality large enough. Further, they demonstrate that a local authority does not necessarily take local heterogeneity into account better than a central authority. More heterogeneity in the size of the private benefits favours centralization if the expected externality is sufficiently large.

List (1997) uses a differential game approach to analyse the aspects of environmental policy in a federal system with asymmetric information. Dynamic games with symmetric information usually derive the result that central pollution control Pareto dominates local pollution control (Dockner & van Long 1993, and Kaitala et al. 1995). List introduce asymmetries between players as well as informational advantages for localities and derives the opposite result. Now local pollution control may Pareto dominate central control if damages from pollution are highly different across regions. More specifically, List assumes that agents across regions have different preferences for the environment and that damages are also different across regions. Local authorities can observe their constituents’ tastes for environmental quality and tailor policies closely to match these preferences. The central authority, however, has imperfect information on local preferences. This means that the central authority has to impose uniform standards across regions. List demonstrates that there exists a threshold value for one of the states’ pollution costs for which the state will strictly prefer decentralization even if it receives all welfare accrued under central control. This is because a central authority, imposing uniform regulations, will restrict production of the polluting good so much that the state becomes worse off. In the limit, both regions could be better off under local control if substantial asymmetries exist.
2.3 Shared responsibilities

It is characteristic of the literature mentioned above that environmental policy in a federation is analysed as either a fully centralized regime or a fully decentralized regime. In practice, however, environmental policies are often set at both the central and the local level. Silva & Caplan (1997) assume that neither the central nor the local authority possesses full control over the environmental policy instruments. The central authority is assumed to control pollution taxes, whereas the local authority control the instruments to produce pollution abatement. Two types of federal systems are examined. In the first, the central authority is assumed to be a Stackelberg leader, and the two local authorities are followers. This system features centralized leadership in environmental policy making. The second system features decentralized leadership. Here the local authorities are the Stackelberg leaders and the central authority is the follower. In both systems the central authority can make income transfers which may influence the local authorities’ pollution abatement. Moreover, it is assumed that there are regional taste differences over pollution control. Information is complete and labour is immobile. The result is that decentralization of responsibilities over pollution abatement will always generate larger than socially desirable levels of pollution in a system with centralized leadership. However, in a system of decentralized leadership, decentralized control over pollution abatement will always produce a socially efficient environmental policy. This last result, however, depends crucially on the assumption about interregional transfers, tastes, and information.

Segerson et al. (1997) does not explicitly analyse the question of the appropriate division of environmental responsibilities between different levels of authorities. However, they examines the question as to which level should pay for the cost of implementing environmental policy. When a central authority imposes mandates on local authorities that require the local authorities to meet minimum standards or environmental quality goals, the mandates can either be fully funded from the central authority or not funded at all. Segerson et al. does not consider asymmetric information as such, but the central authority suffers from ‘fiscal illusion’, i.e. it does not consider the costs incurred by the local authorities when the central authority decides upon its mandates. Depending on the funding decision, a double moral hazard problem may exist. On the one hand, if the central authority does not fund the mandates it creates a moral hazard problem for the central authority because it does not recognize the full cost of environmental regulation. The result is over-regulation. On the other hand, if the mandates are fully funded it creates a moral hazard problem for the local authorities because they will not face the proper incentives for innovation and cost-minimization. In addition, in the absence of federal mandates the local authorities may implement an environmental policy which is ‘too lax’ due to factors such as interjurisdictional externalities. Both systems (fully funded and unfunded mandates), will thus be inefficient. Instead, the double moral hazard problem should be solved by a funding rule under which the central authority would be required to fund mandates that exceed the efficient mandate but would not be required to fund those that are less than the efficient mandate.

Both models emphasize that responsibilities may be allocated at different levels at the same time, i.e. the models are characterized by neither full decentralization nor full centralization. As pointed out by Silva & Caplan (1997) it is important to model systems using a mixture of centralized and decentralized pollution control. Moreover, the models focus on transboundary externalities and assume that the local authority has no incentive to take these externalities into account unless they are given relevant incentives. In Silva & Caplan (1997) relevant incentives are created by making the central authority a Stackelberg follower. In Segerson et al. (1997) the central authority moves
first by creating an efficient funding rule. The efficient funding rule implies that the central authority should be required to provide full funding if it imposes a mandate exceeding the social optimum and no funding if it imposes a mandate short of the social optimum.

The model presented in section three is in accordance with the above mentioned models in having shared responsibilities, but the focus is on local pollution. The model assumes that central and local authorities possess different kind of private information, which ideally should be used in formulating environmental policies. The local authority may have private information because some information is gained by being close to the local community, whereas the central authority may have private information because its information is obtained from technical experts placed at the central authority due to economies of scale. Like Segerson et al. (1997), we derive an efficient funding rule but for quite different reasons. In Segerson et al. (1997) the funding rule depends upon whether the centrally imposed mandate is above or below the socially efficient mandate. In our model, the funding rule depends upon the mix of central and local information.

3 The model

We consider a model with a central authority and a local authority. The central authority maximizes the central welfare function, and the local authority maximizes the local welfare function. The two welfare functions differ from each other. Information about the welfare function is private; i.e., the central authority knows its own welfare function, but not the local welfare function. The local authority knows the local welfare function, but not the central. The two authorities have the same basic goal. The objective of the authorities is to determine the level of environmental quality. Environmental quality is a function of a pure local externality. Despite the fact that the local authority has all the competences to determine the level of environmental quality, the central authority still play a part because we assume that both central and local authorities possess information relevant to determining environmental quality. The local authority is better informed than the central authority about local demand for changes in environmental policy. Therefore, they are superior to the central authority in tailoring environmental policy to local conditions and preferences. The central authority is better informed about many scientific aspects related to changes in environmental quality. Local authorities may be better informed about, say, the willingness to pay for increases in drinking water quality, whereas the central authority knows more about potential health risks of different levels of pesticides in the drinking water. Hence, in this model the central authority possesses important information which should be ‘pooled’ at the local authority level.

The simple solution of course, is to simply transmit information from the central to the local authority. This process, however, is not without difficulties. Transmission of information does not necessarily mean that it is used. The local authority may not have incentives to make use of central information. Casual empiricism suggests that local authorities are not always particularly enthusiastic about following central authority advice.

It is therefore important for the central authority to construct incentive systems (e.g. grant-in-aid systems) that induce the local authority to choose their decision variables in such a way that the welfare function of the central authority is maximized. This presumes that the behaviour of the local authority is known to the central authority, and that the authority has a well defined welfare
function. These assumptions are in general not fulfilled, and we show how the incentive system can be constructed to promote allocative efficiency, and how the incentive system can be used for transmission of information from the central authority to the local authority.

The local authority determines its level of environmental quality so that the consumers’ surplus plus revenue less the local costs is maximised. Consumers’ surplus is based on a local authority estimate of the demand curve. Local authorities take into account potential grants-in-aid from the central authority.

Assume that

\[ X \] is the level of environmental quality, \( X_L \) and \( X_C \) is the local and central environmental quality, respectively.
\[ D_L(X) \] is the central authority estimate of the inverse demand curve.
\[ D_L(X) \] is the local estimate of the demand curve.
\[ C(X) \] is the total cost curve, and \( MC(X) \) the marginal cost curve.
\[ G(X) \] is the total grant-in-aid curve, \( MG(X) \) the marginal grant-in-aid curve.

The local maximization problem is

\[
\max_{X_L} W_L = \int_0^{X_L} (D_L + MG - MC)(X) \, dX, \quad X \geq 0. \tag{1}
\]

If \((D_L + MG - MC)(0) > 0\) and \(D_L + MG - MC\) is monotonously decreasing with respect to \(X\), the optimal level of environmental quality is determined by the first-order condition

\[
\frac{\partial W_L}{\partial X_L} = (D_L + MG - MC)(X) = 0. \tag{2'}
\]

By inversion, we obtain the optimal value of \(X_L\)

\[
X_L^* = (D_L + MG - MC)^{-1}(0) \tag{2''}
\]

where \(X_L^*\) is the optimal level of environmental quality chosen by the local authority, ignoring the central demand curve. The central authority has an estimate of the demand curve, and finds that it should also be included when the local authority decides the level of environmental quality.
However, the central authority is uncertain about the local demand curve. This is illustrated in figure 1, where the central authority does not know whether the local demand curve is below the central demand curve \((D^1_c)\), or whether it is above \((D^2_c)\). Thus, from the point of view of the central authority, the local demand curve is uncertain, such that an estimate has to be drawn from some well behaved probability distribution as regards some parameters describing the demand curve.\(^2\) The relative uncertainty of the estimates is a function of the good considered. Therefore, we further assume that

\[
\lambda \quad \text{is a non-negative weighting factor expressing how much weight the central authority attaches to local information.}
\]

\[
\varphi(\alpha), \alpha \in \mathcal{A}' \quad \text{is a frequency function for the local estimate with respect to some set of parameters, } \mathcal{A}'.
\]

![Figure 1. Optimal level of externality with uncertain local demand curve.](image)

In some cases, the central authority believes that it has vital information which must be taken into account when the local authority decides the environmental quality. In other cases the central authority believes that knowledge of local conditions is of decisive importance. Therefore the central authority wants to induce the local authority to use a weighted estimate of the demand curve. The central authority decides a weight, \(\lambda\), which reflects the weight the central authority attaches to local information. \(\lambda\) is decisive for the grant-in-aid that the local authority receives from the central authority. In figure 1 the central authority must set \(\lambda\) so the weighted demand curve is between \(D^1_c\) and \(D^2_c\) (or \(D^3_c\)). If \(\lambda = 0\), local information is not taken into account. However, the greater the value of \(\lambda\), the closer the weighted demand curve is to the local estimate.

\(^2\) From the point of view of the local authority the central demand curve is uncertain. However, the local authority does not consider the central demand curve.
If $\lambda \to \infty$, central information is not taken into account. Hence, the greater the value of $\lambda$ the greater the importance of local information relative to central information.

In this way, local environmental quality is decided in a two step procedure. In Step 1, the central authority decides how much weight should be attached to central and local information and thereby the grant-in-aid schedule. In Step 2, the local authority decides the level of environmental quality, given the grant-in-aid schedule. The maximization problem for the central authority is

$$
\max_{X_{C}(\alpha)} W_{C} = \int_{A'} \varphi(\alpha) \int_{0}^{X_{C}(\alpha)} [(D_{C}^{*} + \lambda D_{L}^{\alpha}) - MC](X) \ dX d\alpha.
$$

(3)

The subscript $C(\alpha)$ indicates that in contrast to (1), the central environmental quality is a function of $\alpha$. In case of linear demand curves the first integration could be over the intercepts of the ordinate axes and over the slopes of the demand curves. The second integral gives the consumers surplus plus revenue, less total costs for every possible local estimate $D_{L}^{\alpha}$.

The maximization of (3) implies that an optimal environmental quality should be found for each level of the local authority estimate parameterized by $\alpha$. That is, for every value of $\alpha$, we determine the environmental quality chosen by the central authority, by maximizing the second integral in (3). The first-order condition becomes

$$
\frac{\partial W_{C}}{\partial X_{C}(\alpha)} = \int_{A'} \varphi(\alpha)(\frac{D_{C}^{*} + \lambda D_{L}^{\alpha}}{1 + \lambda} - MC)(X) \ d\alpha = 0.
$$

(4')

By inversion, we obtain the optimal level of environmental quality chosen by the central authority

$$
X_{C(\alpha)}^{*} = (\frac{D_{C}^{*} + \lambda D_{L}^{\alpha}}{1 + \lambda} - MC)^{-1}(0).
$$

(4'')

$X_{C(\alpha)}^{*}$ is the optimal level of environmental quality chosen by the local authority, taking into account the central information. The central authority has no direct control over the local level of environmental quality, but several grant-in-aid systems can be chosen by the central authority so that the local choice of environmental quality is equal to $X_{C(\alpha)}^{*}$ for all functions of $D_{L}^{\alpha}$. According to (2), the local authorities ensure that $(D_{L}^{*} + MG - MC)(X) = 0$. The task for the central authority is to make incentive systems that would guarantee that $X_{C(\alpha)}^{*}$ and $X_{L}^{*}$ coincide for each value of $\alpha$. The family of these systems are given by the functions $MG$, which satisfies (6) for all functions of $D_{L}^{\alpha}$.
\[ k(D_{L}^{\lambda} + MG - MC)(X) = \frac{D_{C} + \lambda D_{L}^{\lambda}}{1 + \lambda} - MC)(X) \]  

(5)

where \( k \) is a positive constant. Thus

\[ MG(X) = \frac{1}{k} \left( \frac{D_{C} + \lambda D_{L}^{\lambda}}{1 + \lambda} \right) + (k-1)MC - D_{L}^{\lambda})(X). \]  

(6)

The most interesting interpretations of (7) is if \( k = 1 \) or \( k = \frac{\lambda}{(1+\lambda)} \), where we get (7') and (7''), respectively.

(7') gives an incentive for the local authority to select, what from the point of view of the central authority, is the correct level of environmental quality. However, there are two problems with this. First, as mentioned, \( D_{C} \) is unknown to the central authority. Second, the central authority cannot expect the local authority to reveal the correct information about the demand curve estimate. Therefore (7') must be replaced with (7'') which is independent on \( D_{C} \). We interpret (7'') graphically by figure 2a and 2b. In figure 2a we have depicted the central authority demand curve (\( D_{C} \)) and the marginal cost curve (MC). From these curves we have constructed two marginal grant-in-aid schedules (\( MG_{1} \) and \( MG_{2} \)) for the weights \( \lambda = 1 \) and \( \lambda = 2 \) respectively. In figure 2b the net marginal costs curves are depicted (MC less MG) Further two different estimates of local demand curves (\( D_{L}^{1} \) and \( D_{L}^{2} \)) are shown. From these curves, the level of environmental quality is determined. \( X_{0} \) is the level of environmental quality based exclusively on central information (based on the weight \( \lambda = 0 \)). \( X_{1} \) and \( X_{2} \) are based on the weight \( \lambda = 1 \), and \( X_{1} \) and \( X_{2} \) are based on the weight \( \lambda = 2 \). Note that the lower the weight \( \lambda \), the closer the levels of environmental quality are to \( X_{0} \). Hence, the smaller \( \lambda \), the higher grant-in-aid. Moreover, the marginal net gain of environmental quality according to the central authority estimate changes from positive to negative at the level \( X_{0} \). Therefore, the marginal grant-in-aid changes in the same way at that level.
Below $X_0$ the grant-in-aid is positive, but above $X_0$ it is negative. In this way the central authority may overcome the difficulties of transmitting information from the central to the local authority because by choosing (7'') the central authority gives the local authority an incentive to take the central information into account when it decides on the level of environmental quality.

4 The Optimal Mix of Central and Local Information

The weight $\lambda$ is of central importance to the construction of the grant-in-aid curve. Therefore it is important to discuss the considerations behind choosing a given value of $\lambda$. One argument could be that $\lambda$ is simply a measure of the desired degree of autonomy of the local authority. Another argument could be that $\lambda$ should reflect the relative degree of uncertainty of the central and local estimates. We choose the second approach.

The central authority can choose $\lambda$ with certainty because it knows its own demand, and thus how much weight to attach to local information. We now assume that the central authority is uncertain of its own demand. From the point of view of the central authority, both demand curves are now uncertain. We assume that: (1) demand curves are linear with the same slope, (2) the uncertainty is related to the intercept on the ordinate axis, (3) the central and the local estimates are
stochastically independent and have the same mean equal to the true intercept, marginal costs are constant. We assume that

\begin{align*}
D_c - bX & \quad \text{is the central estimate of the demand curve} \\
D_l - bX & \quad \text{is the local estimate of the demand curve} \\
MC & \quad \text{are the constant marginal costs} \\
T - bX & \quad \text{is the true inverse demand curve}
\end{align*}

We choose the maximand

\[ V = \int_{0}^{x_l} h(X_l) \left( (T - bX - MC) \right) \, dX dX_l \tag{8} \]

where \( h(X_l) \) is the frequency function for \( X_l \). However, using (2) \( X_l \) is determined by

\[ X_l = \frac{D_l + G - MC}{b - g} \tag{9} \]

where \( MG = G + gX \). Using (7’’) we get

\[ X_l = \frac{D_c + \lambda D_l}{1 + \lambda} - \frac{MC}{b} \tag{10} \]

Thus, we may rewrite (8) as

\[ \max \int h_1(D_l) \int h_2(D_c) \int_0^x (T - bX - MC) \, dX dD_c dD_l \tag{11} \]

where \( h_1(D_l) \) and \( h_2(D_c) \) are the frequency functions for \( D_l \) and \( D_c \) respectively. We then get the optimal value of \( \lambda \) as

\[ \lambda^* = \frac{\sigma^2(D_c)}{\sigma^2(D_l)} \tag{12} \]
where \( \sigma^2(D_L) \) and \( \sigma^2(D_C) \) denote the variances on \( D_L \) and \( D_C \). In general it is not possible to obtain an analytical determination of \( \lambda^* \), but here we have obtained a simple and sensible expression for the optimal weight.

In the discussion of centralization vs. decentralization emphasis has been placed on both the results of the decision process and the decision process itself. In the model presented here we can define a decision process as over-decentralized (under-decentralized) according to whether \( \lambda \) is higher (lower) than \( \lambda^* \).

5 Conclusion

Environmental policy in a federal system focus on whether we should set national standards applicable to all areas in a state, or whether we should allow local authorities to determine specific standards for their own jurisdictions. The answers to these questions depend on the perspective. Conventional wisdom argues for decentralization in absence of spillover effects and for some degree of centralization with the presence of spillover effects. This view could be changed with an introduction of capital and labour mobility and with informational asymmetries.

In this paper, we have focused on informational asymmetries. The central authority and the local authority have the same objective, but have different information. The local authority chooses the level of environmental quality, but its choice is influenced by the incentive system given by the central authority. In principle, the central authority could use a ‘forcing contract’, but since it recognises that its information is imperfect, it will use a flexible grant-in-aid system where a weighted combination of local and central estimates is used. The weight should reflect the relative quality of the two estimates. If the central authority is weighting its estimate higher (lower) than its quality indicates, we could call the system relatively over-centralized (under-centralized), even though the competence is located at the local level.

References


**European Community Documents**
