Optimal Regional Redistribution Under Asymmetric Information

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What is the optimal way to redistribute among regions? There are several reasons why this question may be relevant. One is risk sharing: with idiosyncratic shocks to regional income, different regions in a federal state or different nation states in a confederation may draw mutual benefits from risk-sharing arrangements. This argument is often made with reference to Europe, where the single currency and tight limits on budget deficits have reduced the ability of national governments to cope with idiosyncratic shocks. A second reason may be that regional redistribution is a political prerequisite for decentralization, to compensate the losers from reforms. In countries such as Italy that are considering to decentralize some functions of government and to finance them locally, it is commonly accepted that any decentralization must be accompanied by regional redistribution, to compensate the poor regions for their smaller tax bases. Indeed, regional redistribution according to a preset formula is common in many federal states, such as Canada, Germany, or Australia (see Arunkant A. Shah, 1994).

There is a large theoretical literature on how to redistribute among individuals, dating back to the seminal work of James A. Mirrlees (1971). But not much is known about how to optimally redistribute among regional governments. Regional redistribution is more complicated because regional governments are themselves principals in a principal-agent problem with their citizens. As a consequence, in addition to the standard distorting effects of taxation, the design of regional redistribution must also consider the incentive effects upon the choice of regional tax rates. Furthermore, while individual taxpayers are many, regional jurisdictions are few. This makes strategic behavior to affect the transfer paid or received more important. Hence, the inefficiencies of redistribution are potentially more devastating when it is carried out among regional governments than among individuals. The details of the redistributive mechanism are accordingly more likely to be relevant.

The theory of fiscal federalism has long studied the optimal design of intergovernmental transfers, but it has seldom asked how to design purely redistributive schemes. The early literature focused on spillover effects across regions due to mobility of tax bases or externalities in the provision of public goods (see the seminal contribution of Wallace E. Oates [1972]; Robin W. Boadway and Frank R. Flatters [1982]; and for more recent examples, David E. Wildasin [1991] and Manasse and Christian Schultz [1999]). A recent line of research, related to our paper, has studied optimal intergovernmental grants under asymmetric information over some aspects of the provision of local public goods. For instance, Helmut Cremer et al. (1996) and Sam Bucovetsky et al. (1998) consider asymmetric information over the local preferences for public goods, whereas Boadway et al. (1995), Horst Raff and John Douglas Wilson (1997), and Richard C. Cornes and Emilson C. D. Silva (2000) study asymmetric information over the local technology for producing local public goods. Ben Lockwood (1999) summarizes this recent literature as well as offering his own analysis.

This paper focuses on pure redistribution among two regional governments. We abstract from mobility of tax bases and externalities in public goods not because they are unimportant, but because they are already well understood. Under conditions of full information, unlimited commitment capacity, and no spillover effects across regions, optimal redistribution is lump sum. But these ideal circumstances are seldom

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met. There are two possible problems. The first and more general is *lack of commitment* capacity by the central government. *Ex post*, a benevolent government finds it optimal to equalize regional incomes irrespective of how the regional differences came about. This creates obvious moral hazard problems: in equilibrium, both regional governments have an incentive to undertax or overspend, depending on the circumstances, to gain from the redistributive scheme at the expense of the other region. The solution to this problem is to commit *ex ante* to a transfer rule based on regional differences that are not manipulable by the regional government. But such commitments may be hard to enforce. The second related problem is *lack of information.* Exogenous regional circumstances change over time. Thus, the parametric differences across regions that enter the *ex ante* optimal redistributive mechanism may be difficult to observe or incorporate in legislation as verifiable contingencies. If so, there is a problem of asymmetric information: the redistributive rule cannot be contingent on all the information available to regional governments.

Here we consider asymmetric information over the size of regional tax bases. Regional governments are assumed to know more than the federal government can incorporate in the transfer mechanism. We model this as a pure adverse selection problem, in which the informational advantage of regional governments is exogenous. Regional governments fix the tax rates and choose the quantity of local public goods, knowing the size of the tax base in their own region. The only role of the federal government is to design and implement a scheme for horizontal (i.e., without contributions from the federal budget) regional redistribution. The federal government verifies regional statutory tax rates, but not the size of the regional tax base. In particular, the federal government ignores the elasticity of the regional tax base and the after-tax private disposable income associated with a given tax rate. A previous version of this paper (1996) also studied a problem of moral hazard, where the federal government cannot observe the effort of regional governments in fighting tax evasion.

These informational constraints are likely to arise in many real-world situations, due either to lack of information or to the impossibility of verifying available information. Sheer lack of information is certainly relevant in the case of loose confederations such as the European Union, where statistics and major taxes are administered nationally.[1] In federal countries, lack of information could also be a problem for some regional tax bases, such as real estate taxes. Statutory tax rates on real estate are readily observable, but local governments usually have better information on the true market value of properties in their jurisdiction compared to the federal government. Even if the size of regional tax bases is observed by the central government, as in many federations, there remains a verifiability problem: not all available information can be incorporated in the transfer rule. The incentive problems created by this incomplete verifiability could thus be relevant even for well-informed federal governments.

One of the central results of the paper is that, to cope with asymmetric information, optimal regional redistribution must distort the tax rate chosen by the poor region away from the second best. The role of this distortion is to induce separation of different types and create incentives for truth-telling. Whether the poor region's tax rate is distorted up or down depends on which region values tax revenue more at the margin. If, as plausible, tax revenue is more valuable for the poor region, then a higher tax rate is a reliable signal of a smaller tax base. In this case, the optimal transfer rule entails a premium on "fiscal effort": to achieve separation, higher tax rates are rewarded with a transfer.

Thus, asymmetric information affects the qualitative properties of regional fiscal policies. In the model of this paper, under full information and lump-sum interregional transfers, public spending is equalized across jurisdictions and the regional tax rate is higher in the rich region, since the latter has a more inelastic tax base. With asymmetric information, on the other hand, the poor region may have a higher tax rate than the rich (if the optimal transfer rule entails a premium on fiscal effort). Moreover, since distorting the poor region is costly, redis-

[1] Laura Bottazzi and Manasse (1998) study the consequences of this asymmetric information for the functioning of the European Monetary Union.

tribution is incomplete and the poor region always spends less. These results are reminiscent of those obtained in the theory of optimal income taxation (Mirrlees, 1971; Joseph E. Stiglitz, 1982), where it is shown that the richest individual is undistorted at the margin and redistribution is below the first-best level. The incentive scheme studied in this paper is more complex, however, due to strategic interactions among regions.

The paper outline is as follows. Section I sets out the basic model. In Section II, we study the benchmark case of optimal regional redistribution with full information and full commitment by the federal government. This section also considers the consequences of having full information but relaxing the commitment assumption. The equilibrium under adverse selection is then characterized in Section III. Section IV discusses the extension to moral hazard. Section V concludes.

I. The Model

Consider two regions, identical in all respects except in per capita income. They produce only one type of good, which can be transformed into either private or public consumption. Thus, there is no regional trade. There is only one input, labor, and it is immobile across regions. The production technology is linear. There are two levels of government: a regional government, that raises taxes and provides a local public good; and a federal government, whose only task is to redistribute among regional governments. Alternatively, the federal government could be thought of as simply enforcing a contract between the two regions.

Individuals within each region are all identical. Population size is normalized to one. Individual preferences are represented by the utility function:

$$U = c + V(x) + H(g) \tag{1}$$

where c and g denote private (per capita) and public consumption respectively, and x is leisure time. The functions $V(\cdot)$ and $H(\cdot)$ are well-behaved concave functions. Throughout the paper the variables without superscripts refer generically to both regions. Variables referring to the rich region will be indicated with "′", to the poor region with "*". To capture differences in per capita income, we assume that the "effective" time endowment of individuals differs across regions. Individuals allocate their time endowment, $1 + e$, between leisure and working time, l, so as to satisfy:

$$1 + e = l + x \tag{2}$$

where e is a parameter that differs across regions and $e' > e^*$. Thus, residents in the rich region are more productive, and we formulate this assumption by saying that they have more "effective" time.

Regional taxes are proportional to labor income. Thus, the individual budget constraint is:

$$c = l(1 - t) \tag{3}$$

where t is the regional tax rate and the real wage is unity. Denoting the interregional transfer *received* by τ, the regional government budget constraint can be written as:

$$g = tl + \tau. \tag{4}$$

Finally, the federal budget constraint implies:

$$\tau' + \tau^* = 0. \tag{5}$$

Individual decisions in this economy are very simple, and we can easily derive the individual labor supply in both regions as a function of the regional tax rate and of the productivity parameter:

$$l = L(t) + e \tag{6}$$

where the function $L(t)$ is decreasing in t by concavity of $V(\cdot)$.[2] Thus, the productivity parameter e differentiates per capita income, and hence the tax base, of the two regions. For the same tax rate, the rich region extracts more tax revenue from the consumer.[3]

[2] The consumer's first-order condition for an optimum implies: $V_x(1 + e - l) = 1 - t$, where the subscript denotes a partial derivative. Thus, the function $L(t)$ is defined as $L(t) = 1 - V_x^{-1}(1 - t)$, and $L_t = 1/V_{xx} < 0$.

[3] As in much of the existing literature (i.e., Robert E. Lucas, Jr., 1990), we are here taking a short cut: we postulate distorting taxes in a representative consumer economy. Implicitly, we are thus assuming that there is some unobserved individual

Finally, the consumer indirect utility function in both regions can be written as a function of the relevant policy variables and of the productivity parameter:

$$(7)\quad W(t,\,\tau,\,e) = (1-t)[L(t)+e] + V(1-L(t)) + H(t[L(t)+e]+\tau).$$

The first term on the right-hand side of (7) is the utility from private consumption [obtained by (3) and (6)]; the second term is utility from leisure [obtained by (2) and (6)]; the last term is utility from the public good [obtained by (4) and (6)]. The function $W(\cdot)$ is the same in both regions, but the variables t, τ, and e naturally vary across regions. Equation (7) completely summarizes the welfare effects of alternative regional and federal policies. Hence, in the remainder of the paper we use it to evaluate the welfare effects of alternative fiscal arrangements.

II. Optimal Redistribution with Full Information

This section describes optimal redistribution across regions when there are no incentive constraints whatsoever. We first describe the optimal allocation when fiscal policy is fully centralized, and the same benevolent social planner chooses all policy instrument. We then show that this allocation can be decentralized, provided that the federal government can enter into binding commitments and has full information about regional differences in per capita income; that is, when the productivity parameter e is observable and verifiable in both regions. This is the natural benchmark against which to contrast alternative arrangements when information or commitment become imperfect. Finally, we investigate the consequences of relaxing the commitment assumption, while still retaining full information.

A. *Full Centralization*

In this benchmark solution, a central planner chooses all policy instruments to maximize social welfare throughout the federation:

$$(8)\quad \text{Max } W(t',\,\tau',\,e') + W(t^*,\,\tau^*,\,e^*)$$

by choice of t', t^*, τ', and τ^*, subject to the federal budget constraint (5).

The main features of the solution are summarized in the following proposition, proved in the Appendix. Let $\varepsilon(t,\,e) = -tL_t(t)/[L(t)+e] > 0$ be the elasticity of labor supply with respect to the tax rate. Then:

PROPOSITION 1: *The solution to problem* (*8*) *implies:* (*i*) $g' = g^*$; (*ii*) $\varepsilon(t',\,e') = \varepsilon(t^*,\,e^*)$; (*iii*) $t' > t^*$ *if the elasticity of labor supply is increasing in the tax rate* t; (*iv*) $\tau^* = [t'l' - t^*l^*]/2 = -\tau'$.

Thus, quite intuitively, both regions have the same quantity of local public goods, so as to equalize the marginal benefits of public spending across regions. Moreover, the distorting effects of taxation, captured by the elasticity of labor supply, are also equalized across regions. In this model, the rich region faces a more inelastic labor supply; hence, taxes in the rich region are less distorting, and the optimal tax rate is accordingly higher. Finally, the equilibrium interregional transfer that is implied by the regional government budget constraints redistributes half of the rich's extra revenue to the poor region.

B. *Decentralization with Full Information and Commitment*

This optimal solution can easily be decentralized if there is full information and the federal

heterogeneity that prevents regional governments from using lump-sum taxes. For example, consumers could differ in their productivity levels (their "wages"), with this individual component as well as individual labor supply not observed by regional governments. In our framework, this could be accomplished by letting the individual time endowment e_i differ from the regional average by an idiosyncratic, zero-mean component, v_i, so that $e_i = e + v_i$. The regional government observes average output or employment in the region, but not individual labor supply—for instance because it observes the output of identical firms, each employing a representative sample of the entire regional population of individuals. Given the linearity of labor supply in the idiosyncratic parameter [see equation (6)], the analysis would be identical, with the regional and federal governments caring about the average consumer in their jurisdiction.

government has sufficient commitment power. Specifically, consider the following sequence of events: (i) the values of the productivity parameters (e', e^*) are observed by regional and federal authorities; (ii) the federal government sets the interregional transfer τ; (iii) regional governments set their policy instruments. Suppose further that the federal government maximizes social welfare in the two regions, as defined by (8), while the two regional governments only care about social welfare in their own region. Then it is easy to show that the equilibrium of this game replicates the second-best equilibrium illustrated above.

PROPOSITION 2: *Under commitment and full information by the federal government, the allocation described in Proposition 1 can be decentralized by means of appropriate lump-sum interregional transfers.*

To prove this proposition, note first that the allocation described in Proposition 1 fully characterizes the second-best equilibrium solution. In such an equilibrium, the regional tax rates and the interregional transfer can be expressed as known functions of the productivity parameters (e', e^*). Let $\tau^* = -\tau' = J(e', e^*)$ be the value of the interregional transfer, as a function of (e', e^*), that equates public spending in the two regions in the fully centralized equilibrium of Proposition 1. If the federal government commits to this function, then it remains optimal for both regional governments to set their tax rates according to Proposition 1 (see the proof in the Appendix). By construction of the function $J(\cdot)$, public spending is fully equalized across regions, and the second-best equilibrium still obtains.

Thus, under full information, the federal government commits to a lump-sum transfer from the rich to the poor region. The intuition behind Proposition 2 is clear when it is recalled that we assume away any spillover effects across regions. Hence, the optimal transfer does not distort regional decisions and the second best is attainable with lump-sum transfers.

Alternatively, the second-best equilibrium can be interpreted as the outcome of an optimal risk-sharing contract between the two regions, written under a veil of ignorance about who is going to be rich and who is going to be poor, and assuming that the distribution of risks is symmetric.[4]

To redistribute in a lump-sum fashion, the transfer must be a function of the exogenous endowments e. This requires that the endowments are verifiable and the federal government has sufficient commitment power. On the contrary, a redistributive rule based on collected tax revenues or observed regional public spending would be highly distorting. To illustrate this point, the remainder of this section considers what happens if a binding commitment to a transfer rule conditional on e is not possible.

C. *No Commitment and Full Information*

Suppose that the timing assumption is reversed: the interregional transfer is set by the federal government *after* regional governments have already committed to a policy. The federal government still cares about the welfare of both regions and weights them identically, while regional governments only care about welfare in their own region. Now, there is an incentive problem. *Ex post,* the federal government continues to find it optimal to redistribute from rich to poor. But the amount redistributed is endogenous, and depends on regional policies. This creates an incentive for regional governments to deviate from the second-best policy, to exploit the transfer rule to their advantage. The nature of the distortion depends on what is the policy instrument of regions.

Consider first the case in which regions set the tax rate, while public spending is residually determined after the interregional transfer has been set. Thus, the timing of events is: (i) the values of the productivity parameters (e', e^*) are observed by regional and federal authorities; (ii) regional governments simultaneously set tax rates, t', t^*; (iii) the federal government sets the interregional transfer τ.

It is easy to show that, whatever the regional tax rate, it remains optimal for the federal government to equalize public spending in the two regions. Thus, the interregional transfer is still determined as in part (iv) of Proposition 1: $\tau' = [t^*l^* - t'l']/2 = -\tau^*$. But under this new timing, the two regional governments no longer

[4] Torsten Persson and Guido Tabellini (1996) focus on risk sharing under relevant asymmetries in the risk distribution.

take τ as given. They instead take *the reaction function* of the federal government as given. Hence, when setting regional taxes, both regional governments face the following budget constraint [obtained by inserting the above expression for τ in (4)]:

$$(4)' \qquad g = t'l'/2 + t^*l^*/2$$

for $g = g', g^*$. It is then easy to show that public spending and regional tax rates are lower in this equilibrium than with full commitment.[5] The reason is very intuitive. Both regional governments now realize that half of regional tax revenue is lost, because it is compensated by smaller interregional transfers received (or by larger interregional transfers paid). Hence, they have an incentive to undertax relative to the second best. Under the assumed timing, there is nothing the federal government can do to remedy the situation. Since it is *ex post* optimal to equalize public spending, the federal government is trapped in a third-best equilibrium.

Next, consider the case in which both regional governments fix spending, while taxes are residually determined after the interregional transfer has been set. Here too, the regional policy is distorted, but in the opposite direction: there is overspending, not underspending, compared to the second best. To see this, consider the choice of τ by the federal government. For given public spending in the two regions, the *ex post* optimal value of τ equalizes the elasticity of labor supply in the two regions, as in part (ii) of Proposition 1. The reason is that this equalizes marginal tax distortions across regions. But under this transfer policy, both regions have an incentive to overspend. By committing to a large value of g, a regional government increases its tax distortion and thus forces the federal government to direct resources in its favor.[6]

We summarize this discussion in the following proposition.

PROPOSITION 3: *Suppose that federal commitment to a lump-sum interregional transfer is impossible. Then, the decentralized equilibrium entails: (i)* $g' = g^*$ *but too little spending, or: (ii)* $\varepsilon(t', e') = \varepsilon(t^*, e^*)$ *but too much spending, compared to the second best. Case (i) holds if regional governments commit to* t, *case (ii) holds if regional governments commit to* g.

From a positive point of view, it is perhaps more realistic to assume that regional governments set g in advance, since spending decisions are more irreversible than decisions over taxes. In this case, lack of commitment in regional redistribution results in overspending. This is really a version of the well-known "soft budget constraint" problem, also discussed by Yingyi Qian and Gérard Roland (1998).

III. Adverse Selection

The previous results underscore the need for regional redistribution to be based on preset formulas to which the federal government can credibly commit. This creates a potential tradeoff between commitment and information. Sustainable commitments have to be *simple:* they cannot depend on too many contingencies. Simple rules for lump-sum redistribution across regions can be written into federal legislation. But it is unlikely that such legislation can incorporate detailed information about features of regional tax bases. Regional circumstances change over time, and exogenous differences in the size of regional tax bases may not be verifiable. These regional circumstances, on the other hand, are likely to be observed by regional

[5] The first-order condition for the regional government optimization problem implies:

$$H_g(g) = 2/[1 - \varepsilon(t, e)].$$

Comparing this expression with (A3) in the Appendix, it follows immediately that public spending is lower in this equilibrium than in the second best.

[6] This point is best illustrated in the limiting case $e' = e^*$. In this case the *ex post* optimal transfer policy simplifies to: $\tau' = (g^* - g')/2 = -\tau^*$. Inserting this reaction function in each regional government budget constraint, as before, yields: $g' + g^* = 2tl$ for $l = l', l^*$ and $t = t', t^*$. Thus, the optimal level of spending for both governments now satisfies:

$$H_g(g) = [1 - \varepsilon(t, e)]/2.$$

Comparing this expression with (A3) in the Appendix, there is overspending relative to the second best. Relaxing the assumption that $e' = e^*$ does not change the qualitative feature of the result, but makes the computations harder because the symmetry of the equilibrium is lost. The full results are available from the authors upon request.

governments before they make policy decisions. Hence, the federal legislator often operates in a situation of asymmetric information with respect to regional governments. The asymmetry of information is even starker in the case of redistribution within a confederation of countries (as opposed to a federation of regions), where even observability, and not just verifiability, is a problem. In the European Union, or in countries such as Russia or China (Jean-Jacques Laffont, 1995), national or regional governments are the primary source of statistical information and are in charge of tax-enforcement decisions, while federal authorities are at a disadvantage in assessing the quality of this information.

To study the incentive problems that arise with asymmetric information, we now reverse the assumptions made at the end of the previous section. The federal government is able to commit to a specific transfer rule, but regional endowments are not verifiable. Regional governments then have an incentive to exploit their informational advantage to affect the transfer they pay or receive. The optimal transfer scheme trades-off the equalization concern of federal government against the need to offer incentives for truth-telling.

A. *The Problem*

In this section, we study this issue as a problem of adverse selection. That is, the unverifiable regional differences are exogenous. Since we already know that any verifiable inequality should be dealt with a lump-sum interregional transfer, we only focus on unverifiable regional differences. Thus, we assume that the two regions are equal in expected value; but in some states of nature, one is rich and the other is poor, and the federal government cannot verify which is which. Specifically, suppose that in both regions the parameter e of the regional tax base is a random variable with two possible and equally likely realizations, e' and e^*, with $e' > e^*$. The realization of e is uncorrelated across regions. Thus, there are four possible and equally likely states of nature. Both regions are rich: (e', e'). Both regions are poor: (e^*, e^*). One region is rich and the other poor: (e', e^*); and vice versa: (e^*, e'). The value of e is known at the outset by each region and it is the only aspect over which regions can differ, so that e also defines the "type" of region. The realization of e is private information: regional governments observe their own type, but not that of the other region, about which they form expectations. The federal government only knows the distribution from which regional types are drawn; thus, it faces a pure "adverse selection" problem.

The problem we discuss in this section differs from the standard problem of optimal income taxation in two respects. First, there is an intermediate level of government that interacts with individual economic agents. Second, since there are only two regions, the federal government budget constraint plays a strategic role: what one regions pays, the other gets. Thus, the transfer received in equilibrium by each region depends on the behavior of *both* regions.

Throughout the rest of the paper, we also assume that the federal government observes regional tax rates, t, but cannot verify regional public spending, g, nor total tax revenue, tl.[7] We need this assumption because otherwise the federal government could recover the unobservable parameter e from the budget constraint (4), by its observation of the tax rate and of tax revenue.[8]

Under these assumptions, the problem of finding an optimal transfer rule can be represented as the equilibrium outcome of the following four-stage game:

1. The federal government designs an interregional transfer rule $\tau = T(t_1, t_2)$ as a function of the tax rates chosen by the two region (the only variables that can be verified).
2. Nature moves and determines whether each region receives a high (e') or low (e^*) endowment of effective labor time. Only regional governments observe the realization of e in

[7] Cremer et al. (1996) take the opposite route, and assume that only g is observable; in their model this choice is unavoidable, however, as regional income is exogeously given and taxation is lump sum. In one of his examples, Lockwood (1999) also considers unobservable regional endowments.

[8] This assumption could be relaxed by adding other unobservable parameters in the configuration of regional taxation, such as tax deductions or exemptions. This would greatly complicate the model without changing the nature of the problem, however. Ultimately, what is needed is that the size and the elasticity of the regional tax base are unverifiable by the federal government. This feature is captured most simply by the assumption that only the tax rate is verifiable.

their own region, and each forms expectations about the other region's endowment.
3. Both regions simultaneously choose their tax rates before the identity of the opponent is revealed, taking as given the transfer rule $T(\cdot)$, and expecting the other region to play its equilibrium strategy.
4. Regional governments pay or receive the transfer according to the rule itself.

Given the coercive powers of the federal government, it is natural to assume that both regions are forced to play this game and thus we do not impose any participation constraint. By invoking the direct revelation principle (see, for instance, Drew Fudenberg and Jean Tirole, 1991 Chapter 7), if an equilibrium of the complex game stated above exists, it is equivalent (for the principal) to that of a simpler game. In the latter game: (i) both regions report their type to the federal government; (ii) on the basis of these reports, the federal government chooses the transfer and dictates the appropriate tax rate to each region. In an equilibrium with truthful and obedient strategies, regional governments reveal their true type and implement the proposed tax rates. We can then solve the problem analytically by letting the federal government directly choose the regional tax rates t and the transfer τ for each type, subject to the incentive-compatibility constraints of the two regions and to the balanced-budget constraint (5).

The balanced-budget constraint implies that in the "symmetric" states in which both regions are of the same type, the interregional transfer is zero. This happens with probability ½. Hence, when setting its regional tax rate, each region always assigns a probability ½ to the event $\tau = 0$. With probability ½ the two regions differ, in which case each region receives a (positive or negative) transfer τ. Hence, we can write the expected utility of type e as a function of his own tax rate and of the transfer τ received when the types differ as:

$$(9) \quad U(t, \tau, e) = \frac{1}{2} W(t, 0, e) + \frac{1}{2} W(t, \tau, e)$$
$$= (1 - t)(L(t) + e)$$
$$+ V(1 - L(t)) + \frac{1}{2} H(r)$$
$$+ \frac{1}{2} H(r + \tau)$$

where $r \equiv t(L(t) + e)$ is regionally raised tax revenue.

By symmetry, the same types ought to be treated equally. Hence, the optimal transfer rule maximizes the expected utility of the federal government, under the relevant incentive-compatibility conditions:

$$(10) \quad \max_{t', t^*, \tau} U(t', -\tau, e') + U(t^*, \tau, e^*)$$
$$s.t.$$
$$I.C.1 \quad U(t', -\tau, e') \geq U(t^*, \tau, e')$$
$$I.C.2 \quad U(t^*, \tau, e^*) \geq U(t', -\tau, e^*),$$

where I.C.1–I.C.2 are the incentive-compatibility constraints for Bayesian strategy implementation. That is, in equilibrium each agent is induced to tell the truth.[9] I.C.1 says that a rich region must prefer to tell the truth, in which case it gets the tax rate t' and a lottery where it *pays* τ or zero with equal probabilities, rather than pretend to be poor, in which case it gets a lottery where it *receives* τ or zero with equal probabilities, but must also set the tax rate t^*. I.C.2 has a similar interpretation for the poor region.

In Figure 1 we illustrate the indifference curve of a generic type e in the space of contracts (t, τ). The curve is defined as the locus where *expected* utility $U(\cdot)$ is constant. The slope of this curve is the marginal rate of substitution between the interregional transfer and the tax rate, $S(t, \tau, e)$:

$$(11) \quad d\tau/dt_{|U=\bar{U}} = -\frac{U_t(t, \tau, e)}{U_\tau(t, \tau, e)} \equiv S(t, \tau, e).$$

Note that the indifference curve reaches a unique minimum in τ at the point $U_t = 0$, that

[9] The Bayesian strategy incentive constraint is less demanding than that under dominant strategy implementation. Furthermore, it greatly simplifies both the exposition and the implementation of the game. On the other hand, it has the disadvantage that it is sensitive to the beliefs about the reports of the other agents in the game—see Fudenberg and Tirole (1991). The working paper version of this work (1996) solves the game under dominant strategy implementation and obtains qualitatively similar results.

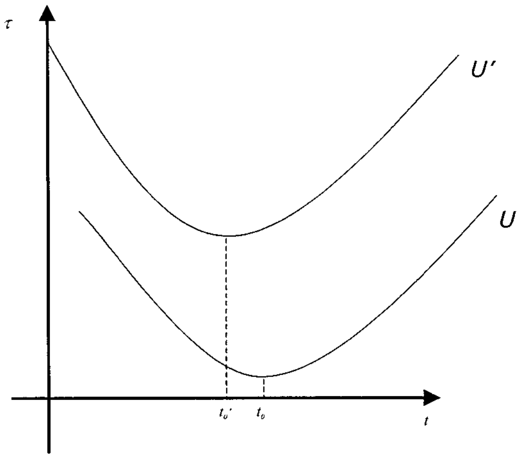

FIGURE 1. INDIFFERENCE CURVES

is at the (*ex ante*) optimal tax rate, t°. Intuitively, the transfer needed to keep expected utility constant is smallest at the optimal tax rate. Regional welfare is increasing in τ for a given t; thus, expected utility increases as we move upwards. Finally, the numerator $U_t(t, \tau, e) = \frac{1}{2} W_t(t, 0, e) + \frac{1}{2} W_t(t, \tau, e)$ is positive (negative) when $t < (>)\ t^\circ$. Therefore, the indifference curve has the U-shape indicated in the picture.[10] This is because at "low" levels of t, the marginal (expected) utility of spending exceeds the marginal (expected) welfare cost of distortions, and vice versa at "high" levels of t. Also note that the optimal tax rate t° is decreasing in τ, so that the minimum point of the indifference curves moves upwards and to the left as utility increases.[11]

B. *The Optimal Transfer Rule*

We are now ready to characterize the solution to problem (10). We assume throughout that the second-best equilibrium described in Section II is not implementable (i.e., it violates at least one of the incentive constraints I.C.1–I.C.2).[12] We first show that, to induce separation, the tax rate in the poor region must be distorted, while that in the rich region is left undistorted. Since these distortions are costly, redistribution is incomplete. Thus, as usual, asymmetric information forces the principal to leave some informational rents to the agents: the rich region is better off under asymmetric information, since the transfer paid is smaller and its choice of tax rate is not distorted. Then, we show that the direction of the distortion depends on the properties of the indifference curve drawn in Figure 1.

Let the equilibrium solution to this adverse selection problem be denoted with the subscript A. Moreover, let g_A^{ij} be equilibrium public spending by region of type i, when the other region is of type j; thus: $g_A'^{*} = t_A'(L(t_A') + e') - \tau_A$, $g_A'' = t_A'(L(t_A') + e')$, and so on. Finally, let g_A', g_A^* be *expected* equilibrium public spending by a rich and poor region respectively; thus: $g_A' = \frac{1}{2} g_A'^{*} + \frac{1}{2} g_A''$ and $g_A^* = \frac{1}{2} g_A^{*\prime} + \frac{1}{2} g_A^{**}$. Then our first result is:

PROPOSITION 4: *The solution to problem (10) entails:*

(*i*) $t_A' = \text{argmax } U(t, -\tau_A, e')$; $t_A^* \neq \text{argmax } U(t, \tau_A, e^*)$;
(*ii*) $g_A'' > g_A'^{*} > g_A^{*\prime} > g_A^{**}$;
(*iii*) $g_A' > g_A^*$;
(*iv*) $\tau_A > 0$.

The proof is in the Appendix. As stated in part (i) of the Proposition, the rich region sets its tax rate optimally (in expected terms) and thus is at the minimum point of its indifference curve, whereas the poor region is distorted in the choice of its tax rate.[13] Thus, the interregional transfer paid is lump sum for the rich

[10] These properties, as well as uniqueness of the optimal tax rate t°, follow from the second-order conditions of the optimal taxation problem. See footnote 17.

[11] This result can be obtained by simply noting that $\partial(\partial U/\partial t)/\partial\tau = H_{gg}(tl + \tau)(1 - \varepsilon)l < 0$, and it is due to our assumption of constant marginal utility for private consumption, but decreasing marginal utility for public consumption.

[12] Clearly, this is the only case in which asymmetric information matters. If the second best were implementable, it would also be the solution to problem (10). We cannot rule out that this is indeed the case: the optimal tax rates of the two types could be sufficiently far apart to induce separation at the second best, without any further distortion.

[13] Note, however, that this undistorted tax rate t_A' is optimal *ex ante* but not *ex post:* unlike in Section II, here regional tax rates are set without knowing the aggregate state, and thus without knowing the size of the interregional transfer.

region. This is a typical result of optimal separating mechanisms (the "no distortions at the top" condition). It appears also in the literature on optimal income taxation, where it is shown that the marginal tax rate on the richest individual is always zero at the optimum (see, for instance, Stiglitz, 1982). Here the set up is different, because a balanced-budget constraint complicates the strategic interaction between the agents, and because the agents (the regional governments) are themselves principals in another game vis à vis the private sector. But the basic intuition is similar. It is never optimal to distort the rich region, as the only reason for distortion is to make her unwilling to mimic the poor. This can always be achieved at a lower welfare cost by distorting the poor region's allocation only.

Since these distortions reduce expected national welfare, optimal interregional redistribution is incomplete. Indeed, as stated in parts (ii) and (iii) of Proposition 4, public consumption is not equalized across regions, neither *ex post* [see (ii)] nor *ex ante* [see (iii)]. In particular, the rich region paying the transfer enjoys more public consumption (g'^*) than the poor region receiving it ($g^{*\prime}$). Thus, asymmetric information "bites," and forces the federal government to leave informational rents to the rich region.

We now show that the direction of the distortion in the poor region tax rate can be up or down, depending on the relative slopes of the indifference curves of the two regions [at the allocation of the poor, (t^*_A, τ_A)]. Consider first the case illustrated in Figure 2, where the indifference curve of the poor region (*PP*) is flatter than that of the rich (*RR*)—formally, the poor region has a smaller marginal rate of substitution between the transfer and the tax rate: $S(t^*_A, \tau_A, e^*) < S(t^*_A, \tau_A, e')$. This means that the transfer is more valuable to the poor than to the rich, or equivalently that tax effort is less costly for the poor region. To induce separation, the equilibrium allocation then puts a premium on fiscal effort by the poor: in exchange for a positive transfer, the poor region is forced to set a higher tax rate than optimal. The equilibrium is illustrated in Figure 2. Consider first the rich region. If it reveals its type, it *pays* τ_A with probability ½ and sets the corresponding optimal tax rate t'_A (point *A* in Figure 2). If instead it pretends to be poor, it *receives* τ_A with probability ½, but it has to accept to levy the tax rate t^*_A, distorted upwards (point *B* in Figure 2). In both cases, with probability ½ the transfer received is zero irrespective of the announced type. By construction, *A* and *B* lie on the same indifference curve. Hence, the rich region does not gain by deviating from *A* to *B*. A similar argument shows that the poor region is always better off at point *B* than at point *A*. Thus, the poor would never want to lie in equilibrium, and I.C.2 does not bind. Hence, the point (t'_A, τ_A, t^*_A) is an equilibrium in Bayesian implementation. Note that, as shown in Figure 2, in equilibrium the poor region not only taxes more than in the second best, but also more than the rich region.

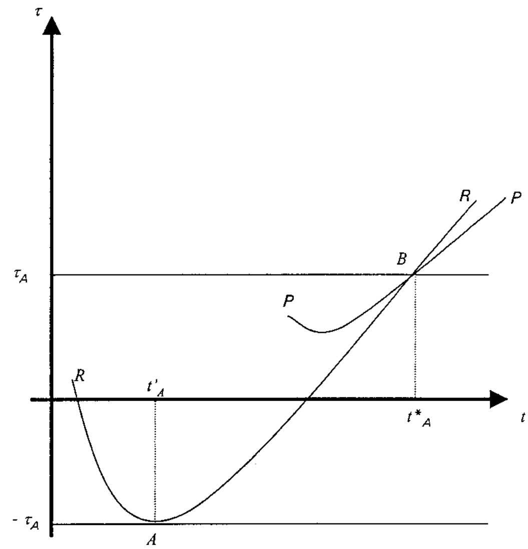

FIGURE 2. EQUILIBRIUM CONTRACT WITH ADVERSE SELECTION

Consider next the opposite case, where the rich region's indifference curve is flatter than that of the poor (at the poor allocation). This means that tax effort is more costly for the poor than for the rich, or equivalently that the transfer is less valuable for the poor than for the rich region. Then separation can still be achieved, but now the poor region tax rate is distorted down, not up, and in equilibrium it is also below that of the rich.

These features of the equilibrium are summarized in the following proposition (formally proved in the Appendix).

PROPOSITION 5:

(*i*) *If* $S(t_A^*, \tau_A, e^*) < S(t_A^*, \tau_A, e')$, *then:* $t_A^* >$ argmax $U(t, \tau_A, e^*)$ *and* $t_A^* > t'_A$.
(*ii*) Conversely, if $S(t_A^*, \tau_A, e^*) > S(t_A^*, \tau_A, e')$, *then both inequalities are reversed.*

How can we interpret these conditions on the relative slopes of the indifference curves of the two regions, and which case is more plausible? Consider the marginal rate of substitution $S(t, \tau, e)$ as a function of the parameter e. As e increases, $S(\cdot)$ is affected by two opposite forces [for given (t, τ)]. On the one hand, as the tax base rises, the marginal (expected) utility of public consumption falls for a given t. This "income effect" reduces the willingness to raise taxes in exchange for the transfer τ, and the indifference curve becomes flatter—$S(\cdot)$ falls. On the other hand, a higher tax base e also reduces the elasticity of labor supply, making the tax rate less distorting on average (see the Proof of Proposition 1 in the Appendix). This "substitution effect" raises the willingness to tax, and makes the indifference curve steeper—$S(\cdot)$ increases. Thus, the case illustrated in Figure 2, where the poor region in equilibrium is distorted upwards, occurs if the income effect dominates over the substitution effect. In general, this case is more likely the more concave is the utility function $H(\cdot)$ compared to the distorting effects of the tax.[14] We should then expect the optimal mechanism to entail a premium on fiscal effort by the poor when regional government spending consists of essential public goods such as health or primary education.

C. *Implementation*

Propositions 4 and 5 characterize the optimal allocation, under the informational constraints on the regional tax bases. There is more than one mechanism that can implement it. One straightforward example is the following. Let the federal government present each regional government with a transfer schedule $T(t_1, t_2)$ as a function of the *own* tax rate (t_1) and of the tax rate chosen by the *other* region (t_2). Then both regional governments, having observed their own endowment, simultaneously choose the tax rate that maximizes their own expected utility subject to $T(t_1, t_2)$. The following transfer schedule implements the previous equilibrium:

(12)
$$T(t_1, t_2) = \begin{cases} 0 \text{ for } t_1 = t_2 = t_A^* \quad \text{or} \quad t_1 = t_2 = t'_A \\ -\tau_A \text{ for } t_1 = t'_A, \quad t_2 \neq t_1 \\ \tau_A \text{ for } t_1 = t_A^*, \quad t_2 \neq t_1 \\ -\infty \text{ for } t_1 \neq t'_A, t_A^*. \end{cases}$$

Thus, the transfer schedule gives zero to both regions if they select the same tax rate. It gives the equilibrium transfer if they separate each other according to the equilibrium tax rates. And it punishes any region which selects a nonequilibrium tax rate. This scheme does not violate the budget constraint (though it allows the federal government to waste tax revenue out of equilibrium). Faced with this scheme, both regions clearly find it optimal to implement the equilibrium allocation described in Propositions 4 and 5.

IV. Extensions

So far the informational advantage of regions has been assumed exogenous. Regional governments in many countries are wholly or partially responsible for monitoring their own tax bases and enforcing tax collection, however.[15] This adds a moral hazard component to the optimal redistribution problem, since the size of the regional tax base is partly determined by the monitoring effort of the regional government. In the working paper version of this article (1996) we show that incorporating moral hazard through a regional decision on tax enforcement

[14] This can be seen formally by taking the partial derivative of $S(\cdot)$ with respect to the parameter e. The working paper version of this article (1996) provides more details.

[15] For example, local taxes on housing are audited by local and regional governments in Denmark, Germany, Australia, the United States, and the United Kingdom, and jointly with the central state in Spain and Italy. Only very centralized states, such as France, leave this task entirely to the central government.

does not change the main characteristics of the optimal contract:[16] rich regions remain undistorted in their choice of the tax rate, while poor regions are distorted, and regional redistribution falls short of the first best.

While moral hazard in regional tax enforcement does not change the main features of the optimal contract, it might reduce the equilibrium level of regional redistribution. In the working paper version, we considered the case illustrated in Figure 2, with $S(t_A^*, \tau_A, e^*) < S(t_A^*, \tau_A, e')$. In such a case, the poor region signals its bad luck through a higher tax rate. When regional governments are allowed to choose tax enforcement, however, fiscal effort becomes a less reliable signal of bad luck. The reason is that rich now finds it less costly to mimic the poor by increasing its tax rate (which is observable), while at the same time reducing tax enforcement (which is not). To enforce separation, the interregional transfer must fall, which implies that even less redistribution is possible with moral hazard than with adverse selection alone. This harms the poor and benefits the rich. Quite strikingly, this occurs even though it is the poor and not the rich region which may allow for tax evasion in equilibrium.

V. Concluding Remarks

We started with a simple question: how to optimally redistribute among regions with different per capita tax bases. The paper suggests the following answer. Any verifiable exogenous difference in the size of regional tax bases should be compensated by equalizing interregional lump-sum transfers. There are likely to remain unknown or unverifiable regional differences, however, since the relative position of regions is imperfectly observed and changes over time. Furthermore, there is a trade-off between the ability of federal government to commit to a redistributive formula and the number of contingencies this formula can rely upon. To deal with unverifiable differences, an optimal transfer mechanism should then induce truth-telling by distorting the choices of regions that claim to be poorer than expected. Since statutory tax rates are observable, the optimal transfer should then distort the choice of the tax rates by these regions. The direction of the distortion depends on the relative marginal evaluation of tax revenue by the regions. If poor regions value tax revenue more, fiscal effort is less costly for them. Hence, fiscal effort is a credible signal of bad luck and the optimal transfer mechanism puts a premium on fiscal effort of the poor. Vice versa in the opposite case. Distorting the choice of the poor is costly, however. For this reason, optimal redistribution is incomplete, and the rich region gets some informational rents.

This paper focused on incentive problems that arise from lack of commitment and informational asymmetries, abstracting from political incentive constraints. Our qualitative results are likely to survive under modified governments objective functions, like those that could be derived from models of electoral competition with probabilistic voting and/or lobbying (see Persson and Tabellini, 2000), though with a positive (as opposed to normative) interpretation. But adding politics to the analysis also raises new interesting questions. Once an interregional transfer scheme is in place, it can be exploited by politically powerful regions to redistribute in their favor, not just to share risks. What determines political power and influence in this redistributive struggle among regions? Regional politicians are also likely to enjoy an information advantage vis-à-vis their citizens. Regional redistribution "levels the playing field" between competing regions, thus allowing citizens to better compare the relative performance of regional politicians. What are the properties of an optimal redistributive mechanism when there is also an agency problem between citizens and politicians? More generally, what is the optimal instrument assignment to different levels of government once these additional (political) incentive constraints also shape collective decisions? Some of these questions have been addressed in the recent literature—see, in particular, Pierre Salmon (1987), Patrick Bolton and Roland (1996), Persson and Tabellini (1996), Timothy S. Besley and Stephen Coate (1998), Lockwood (1998), Bordignon and Sandro Brusco (1999), and Bordignon and Enrico Minelli (1999)—but much more remains to be done.

[16] Laffont (1995) also discusses moral hazard in a related context.

APPENDIX

PROOF OF PROPOSITION 1:

Invoking the envelope theorem, the first-order conditions for a maximum of (8) with respect to t and τ, subject to (5), can be written respectively as:

$$\text{(A1)} \qquad -l + H_g(g)[l + tL_t(t)] = 0$$

$$\text{(A2)} \qquad H_g(g') = H_g(g^*)$$

where (A1) holds for both regions, and where l is given by (6). Equation (A2) immediately implies (i) and, together with the budget constraints (4) and (5), it also implies (iv). To prove parts (ii) and (iii) of the proposition, it is useful to rewrite (A1) in the following more revealing form:

$$\text{(A3)} \qquad H_g(g) = 1/[1 - \varepsilon(t, e)]$$

where $\varepsilon(t, e) = -tL_t(t)/[L(t) + e] > 0$ is the elasticity of labor supply with respect to the tax rate. Thus, the larger is this elasticity, the more distorting is the income tax, and the smaller is the optimal amount of public consumption. Equations (A3) and (A2) imply (ii). Moreover, since the elasticity is decreasing in e, and since $e' > e^*$, part (iii) of the proposition immediately follows.[17]

PROOF OF PROPOSITION 4:

We prove the proposition in several steps. It is straightforward to show that, at the optimal contract with $\tau > 0$, the incentive-compatibility constraints I.C.1 and I.C.2 cannot *both* be binding at the same time—otherwise the planner would be better off setting $\tau = 0$; we skip this simple part of the proof. We then conjecture that only I.C.1—that on the rich region—binds, and characterize the optimal contract under this assumption. Next, we show that this conjecture is correct: the poor region's I.C. constraint cannot be binding at the optimum. Finally, we show that $\tau = 0$ cannot be part of the optimal solution either. This concludes the proof.

LEMMA 1: *Suppose that I.C.1 is the only binding constraint and that* $\tau > 0$. *Then: (i)* $t'_A = \text{argmax } U(t, -\tau_A, e')$; *(ii)* $t^*_A \neq \text{argmax } U(t, \tau_A, e^*)$; *(iii)* $g''_A > g'_A{}^* > g^*_A{}' > g^{**}_A$; *(iv)* $g'_A > g^*_A$.

PROOF:

Ignoring I.C.2, we can write the Lagrangean of problem (10) as:

$$\text{(A4)} \quad L = U(t', -\tau, e') + U(t^*, \tau, e^*) + \lambda[U(t', -\tau, e') - U(t^*, \tau, e')]$$

where λ is the Lagrange multiplier of I.C.1. If this constraint binds, the first-order conditions of this optimization problem are:

(A5)

$$(a) \qquad (1 + \lambda)U_t(t', -\tau, e') = 0$$

$$(b) \qquad U_{t^*}(t^*, \tau, e^*) = \lambda U_{t^*}(t^*, \tau, e')$$

$$(c) \qquad U_\tau(t^*, \tau, e^*) - U_\tau(t', -\tau, e') = \lambda[U_\tau(t', -\tau, e') + U_\tau(t^*, \tau, e^*)].$$

Part (i) of the lemma follows directly from equations (A5(a)).

Part (ii) follows from (A5(b)), since $\lambda > 0$ and given that, with $e' > e^*$, the two partial derivatives in (A5(b)) cannot both be zero for the same values of t and τ.

Parts (iii) and (iv). Note that, using the notation in the text, $g'^* = g'' - \tau$, $g^{*\prime} = g^{**} + \tau$. Also note that (A5(c)) can be rewritten as $H_g(g^{**} + \tau) - H_g(g'' - \tau) = \lambda[H_g(g'' - \tau) + H_g(g^{**} + \tau)]$. The right-hand side is always positive when $\lambda > 0$, and so the left-hand side must also be positive. By the concavity of $H(\cdot)$, this implies $g' - \tau > g^* + \tau$, and a fortiori, the other inequalities in (iv).

LEMMA 2: *At the optimum, I.C.2 cannot be binding.*

[17] Throughout the paper we assume that the second-order conditions of this optimal taxation problem are satisfied everywhere. A sufficient (but not necessary) condition is that the elasticity of labor supply is increasing in t. In turn, a sufficient (but not necessary) condition for the elasticity of labor supply to be increasing in t is that either $V_{xxx} \geq 0$ or that $-(L + e)V_{xx} \geq V_{xxx}$—see also footnote 2.

PROOF:

It remains to prove that our initial conjecture is right, namely that I.C.2 does not bind in equilibrium. Suppose by contradiction that this was the case (and note that then I.C.1 cannot also bind). Repeating the same steps as above, one would find that, at the poor equilibrium allocation, the tax rate for the *poor* would be undistorted, the tax rate of the rich is distorted, and both allocations lie on the same indifference curve of the *poor*. But this yields a contradiction. By mimicking the rich, the poor would have to give up a transfer, whose value is positive in expected value, and on top of that, he should also accept a distorted tax rate. This results in a net welfare loss, contradicting the initial conjecture that the poor was indifferent between mimicking or accepting the equilibrium allocation.

LEMMA 3: *At the optimum,* $\tau_A > 0$.

PROOF (BY CONTRADICTION):

Suppose on the contrary that at the optimal contract $\tau_A = 0$. In this case I.C.1 would, of course, not be binding, so that $\lambda = 0$. The first-order conditions in the proof of Lemma 1 would still characterize the optimum, so that each region would not be distorted in its choice of the tax rate [part (b) in (A5)], and [by part (c) in (A5)] $H_g(g^{**}) = H_g(g'')$. But this cannot be true if $e' > e^*$. This contradiction establishes the lemma.

PROOF OF PROPOSITION 5:

By substituting for part (b) in part (c), we can rewrite part (c) of (A5) as:

$$S(t_A^*, \tau_A, e^*)/S(t_A^*, \tau_A, e')$$
$$= (1 - U_\tau(t', -\tau_A, e')/U_\tau(t^*, \tau_A, e^*))$$
$$\div (1 + U_\tau(t', -\tau_A\tau, e')/U_\tau(t^*, \tau_A, e'))$$
$$< 1.$$

Part (b) also tells us that sign $S(t_A^*, \tau_A, e^*) =$ sign $S(t_A^*, \tau_A, e')$; thus, the previous inequality can hold in two cases. Either $S(t_A^*, \tau_A, e') > 0$ and then $0 < S(t_A^*, \tau_A, e^*) < S(t_A^*, \tau_A, e')$; or $S(t_A^*, \tau_A, e') < 0$ and then $0 > S(t_A^*, \tau_A, e^*) > S(t_A^*, \tau_A, e')$. In the first case, the poor region is distorted upwards and in the second case downwards. Furthermore, we know that the optimal tax rate is decreasing in the level of the transfer; this fact, combined with the above immediately establishes that $t_A^* >$ argmax $U(t, \tau_A, e^*)$ in case (i) of Proposition 5, with the inequality reversed in case (ii) of Proposition 5. The statement that $t_A^* > t'_A$ in case (i) [and vice versa in case (ii)] follows immediately by recalling that the rich region is undistorted at its allocation, and that at the optimum both (t_A^*, τ_A) and $(t'_A, -\tau_A)$ lie on the same indifference curve for the rich.

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