Decentralized public decision making: the moral hazard problem*

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1. Introduction

The issues involved in designing a system of regional governments have been in recent years at the center of a policy debate all over Europe, not only in countries with strong traditions in favor of centralization – such as France – but also in countries that allowed for some decentralization – such as Germany or (more recently) Belgium. There are many aspects to the debate, such as the perception of national identity or various political strategies and calculations, that do not concern economic issues directly. However, the *assignment issue* in the design of regional government – namely, the allocation of authority for public expenditures among different levels of government – is part of the economics of decentralization. This allocation emphasizes the sharing of responsibility among different self-interested agents involved in a collective decision process. To document this debate with a concrete example, let us start with a brief description of the case for decentralization and regional government in France and the recent reform there.

Since 1982-83 there have been in France substantial changes in the organization of subcentral government. Before that period, public decision making was highly centralized according to principles inherited from the Napoleonic era. All important decisions were made, or at least approved, by bureaus in Paris. At the local level, in each of the 90 *départements*, the main powers were concentrated in the hands of civil servants appointed by the central government – *préfets* (or *recteurs* in the area of education). The *communes* (cities) created at the end of the last century (and now numbering more than 36,000) had elected mayors with greater powers, although still subject to a priori control by the *préfets*. Twenty-two *régions* had been designed in the late 1960s to include an average of our or five *départements*. The regions had indirectly elected assemblies but were run by an executive appointed by and accountable to the central government. Although allowed to contribute to the financing of investment projects undertaken by the state or their constituent local authorities, the primary function of the assemblies was to implement regional aspects of the central policy.

The reform, which started in 1982-83 and is still in progress, has introduced five major changes.[1] First, *communes, départements* and *régions* are now full-scale subcentral jurisdictions, all three endowed with a parliamentary system. In each jurisdiction there is a council elected directly by the citizens and an executive branch elected by the council. The local executive branches can have their own bureaucracy. Second, these three types of subcentral government are in principle completely

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1. See Gilbert and Delcamp (1993) for an account of the major administrative changes in France since 1982. See also Gérard-Varet (1995), a report prepared for Commissariat Général du Plan, Paris.

independent and, although they may overlap in responsibilities with respect to the same territory, there is no hierarchy among them.

Third, public expenditures have been partly decentralized: *communes* are in charge of urban planning and development, *départements* are responsible for the welfare program and social affairs, and the role of *régions* in development and economic planning has been strengthened. The *régions* have also been given specific responsibility for vocational and professional training and may be required to prepare, in cooperation with the *préfet*, a regional plan for medium-term investment (covering vocational training, research and technology, industrial aid, agricultural development, and communication). In practice, all local governments intervene on economic issues (such as unemployment), and all of them are competent in such areas as culture, tourism, and education. Fourth, the a priori control by the *préfet* has been abolished and replaced by the a posteriori control of a special court.

The fifth change concerns local government finance. Although taxing power is still determined by the central government, resources for the local governments have been increased. Before 1982, *communes* and *départements* shared various direct taxes: a housing tax based on rental income, two property taxes (on developed and nondeveloped land) based on the official market value of land and buildings, and a business tax – *taxe professionnelle* – designed as a tax on value added based on the value of business assets and a fraction of business wage bills. The rates of these taxes were linked by a central formula. The *régions* also received grants from the central government, which they redistributed as specific grants and capital subsidies because their budgetary powers were strictly limited by a centrally set ceiling. The three subnational levels were also allowed to borrow. However, with the 1982 reform, local jurisdictions can now freely choose the rates of the taxes they control. Regions are given the same direct tax bases as the other tiers of local government, and a vehicle registration tax, a vehicle license tax, and a tax on property sales and related registration fees (subject to a ceiling rate) have been transferred from the center to the regions. A new grant scheme has been designed to replace the previous arrangements whereby local and regional authorities received central grants for specific investment projects.

These reforms, introduced in France over a decade ago, have created quite a complicated system of public decision making. The debate over this evolution presently involves two major issues: one concerns the scope and scale of subcentral governments; the other, fiscal implications.

1. *Communes, départements*, and *régions* are competing with regard to how responsibilities should be shared. Should the shape of local and regional jurisdictions be redefined? What sort of contractual arrangements should be promoted among the different tiers of government (in particular, with respect to public investment)?

2. Should subcentral government be allowed to expand or not? How should fiscal responsibilities be shared among jurisdictions (sharing taxes, grants…)? What taxes (if any) should be allocated[2] to the different local jurisdictions? If the regions are wholly dependent on their own resources to pay for their spending, then what should be the scale of the redistribution in the overall burden of taxation? What pattern of grants from central government should be made available to correct major gains or losses?

2. It is widely recognized that the taxes raised by subcentral government in France are distorting, regressive, and inequitable across jurisdictions. If these taxes are allowed to grow then the transfer of taxes currently raised by the central government (income tax or VAT) should probably be reconsidered.

In this paper we concentrate on a theoretical analysis of one particular aspect of these questions by considering the model of a two-tier government system that allows for "large devolutions" to regions.[3] We concentrate on a notion of *political decentralization*, where regions are independent decision units, in contrast to an *administrative decentralization*, where regions would only be vehicles for the implementation of central government decisions. There is a widely shared view among economists that decentralization of public decision making is only ceteris paribus a good thing. There are limits to the extent of decentralization, owing to inefficiencies and inequities that need to be corrected by the central government. However, a preliminary question is to consider conditions under which there are no "distributive incentives" against cooperative agreement, from the point of view of both regional and central government.

In the two-tier government system that we model, the central government covers the whole nation and regional governments cover predefined regions. The regional jurisdictions are independent levels of democratic decision making that give citizens the power to make regional choice with respect to actions covering public investments, the provision of local public goods, and fiscal policy. Under the constitutional arrangement, taxation powers have already been assigned to regional governments. In particular, there are redistributions across individuals made at the level of each jurisdiction. Thus, decentralization of choice at the regional level reflects regional differences in preferences.

It is well known that, in general, local public expenditures have spillover or "externality" effects that are not taken into account by the regional government, leading to collective inefficiencies nationwide. We consider here a situation where the actions of the regional jurisdictions affect the probability of "shocks" at the national level. It may then be in one region's interest to adopt measures that impose costs or have adverse effects on nonresidents. This is a typical example of the *moral hazard* problem arising when interactions among agents occur with imperfect monitoring.

Similar observations, made for the case of the management of a global common property, traditionally support a pessimistic view on the future of cooperation within decentralized systems.[4] When some individual sovereignty must be respected, even though it is in the interest of all to cooperate, an agreement may well fail: if the cooperation is attained then every single agent could earn higher returns by free riding. These observations are also at the basis of the early literature on "fiscal federalism."[5] Clearly such interjurisdictional externalities are "internalized" by having the concerned functions assigned to the central government,[6] which cannot simply sit back and

3. In 1993, total local government spending in France was almost half of central government spending, accounting for about 10% of GNP. The regions' share of total local spending remains low, at around 5%, but regional spending has been growing (in real terms) at a rate of more than 50% per year, compared with a figure of 5% for the other tiers of local government. Per-capita spending varies across regions from 700 to 1,200 francs. The main sources of regional government revenue in 1993 were their own tax resources, which constituted 49% of total revenue (direct and indirect taxes accounted for about 60% and 40% of tax revenues, respectively). For the other (nontax) resources, the contributions of grants from central government amount to 25%, while borrowing and "miscellaneous income" contributed 13% and 11% (respectively) to total regional government revenue. Variation in tax rates across regions has grown considerably in recent years, as has the contribution of grant income.
4. See Demsetz (1977) or Olson (1965), who provides a classical statement of the "tragedy of the commons". For more recent developments, see the paper by Moulin and Watts (1994), which builds on Hardin (1968). See also Moulin (1995, pp. 26–36 and chap. 6).
5. See Oates (1968) or Olson (1969). The literature has identified, besides externalities, other reasons in favor of centralizing policy decisions: mobility of tax bases and policies distorting private competition. We disregard these issues here to concentrate on the appropriate devices and institutional arrangements needed to offset the distortions of regional decisions created by moral hazard.
6. Oates (1968) observes that, when lower-tier levels of government are given responsibility for functions that have significant spillover effects on other areas, the functions must be reassigned to a higher tier that embraces all of

allow each region to act without any mechanism for inhibiting or monitoring the exercise of regional choice. However, the central government could provide incentives for regional governments to coordinate their actions by promoting contractual arrangements that lead to overall efficiency. For that purpose there are instruments available at the central level, such as grants or fiscal surcharges, that allow interregional redistributions and transfers. When designing a transfer scheme, the central government should take appropriate account of spillovers in order to provide correct incentives to regional governments in their choice of actions supporting collectively efficient outcomes.[7]

A decentralized public policy problem – viewed as a partnership among regional jurisdictions managed by a central authority – can be formalized as a game.[8] Following our previous remarks it must be considered a noncooperative game, where the regional jurisdictions are the players choosing their actions in a self-interest way, given arrangements designed by a central government that cannot perfectly monitor their behavior. The issue here is not that the players retain private information, because the objective functions are common knowledge. Rather, at issue is the lack of natural coordination, which leaves open the possibility of free riding. In game-theoretic terms we have a *noncooperative game with complete but imperfect information*.

The fundamental principle of game theory is that any definite plan that prescribes (or predicts) the behavior of all players in such a situation – if this plan is to be understood by the participants and is not to impute irrational behavior to any of them – must designate a *Nash equilibrium* whereby it is in the interest of every participant to respect the agreement whenever all others do. The possibility of free riding in some public affairs shows that often only a "dismal" equilibrium[9] can be reached, one where the solution is far from the collective optimum. The general response suggested by game theory as a means of circumventing the dismal equilibrium problem – in particular, the moral hazard problem – is to make a "cooperative transformation" of the game: creating a new game where some efficient outcome can be sustained noncooperatively. This can generally be obtained in many ways: by repeating the game; by adding "communication devices"; by modifying the initial payoffs through some sort of contractual procedure. In the circumstances we consider here, one can take advantage of the fact that individual payoffs are measured in money (transferable utilities) and so use monetary transfers (as taxes and subsidies) to achieve the appropriate transformation of the game (regions can be seen as large and long-lived agents with very little risk sensitivity).

Many of the practical situations involved in decentralization of public decision making can hardly be reduced to a static game. This is no doubt the case when we consider local governments deciding upon public investments, all contributing to the capital stock of the overall economy. The stock variable can be very comprehensive. It may include, in particular, the state of the environment (global warming, water pollution, ...). There are intrinsic dynamic features in such situations that cannot be treated simply by repeating the game. Thus, the version of the moral hazard problem used, if one wants to reconsider the assignment issue in a dynamic context, should include a national stock variable, perhaps evolving stochastically, but partly determined by regional investments.

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those affected by the policy. Olson (1969) suggests that an appropriate assignment reflects equivalence between the geographical scope of the decison-making unit and the geographical area within which policy effects are felt.

7. The model that we consider, with a central and regional governments vertically ordered, is closest to the current situation of the EU – where there is only a system of interstate transfers – than to France (or even the United States), where the national (or federal) government has instruments that enable direct distribution among individuals.
8. See Alchian and Demsetz (1972), Holmstrom (1982), Radner et al. (1986), Radner and Williams (1988), or Legros (1989).
9. The expression, coined by Myerson (1985), is an extension of the well-known "prisoner's dilemma." Another example is the collective inefficiency of Cournot oligopoly equilibria. See also Myerson (1991).

These different situations will be captured by extending a model first analyzed in a static mode to a dynamic framework. We consider (Section 2) a finite set of agents, each influencing the determination of a common observable outcome, possibly stochastic, through the choice of a non-observable action. Each agent behaves on the basis of a transferable payoff. With transfers as the instruments used to modify the game, collectively efficient actions can be enforced in several ways, albeit limited by some feasibility requirement on the transfers. If this feasibility constraint is sufficiently weak then there will be no restriction imposed on the outcome function obtaining the right individual incentives from a collective point of view. Otherwise, some condition on the outcome function is required. Then – and this is the central contribution of our paper – we show that such a condition can be extended to dynamic stochastic games (Section 3): a collectively efficient profile of strategies is enforced by a sequence of transfer schemes. This result is obtained for an intertemporal equilibrium concept having strong properties[10] – namely, the "Markov perfect equilibrium." In the conclusion we stress some neglected features of the assignment issue that are crucial to understanding the decentralization of public policy.

2. The moral hazard problem in a static framework

We introduce first the moral hazard problem[11] as a *static game*. We have a finite set $N = \{1, \ldots, i, \ldots, n\}$ of players – the regional jurisdictions – each having to choose simultaneously an *action* a_i – public spending and local taxation – in a finite set A_i. A vector $\mathbf{a} = (a_1, \ldots, a_i, \ldots, a_n) \in A = \bigtimes_{i=1}^{n} A_i$ is called a *joint action*. There is a finite set X of public *outcomes*, which can be considered as different levels of some national public good. The individual actions together determine stochastically some outcome in the set. More precisely, we introduce a *stochastic outcome function*: a function association to each joint action $a \in A$ a probability distribution $p(\cdot \mid a)$ on the set X. The players share common beliefs about their individual actions, and this is incorporated in the function p. The deterministic case is not a priori excluded; it amounts to having a degenerate stochastic outcome function with all probabilities equal to 0 or 1. To each player i is associated a utility function $u_i(x, a_i)$ defined[12] on $X \times A_i$, which represents local welfare or willingness to pay. Then the payoff of player i can be computed as the expectation

$$U_i(a) = \sum_{x \in X} u_i(x, a_i) p(x \mid a).$$

The players' utility functions are common knowledge; that is, we restrict ourselves to the case of *complete information*.

We assume – and this is the moral hazard problem – that only the outcome, and not the actions, are publicly observable. In this static game a joint action a^* is (collectively) efficient if there is no other joint action a such that, for every i, $U_i(a) \geq U_i(a^*)$, with at least one inequality holding strictly. However, in such a game, an efficient joint action cannot in general be enforced as a noncooperative equilibrium (in the sense that no player could increase his or her payoff by unilateral deviation); hence, the main issue is to design specific mechanisms. Because of the non-observability of actions, such mechanisms cannot be based on the observation (or direct monitoring) of individual actions. Assuming that the utilities are measured in some monetary units and are transferable, we will propose

10. See Maskin and Tirole (1989) or Fudenberg and Tirole (1992, chap. 13).
11. For a review of the literature on this problem (and references), see Fudenberg and Tirole (1992, sec. 5.5).
12. Some of our results will apply to the more general case where u_i is defined on $X \times A$.

an enforcement mechanism, managed by a central authority, that can be realized via monetary transfers among the players.[13]

The transferability assumption allows the central authority to use, as an instrument in the design of an incentive mechanism, *transfer schemes*. Such schemes are functions of the form $t : X \to \mathbb{R}^n$ that give, for every i and every x, the amount of money $t_i(x)$ that i receives $(t_i(x) \geq 0)$ or pays $(t_i(x) \leq 0)$ if x is observed. A transfer scheme transforms the basic game into a new game with payoff functions given by

$$\sum_{x \in X} [u_i(x, a_i) + t_i(x)]p(x \mid a);$$

the strategy spaces are still given by $\{A_i\}$.

Transfer schemes must satisfy some feasibility property. The strongest one, ensuring that all the surplus generated is shared among the players, is the *budget-balancing condition*:

$$\forall\, x,\ \sum_{i \in N} t_i(x) = 0. \tag{BB}$$

This is the condition we shall impose in most of our results. A weaker property is to have only the *budget balanced in expected value for some joint action* a^*:

$$\sum_{x \in X} \sum_{i \in N} t_i(x)p(x \mid a^*) = 0. \tag{EB}$$

This constraint, in expected terms, is relevant in contexts where the central authority (the national government) can provide essentially costless insurance.

Whether balanced everywhere or balanced in expected value, the transfer scheme will have to provide the right incentives to achieve the assigned joint action $a^* \in A$. For this, let us assume that every agent has an outside option giving a utility level normalized to zero, and that the joint action a^* leads to a *nonnegative surplus*:

$$\sum_{x \in X} \sum_{i \in N} u_i(x, a_i^*)p(x \mid a^*) \geq 0.$$

A first requirement for a^* to be *enforceable* is that every agent be given incentive to participate – that is, the transfer scheme should satisfy *individual rationality* constraints:

$$\forall\, i \in N, \quad \sum_{x \in X} [u_i(x, a_i^*) + t_i(x)]p(x \mid a^*) \geq 0. \tag{IR}$$

13. This model can be interpreted in several contexts. For example, the outcome x can be the stock of a common resource (a lake, a forest, a pasture) with individual actions giving the level of its free utilization by every owner of the resource (fishing, wood exploitation, grazing). The moral hazard problem is then the "tragedy of the commons." The collective inefficiency of a "subscription equilibrium" for the production of a public good or service (where the actions are individual contributions) is another instance of such a problem. In the context of cooperation on environmental issues, the outcomes describe the state of the environment, which is affected by individual actions, and the utility is often decomposed into the net cost of actions and the damage associated with every state of the environment. Another example is a partnership production, where each agent supplies an unobservable input to a production process and the output is divided among the partners. In a regional context, every local jurisdiction may contribute (by taking actions) to a total fiscal revenue that is redistributed to their inhabitants. Still another context is a Cournot oligopoly in which each firm's output level is not perfectly observable by the other firms in the industry, and where the market price is a (stochastic) function of total output.

A second requirement is that the transfer scheme would satisfy *incentive-compatibility* constraints:

$$\begin{aligned}&\sum_{x\in X}[u_i(x,a_i^*)+t_i(x)]p(x\mid a^*)\\ \geq&\sum_{x\in X}[u_i(x,a_i)+t_i(x)]p(x\mid a_i,a_{-i}^*)\quad\forall\, i\in N,\forall\, a_i\in A_i,\end{aligned}\tag{IC}$$

with $a_{-i}^*=(a_1^*,\ldots,a_{i-1}^*,a_{i+1}^*,\ldots,a_n^*)\in\bigtimes_{i\neq j}A_j$. The IC constraints require that the joint action a^* be a Nash equilibrium of the game with strategy spaces given by $\{A_i\}$ and payoff functions given by

$$\sum_{x\in X}[u_i(x,a_i)+t_j(x)]p(x\mid a).$$

Suppose the objective of the central authority is that the players choose an efficient joint action. With perfect transferability, an efficient joint action a^* is simply defined by the condition

$$a^*\in\arg\max_{a\in A}\sum_{x\in X}p(x\mid a)\sum_{i\in N}u_i(x,a_i).\tag{PO}$$

The problem is to design a transfer mechanism, based on the observed outcome x, that induces the partners to choose such an a^*. The transfer scheme should be feasible in the sense that it should satisfy some budget constraint. If one requires only a balanced budget in expected value (the EB constraint), then a positive result can be obtained without further assumptions, as the following theorem shows.

Theorem 1 *For any utility profile $\{u_i\}$, any efficient joint action a^* leading to nonnegative surplus is enforceable* (IC) *by an individually rational* (IR) *transfer scheme with budget balanced in expected value* (EB)*.*

Proof We must solve a system of inequalities and equalities in $t\in\mathbb{R}^{nX}$:

$$\begin{aligned}&\sum_x t_i(x)[p(x\mid a^*)-p(x\mid a_i,a_{-i}^*)]\\ \geq&\sum_x[u_i(x,a_i)p(x\mid a_i,a_{-i}^*)-u_i(x,a_i^*)p(x\mid a^*)]\;\forall\, i,\forall\, a_i\neq a_i^*;\\ &\sum_x t_i(x)p(x\mid a^*)\geq-\sum_x u_i(x,a_i^*)p(x\mid a^*)\;\forall\, i;\\ &\sum_x\sum_i t_i(x)p(x\mid a^*)=0.\end{aligned}$$

Consider the following necessary and sufficient conditions, as given by well-known separation arguments (see e.g. Fan, 1956). *Either* there is no $\lambda\in\bigtimes_{i=1}^n\mathbb{R}_+^{A_i}$, $\mu\in\mathbb{R}$ and $\gamma\in\mathbb{R}_+^N$ such that

$$\sum_{a_i\neq a_i^*}\lambda_i(a_i)[p(x\mid a^*)-p(x\mid a_i,a_{-i}^*)]+(\gamma_i-\mu)p(x\mid a^*)=0\quad\forall\, i,\forall\, x,\tag{1}$$

or we have

$$\begin{aligned}&\sum_i\sum_{a_i\neq a_i^*}\lambda_i(a_i)\sum_x[u_i(x,a_i)p(x\mid a_i,a_{-i}^*)-u_i(x,a_i^*)p(x\mid a^*)]\\ -&\sum_i\gamma_i\sum_x u_i(x,a_i^*)p(x\mid a^*)\leq 0.\end{aligned}\tag{2}$$

But (1) implies (by summation over x) that $\mu = \gamma_i \geq 0$ for all i, so that

$$\sum_{a_i \neq a_i^*} \lambda_i(a_i)[p(x \mid a^*) - p(x \mid a_i, a_{-i}^*)] = 0 \quad \forall\, i, \forall\, x. \tag{3}$$

By efficiency we may write

$$\begin{aligned}
&\sum_i \sum_{a_i \neq a_i^*} \lambda_i(a_i) \sum_x [u_i(x, a_i) p(x \mid a_i, a_{-i}^*) - u_i(x, a_i^*) p(x \mid a^*)] \\
\leq &\sum_i \sum_{a_i \neq a_i^*} \lambda_i(a_i) \sum_x \left[\sum_{j \neq i} u_j(x, a_j^*) p(x \mid a^*) - \sum_{j \neq i} u_j(x, a_j^*) p(x \mid a_i, a_{-i}^*) \right] \\
= &\sum_i \sum_x \sum_{j \neq i} u_j(x, a_j^*) \sum_{a_i \neq a_i^*} \lambda_i(a_i)[p(x \mid a^*) - p(x \mid a_i, a_{-i}^*)].
\end{aligned}$$

This last expression is null by (3). Using

$$\sum_i \gamma_i \sum_x u_i(x, a_i^*) p(x \mid a^*) = \mu \sum_x \sum_i u_i(x, a_i^*) p(x \mid a^*) \geq 0$$

yields (2). ■

As well illustrated by the example of Radner et al. (1986), Theorem 1 cannot be strengthened by replacing the feasibility constraint (EB) with budget balancing (BB). In their example, there are two agents each having two possible observable outcomes – "high" or "low" – that have positive probability whatever the agents do. An agent who chooses to "work" does increase the probability of "high" output. The agents decide which output they want. It is collectively efficient, in expected payoff terms, for both agents to "work" but, as in a prisoner's dilemma, it is a dominant strategy for each one of them to "shirk."

To solve this problem we shall introduce a condition inherited from the "compatibility condition" introduced by d'Aspremont and Gérard-Varet (1979) in the design, via balanced transfers, of direct revelation mechanisms for efficient collective decision making. This condition was initially stated in "dual" terms. We shall adopt its "primal" version.[14]

Condition C For all $a^* \in A$ and all $\rho \in \mathbb{R}^{nX}$ such that $\sum_i t_i(x) = \rho(x)$,

$$\sum_x t_i(x) p(x \mid a^*) \geq \sum_x t_i(x) p(x \mid a_i, a_{-i}^*) \quad \forall\, a_i \in A_i, \forall\, i \in N.$$

This condition states that, for any given budget and the identically zero utility profile, any joint action profile is enforceable by a transfer scheme balancing this budget. It can be used to solve the team moral hazard problem as follows. Pick any utility profile $\{u_i\}$ and any efficient a^*. We can always construct transfers of the Clarke-Groves-Vickrey type by letting

$$t_i^0(\cdot) \equiv \sum_{j \neq i} u_j(\cdot, a_j^*).$$

14. This is analyzed in d'Aspremont et al. (1995) for the incomplete information case, and in d'Aspremont and Gérard-Varet (1996) for the present model.

Every participant is thus paying for the effects of his own action on the welfare expected by others, so that efficiency implies the IC constraint to be satisfied. Clearly, the budget-balancing constraint might be broken. However, we may use Condition C and put $\rho(\cdot) \equiv -\sum_i t_i^0(\cdot)$ in order to obtain a transfer scheme t satisfying all equalities and inequalities listed in the condition. Then, defining $t^* \equiv t^0 + t$, we get budget balancing in the sense of (BB) while preserving incentive compatibility. Finally, to ensure individual rationality, we may apply the construction given by Legros and Matsushima (1991), who directly obtain individual rationality for a given utility profile $\{u_i\}$ and for a joint action a^* leading to a nonnegative surplus, as soon as the joint action is enforceable by a budget-balancing transfer scheme t^*. Indeed, it suffices to construct the new transfer scheme t' such that, for all $i \in N$ and $x \in X$,

$$t'_i(x) \equiv t^*_i(x) - \sum_x [u_i(x, a^*_i) + t^*_i(x)]p(x \mid a^*) + \frac{1}{n}\sum_j \sum_x u_j(x, a^*_j)p(x \mid a^*).$$

By construction, this new transfer scheme is still budget-balancing and maintains incentive compatibility (since it amounts to adding a term constant in a_i). This proves the following theorem.

Theorem 2 *Suppose the stochastic outcome function p satisfies Condition C. Then, for any utility profile $\{u_i\}$ for which a joint action a^* is efficient and leads to nonnegative surplus, this joint action is enforceable by an individually rational and budget-balancing transfer scheme – that is,* (IC)*,* (IR)*, and* (BB) *hold.*

Condition C is not as restrictive as it may appear. Indeed, the compatibility condition in revelation mechanisms[15] can be shown to be generic: the set of outcome functions satisfying this condition is an open and dense set in the space of all stochastic outcome functions. This means that, with finitely many outcomes and actions and with transferable utilities, the moral hazard problem is "almost always" solvable.

3. A dynamic extension

Many moral hazard situations have an important dynamic dimension. Players typically compete to exploit the same stock (replenishable or not) over time, and there is an underlying stochastic evolution equation that is affected by the individual actions at each time period. A frequently used technique to model such situations is given by *stochastic differential games*.[16] We shall take an abstract formulation of such a dynamic model in which the state variable is the capital stock, stochastically influenced by current instruments and the past value of the stock.

Consider a possibly infinite sequence of periods $t = 1, \ldots, \bar{t}, \bar{t} \leq \infty$. To each period corresponds a state of the stock $x_t \in X$ and a finite set of actions A_{it} for every player $i \in N$. The initial state is $x_0 \in X$. The stochastic outcome function is now a function p, which to each joint action $a_t \in A_t = \times_{i=1}^n A_{it}$ and to each publicly observed state $x_{t-1} \in X$ associates the probability $p(x_t \mid a_t, x_{t-1})$ to obtain $x_t \in X$. At each period t, the utility function of player $i \in N$ is $u_i(x_t, a_{it})$.

15. See d'Aspremont et al. (1990). See also d'Aspremont and Gérard-Varet (1996).

16. Stochastic differential games have been used to address such environmental issues as competition among fisheries in exploiting the same stock of biomass (Levhari and Mirman, 1980; Haurie et al., 1994) and global warming (Van der Ploeg and de Zeeuw, 1992; Germain, 1995). For models of this kind in the context of industrial organization, see Maskin and Tirole (1987, 1988a,b)

At period t, player i has a *history* h_{it} describing the sequence of variables that i has observed through time:

$$h_{it} = (x_0, x_1, a_{i1}, x_2, a_{i2}, \dots x_{t-1}, a_{it-1}).$$

A *strategy* of player i is a finite sequence $(\sigma_{i1}, \sigma_{i2}, \dots, \sigma_{i\bar{t}})$, where σ_{it} is a map from the set H_{it} of all histories at date t to $A_{it}, \sigma_{it}(h_{it}) \in A_{it}$. The expected payoff of player $i \in N$ at state t is

$$\sum_{x_t} u_i(x_t, a_{it}) p(x_t \mid a_t, x_{t-1}).$$

Given a vector of strategies for each player, the total expected payoff over time is

$$U_i(x_0, \sigma) = (1-\delta) \sum_{t=1}^{\bar{t}} \sum_{h_t} \sum_{x_t} \delta^{t-1} u_i(x_t, \sigma_{it}(h_{it})) p(x_t \mid \sigma_t(h_t), x_{t-1}) q_t(h_t \mid \sigma),$$

where $\sigma_t(h_t) = (\sigma_1(h_{1t}), \dots, \sigma_i(h_{it}), \dots, \sigma_n(h_{nt}))$ and $q_t(h_t \mid \sigma)$ is the probability generated by the outcome function and the joint strategy σ to observe history h_t given the strategy. For equilibrium we restrict the class of strategies to the set of Markov strategies. For every i and t, a *Markov strategy* σ_{it} depends upon the history h_{it} only through x_{t-1}:

$$\sigma_{it}(h_{it}) = \sigma_{it}(x_{t-1}).$$

The sequence $(x_0, x_1, \dots, x_{t-1})$ is called a *public history*. In that case, the total expected payoff of any player i can be written as:

$$U_i(x_0, \sigma) = (1-\delta) \textstyle\sum_{t=1}^{\bar{t}} \delta^{t-1} \sum_{(x_1,\dots,x_t)} u_i(x_t, \sigma_{it}(x_{t-1})) p(x_t \mid \sigma_t(x_{t-1}), x_{t-1}) \times q_t(x_1, \dots, x_{t-1} \mid \sigma),$$

where

$$q_t(x_1, \dots, x_{t-1} \mid \sigma) = p(x_1 \mid \sigma_1(x_0), x_0) p(x_2 \mid \sigma_2(x_1), x_1) \dots p(x_{t-1} \mid \sigma_{t-1}(x_{t-2}), x_{t-2}).$$

The concept of collective efficiency can also be extended straightforwardly. An *efficient joint strategy* σ^* is defined as

$$\sigma^* \in \arg\max_{\sigma} \sum_{i \in N} U_i(x_0, \sigma).$$

As in the static case, Nash equilibrium joint strategies cannot, in general, be shown to be efficient. However, as we now show, by looking at a restrictive class of equilibria and introducing transfers, efficient equilibria can be found under the same conditions as in the static case.

A *Nash equilibrium* (closed loop) is defined as usual. It is a vector of strategies (or a joint strategy) σ^* such that, for any $i \in N$ and any strategy σ_i,

$$U_i(x_0, \sigma^*) \geq U_i(x_0, \sigma_i, \sigma^*_{-i}).$$

A Nash equilibrium within a Markov strategy is called a *Markov perfect equilibrium*. This is because it satisfies the property that, for each t and given any x_{t-1}, the continuation payoffs starting from

x_{t-1} are identical regardless of the history that led to that state. Formally, it is a joint strategy σ^* such that, for any $i \in N$, any strategy σ_i, any $t_0 \geq 0$, and any x_{t_0-1}:

$$\begin{aligned} U_i^{t_0}(x_{t_0-1}, \sigma_i, \sigma_{-i}^*) \equiv (1-\delta) \sum_{t=t_0}^{\bar{t}} \sum_{(x_{t_0},\ldots,x_t)} & \delta^{t-1} u_i(x_t, \sigma_{it}(x_{t-1})) \\ & \times p(x_t \mid \sigma_i(x_{t-1}), \sigma_{-i}^*(x_{t-1}), x_{t-1}) q(x_{t_0}, \ldots, x_t \mid \sigma_i, \sigma_{-i}^*) \\ & \leq U_i^{t_0}(x_{t_0-1}, \sigma^*). \end{aligned}$$

A joint (Markov) strategy σ^* is *dynamically enforceable through balanced transfers* if, for every $t \geq 0$, there exists a transfer scheme $T_t(x_{t-1}, \cdot) = (T_{it}(x_{t-1}, \cdot))_{i \in N}$ that is *balanced*. That is, $\sum_{i \in N} T_{it}(x_{t-1}, x_t) = 0$ for any x_t, and σ^* is a Markov perfect equilibrium for the modified game obtained by replacing each $u_i(x_t, a_{it})$ by $[u_i(x_t, a_{it}) + T_{it}(x_{t-1}, x_t)]$. Formally: for any $i \in N$, any $t_0 \geq 0$, any x_{t_0-1}, and any σ_i:

$$V_i^{t_0}(x_{t_0-1}, \sigma_i, \sigma_{-i}^*, T_i) \leq V_i^{t_0}(x_{t_0-1}, \sigma^*, T_i)$$

with, for any σ_i,

$$\begin{aligned} V_i^{t_0}(x_{t_0-1}, \sigma_i, \sigma_{-i}^*, T_i) \equiv (1-\delta) \sum_{t=t_0}^{\bar{t}} \sum_{(x_{t_0},\ldots,x_t)} & \delta^{t-1} [u_i(x_t, \sigma_{it}(x_{t-1})) + T_{it}(x_{t-1}, x_t)] \\ & \times p(x_t \mid \sigma_i(x_{t-1}), \sigma_{-i}^*(x_{t-1}), x_{t-1}) q(x_{t_0}, \ldots, x_t \mid \sigma_i, \sigma_{-i}^*). \end{aligned}$$

We now show that any efficient joint (Markov) strategy is dynamically enforceable using balanced transfers under an extension of Condition C.

Condition $\overrightarrow{\mathbf{C}}$ For every $t \geq 0$ and every $x_{t-1} \in X$, $p(\cdot \mid \cdot, x_{t-1})$ satisfies Condition C.

Theorem 3 *Suppose Condition $\overrightarrow{C}$ holds. Then, for any profile $\{u_i\}$, any efficient joint (Markov) strategy σ^* will be dynamically enforceable by a budget-balancing (and individually rational) transfer scheme.*

Proof The proof proceeds in three steps.

1. By the optimality principle of dynamic programming, since σ^* is an efficient joint strategy, for any x_{t-1} we should have

$$\sigma_t^*(x_{t-1}) \in \arg\max_{a_t} \sum_{x_t} \sum_i u_i(x_t, a_{it}) p(x_t \mid a_t, x_{t-1}).$$

   This means that, at any $t \geq 0$ and for any x_{t-1}, an efficient joint action is selected.

2. By Theorem 2 we have that, at any $t \geq 0$ and for any $x_{t-1}, \sigma_t^*(x_{t-1})$ is enforceable by a budget-balancing (and individually rational) transfer scheme – that is, there exist balanced transfers $T_t(x_{t-1}, \cdot)$ such that, for any $i \in N$,

$$\sigma_{it}^*(x_{t-1}) \in \arg\max_{a_{it}} \sum_{x_t} [u_i(x_t, a_{it}) + T_{it}(x_{t-1}, x_t)] p(x_t \mid a_{it}, \sigma_{-it}^*(x_{t-1}), x_{t-1}).$$

3. By the optimality principle as applied to dynamic games (the "one-stage deviation principle"),[17] this expression implies that σ^* is a Markov perfect equilibrium.

■

4. Conclusion

We have argued in this paper that, under risk neutrality, it is (in general, and contrary to common belief) possible for a central government to design transfers among regional governments in order to solve the basic decentralization tradeoff between incentives and collective efficiency (under budget balancing). The result holds even in a dynamic environment by restriction to a notion of Markov perfect equilibrium. This conclusion can be contrasted to the one of Coase (1960). Coase's theorem states that, in the absence of wealth effects (or under risk neutrality) and under a principle of efficient bargaining (no possibility for further mutual gain), a first-best outcome will be reached regardless of the distribution costs and benefits; transfers play no incentive role but only a redistributive role. Our conclusion is that, even without wealth effects, *incentive and redistributive considerations cannot be separated.*

We have presented a very simple model. In many situations there are, besides nonverifiable individual actions, other variables that contribute to the outcome. For instance, one could require jurisdictions to choose two actions – one centrally verifiable and the other not – with the former more costly because it cannot be tailored exactly to specific features of each region. Provided that these centrally verifiable actions do not generate too large efficiency losses, our conclusions would remain unchanged.

Another dimension of the problem of decentralizing public expenditures arises when the utility functions of the local governments exhibit *risk aversion*. Actually, a central government may be concerned with risk sharing among subcentral jurisdictions, and decentralization – when creating autonomous local jurisdictions – may entail a loss of welfare through reduced opportunities for risk sharing. The point is made by Drèze (1994), who mentions the "ability of a central government *to organize mutual insurance among regions* under its jurisdiction, so that the idiosyncratic shocks affecting individual regions are partly absorbed through stock-dependent transfers between regions." Clearly, in case of idiosyncratic shocks, mutual insurance can be achieved by the adoption of national uniform rules, but these contradict local differentiation. On the other hand, if the rules are set autonomously at the local level then a moral hazard problem arises, making insurance difficult.[18]

In our framework, where a joint collective outcome is stochastically obtained through the actions of the local jurisdictions, the question does not reduce to mutual insurance against local specific shocks. As soon as the utility functions exhibit risk aversion, a collectively efficient arrangement requires efficient risk sharing as well as an efficient profile of actions implemented by the local jurisdictions. This, in general, cannot be sustained as a Nash equilibrium. However, recent results on repeated games with imperfect monitoring[19] show that, even when exact efficiency is unattainable, repetition can make incentive compatibility consistent with profiles arbitrarily close to collective efficiency, at least for patient agents.

17. See Fudenberg and Tirole (1992).
18. See Persson and Tabellini (1996) for a discussion of the difficulties in enforcing decentralized insurance systems under fiscal federalism environments with moral hazard.
19. See Fudenberg et al. (1994) and also d'Aspremont and Gérard-Varet (1996).

Thus, when some collective arrangement embodies an agreement in a suitable equilibrium, the decentralized players will honor the terms of the arrangement because it is in their interest to do so. By allowing for reciprocity, repeated interactions support self-policing. A drawback is that many less attractive arrangements can also be sustained the same way. An alternative approach is to model the situation as a stochastic differential game by introducing monitoring variables and retaliation schemes. However, in the present state of the art, only numerical examples are available.[20]

We have considered decentralization issues only in terms of pure moral hazard problems. However, it may seem reasonable *not* to assume that each region's welfare is common knowledge. But then we have *incomplete information* and the problem becomes more intricate, especially if we retain the moral hazard aspect.[21]

However, the problem has been well analyzed in the transferable utility case with the moral hazard issue discarded – the "pure adverse selection" case.[22] In this scenario the players' individual utilities depend upon their *types* – any possible specification of all the players' private information relevant to the situation. A "belief structure" specifies the probabilities that each player i could assign to each possible combination of types for the other players, as a function of i's own type. The central authority in charge of achieving collective efficiency needs to collect from the players data about their types. Although their goals may differ, the players care about the collective outcome and so the central authority must provide incentives for truth telling. To do so, the central authority must provide incentives for truth telling. To do so, the central authority commits to an *incentive scheme* specifying how the outcome is selected on the basis of the reports, and possibly some money payments also depending on these reports. In order to elicit information, the central authority may have to make promises that it might rather not keep once the information comes out, and so the assumption of commitment is essential. Side payments help the center to obtain information about the agents' true willingness to pay for particular outcomes, thus showing which decision is truly efficient. A result parallel to Theorem 2 (see d'Aspremont et al., 1990) states that, for any profile of utilities, it is "in general" possible for the central authority – by making appropriate use of common knowledge about the belief structure – to design a collectively efficient and incentive-compatible mechanism that preserves budget balancing.

Now, when extended to incomplete information but limited to adverse selection, the analysis reduces to what a benevolent central authority can do with respect to its subcentral delegates with suitable incentive schemes. What is the lesson for decentralization? Rather than wholly independent units making decisions about the level and pattern of local public goods, subcentral governments appear more as *vehicles* for the implementation of a centrally designed policy. In principle, administrative decentralization means that, instead of sending all information to the center, decisions are delegated to appropriately knowledgeable lower tiers of government. Yet delegation cannot possibly be helpful, since anything that a local government can do, the central government can do as well. Decentralization then appears as a subset of centralization, and is at best harmless.

Centralization clearly helps when decisions are so independent that they cannot be delegated. But it is not really plausible that centralization always dominate decentralization, even when restricting the analysis to administrative decentralization. The foregoing arguments actually miss major problems. One is that the participants in a collective decision process may not trust the central authority's

20. See Haurie et al. (1994).

21. There have been recent models in the fiscal federalism literature introducing different specifications of adverse selection. See e.g. Cremer et al. (1994).

22. See Green and Laffont (1979) or d'Aspremont and Gérard-Varet (1979).

commitment to an incentive scheme. The second problem is that the central authority may have a limited ability to process information. Both problems suggest that to evaluate decentralization under incomplete information requires a reappraisal of the principle according to which the appropriate point of view for the analysis of incentives is to consider a central agent acting as a mediator who communicates directly and confidentially with each player.[23] The same line of reasoning is also essential to capture the features of such hierarchical structures as those involving economic agents and voters or local, regional, and central governments.[24]

Progress in understanding any interesting decentralization in public policy can only be expected from models that integrate a combination of private information, moral hazard, and voluntary participation. Voluntary participation raises no difficulty when there is moral hazard only. The issue is different under incomplete information, where a notion of political decentralization implies a restriction to mechanisms satisfying the constraint that every player be willing to participate once apprised of his or her own private information. This restriction strongly limits the coercive power of the central government, and moreover is costly to collective efficiency. There is actually a basic tradeoff: the freedom to choose, which is a safeguard against abuses by central authority, may well be a barrier to efficiency.

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23. This is the "revelation principle"; see Myerson (1991).
24. Tirole (1994) specifically calls for analyzing "fiscal federalism" and the organization of government along these lines.

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