DIRETORIA DE ESTUDOS MACROECONÔMICOS

SEMINÁRIOS DIMAC Nº 99

O Federalismo Leva a Impostos Excessivamente Altos?

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O FEDERALISMO LEVA A IMPOSTOS EXCESSIVAMENTE ALTOS?

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ABSTRACT

Federal systems commonly involve some co-occupation of the same tax base by both federal and state governments. This paper explores the interplay between the vertical tax externalities that consequently arise and the more familiar horizontal externalities from inter-state mobility of the tax base. Conditions are established under which, contrary to conventional wisdom, and even if policy-makers are perfectly benevolent, state taxes are too high in equilibrium. It is further shown, however, that if — as is generally prescribed — states fully tax immobile factors before turning to the mobile base, then the conventional wisdom of under-taxation is restored. (JEL H20, H23)

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Does federalism lead to excessively high taxes?

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Abstract: Federal systems commonly involve some co-occupation of the same tax base by both federal and state governments. This paper explores the interplay between the vertical tax externalities that consequently arise and the more familiar horizontal externalities from inter-state mobility of the tax base. Conditions are established under which, contrary to conventional wisdom, and even if policy-makers are perfectly benevolent, state taxes are too high in equilibrium. It is further shown, however, that if—as is generally prescribed—states fully tax immobile factors before turning to the mobile base, then the conventional wisdom of under-taxation is restored. (*JEL* H20, H23)

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Federalism means multi-leveled government. And multileveled government typically means, in practice, some commonality of tax base between central ('federal') and lower-level ('state') governments. The United States, where personal and corporate income taxes are both co-occupied by state and federal governments, is a leading but by no means the only example. Even when, perhaps as result of constitutional restrictions, the distinct levels have formally different tax bases—income and sales taxes, for example—these may overlap in real terms. Such shared tax bases create a common pool problem, with the tax decisions of each level of government inducing responses by the private sector that affect the shared tax base. Strikingly, the vertical externalities that are thus at the heart of federal tax architecture have—until recently—been largely neglected in the theory of fiscal federalism, which has focused instead on horizontal externalities arising from mobility of the tax base between the states. Vertical externalities make no appearance, for example, in the classics of Wallace E. Oates (1972) and Roger H. Gordon (1983).[1]

Since vertical and horizontal tax externalities are thus inherent in federal tax structures, recognizing and understanding the interaction between them is of considerable importance to the theory of fiscal federalism. They are likely to distort levels of taxation in opposite directions. Horizontal externalities tend to leave state taxes too low,[2] as each state neglects the harm it does others by cutting its tax rate in order to attract mobile tax base. Vertical externalities, in contrast, are likely to leave state taxes too high: each state unduly discounts the pressure on federal spending it creates by raising its own tax rate (so setting off incentive effects that shrink the federal tax base) insofar as those pressures are shared across all states.

With horizontal and vertical externalities thus pointing in opposite directions, it is important to understand the circumstances in which one will dominate the other. The question of whether equilibrium state taxes are likely to be high, too low or just right, for instance, is obviously critical to issues of tax coordination. The central purpose in this paper is thus to elucidate the inter-relationship, and balance, between horizontal and vertical externalities in archetypal federal structures.

To this end we simply take the standard model of horizontal capital tax competition—that of John D. Wilson (1986) and George R. Zodrow and Peter Mieszkowski (1986)—and superimpose a federal government. As in that model, and in much of the subsequent tax competition literature, policy-makers are assumed to act in the best interest of their own jurisdiction, as they perceive it. We ask: Will taxes be too low in equilibrium (the horizontal externality dominating), as is usually supposed, or too high (the vertical externality dominating)?[3] How is the balance between horizontal and vertical externalities affected by the nature of the strategic interaction between federal and state governments?

The model is developed in Section 2 and analyzed in Section 3. Section 4 concludes.

I. Capital income taxation in a federal system

The economy consists of $N \geq 1$ identical states. Output in state j is $F(K_j)$, where K_j denotes the capital located in j; F is increasing, strictly concave and at least three times continuously differentiable. Capital is costlessly mobile across the states, and so relocates until it earns the same post-tax return ρ in each. State j levies a tax t_j on each unit of capital located in its jurisdiction. The federal government levies a unit tax T on capital in each jurisdiction, equivalent to a tax at that rate on national savings. We refer to $\tau_j \equiv t_j + T$ as the consolidated tax rate[4] in state j. The arbitrage condition[5]

$F'(K_j) = \rho + \tau_j$ then defines the demand for capital in j as $K_j = K(\rho + \tau_j)$, with $K' = 1/F'' < 0$. Rents arising in state j, $\Pi \equiv F(K_j) - F'(K_j)K_j$, are assumed to be taxed by state j at the (exogenous) rate $\theta \in [0,1]$, and to be untaxed by the federal government.

There is a single consumer in each state, each with preferences $U(C_1, C_2, g, G) = u(C_1) + C_2 + \Gamma(g, G)$ defined over first- and second-period private consumption, C_1 and C_2, the level g of a local public good provided by the government of the state in which she lives and federal spending per state, G. Both u and Γ are strictly increasing and concave. Each consumer has a fixed endowment e of first-period income, and in the second receives principal and interest on her savings, S, plus after-tax rents earned in her jurisdiction. Savings are $S(\rho)$, with $S' \geq 0$, and indirect utility is

$$U(\rho, \tau, g, G) \equiv u(e - S(\rho)) + (1 + \rho)S(\rho) + (1 - \theta)\Pi(\rho + \tau) + \Gamma(g, G) \,. \tag{1}$$

Noting that $\Pi' = -K$, differentiating (1) and using the first order condition on the individual's savings decision gives

$$U_\rho = S - (1 - \theta)K \;\; ; \;\; U_\tau = -(1 - \theta)K \,. \tag{2}$$

Denoting the N-vector of consolidated tax rates by $\vec{\tau} \equiv (\tau_1, ..., \tau_N)$, the net return $\rho(\vec{\tau})$ is implicitly defined by the market-clearing condition $NS(\rho) = \Sigma_{i=1}^N K(\rho + \tau_i)$, so

$$\frac{\partial \rho}{\partial \tau_j} = \frac{K'(\rho + \tau_j)}{NS'(\rho) - \Sigma_{i=1}^N K'(\rho + \tau_i)} \,. \tag{3}$$

Attention is confined to symmetric equilibria: ones, that is, in which all states set the same tax rate ($\tau_j = \tau, \forall j$). The net return in such an equilibrium is $p(\tau) \equiv \rho(\tau, .., \tau)$, so that

$$p'(\tau) = \frac{K'(\rho + \tau)}{S'(\rho) - K'(\rho + \tau)} \in [-1, 0) \,. \tag{4}$$

Hence, using (3), in symmetric equilibrium

$$p'(\tau) = N \frac{\partial \rho}{\partial \tau_j} . \tag{5}$$

The federal government allocates its total receipts equally across states.[6] There are no inter-governmental transfers, either vertically between the levels of government or horizontally across the states,[7] so that state and federal tax receipts (per state) are

$$g_j = t_j K(\rho + \tau_j) + \theta \Pi(\rho + \tau_j) \tag{6}$$

$$G = \frac{1}{N} \Sigma_{i=1}^N T K(\rho + \tau_i) = T S(\rho). \tag{7}$$

Policy-makers—both federal and at state level—are perfectly benevolent, in the sense that they look (only) to the welfare of their constituents (implying in particular that state policy-makers care nothing for citizens of other states). The strategic variable of each policy-maker is the tax rate at their disposal; and each fully recognizes the revenue constraints (6) and (7) of all others. Each state policy-maker plays Nash relative to

all other policy-makers, state and federal; alternative possibilities for the federal policy-maker are considered.

II. Vertical and horizontal tax externalities

The basic horizontal tax externality at work between the states is familiar and straightforward: the typical state policy-maker neglects the revenue gain that other states enjoy when she raises her tax rate and so induces some capital movement into those other states. This points to the common state tax rate being too low in equilibrium. The vertical structure is less familiar. Since the federal policy-maker sees through the states' budget constraints, there is no 'top-down' vertical externality. There is, however, a 'bottom-up' vertical externality: the states do not attach the proper social value to the impact their decisions have on federal spending. Since federal revenues are shared equally over all states, each state policy-maker recognizes that a contraction of \$1 in federal revenues induced by an increase in the tax rate they charge will only reduce federal expenditure in their state (as in all others) by $\$1/N$. This vertical externality points towards excessively high state taxes.

A. *Will state taxes be too high or too low?*

With no top-down externality, the key question is whether inefficiency in the setting of state taxes will be dominated by the horizontal externality (so that the equilibrium state tax is 'too low,' in a sense to be made precise shortly) or by the vertical externality (so that the state tax is too high). To investigate this, write the welfare of the typical citizen in state j as $W_j(\vec{t},\tau_j) \equiv U\left[\rho(\vec{\tau}),\tau_j,t_jK(\rho(\vec{\tau})+\tau_j)+\theta\Pi(\rho(\vec{\tau})+\tau_j),TS(\rho(\vec{\tau}))\right]$, so that the necessary condition for the typical state tax, evaluated in symmetric equilibrium, is

$$\frac{\partial W_j}{\partial t_j} = \frac{1}{N}\theta K p' - (1-\theta)K + \Gamma_g\left(K + (t^*K' - \theta K)(1+\frac{1}{N}p')\right) + \frac{1}{N}\Gamma_G T^* S' p' = 0\,. \tag{8}$$

Denoting welfare in a symmetric equilibrium by $W(t,T) \equiv U[p(\tau),\tau,tK(p(\tau)+\tau)+\theta\Pi(t,T),TS(p(\tau))]$ the effect of a coordinated increase in all state taxes is then

$$W_t(t^*,T^*) = \theta K p' - (1-\theta)K + \Gamma_g\Big(K + (t^*K' - \theta K)(1+p')\Big) + \Gamma_G T^* S' p'. \tag{9}$$

It is the sign of (9) that is of critical interest. A dominant horizontal externality, meaning a state tax too low in terms of the collective good, corresponds to $W_t > 0$; a dominant vertical externality, with the state tax too high, to $W_t < 0$.[8]

To explore the sign of W_t, subtract (8) from (9 to find:

$$W_t = \left(\Gamma_g tK' + \frac{\Gamma_G}{N}TNS' + \theta K(1-\Gamma_g)\right)\left(1 - \frac{1}{N}\right)p'\,. \tag{10}$$

Since $(1-(1/N))p'$ is unambiguously negative, the direction of inefficiency in the equilibrium state tax turns on the balance between the three effects in the first bracketed term in (10).

The first of these captures the horizontal externality arising from the effect on capital tax revenues of tax-induced capital movements between jurisdictions. This is

more marked—conditional on the state tax rate—the greater the sensitivity K' of the demand for capital to the interest rate; for it is this sensitivity that largely shapes the extent to which capital must move to arbitrage away tax differentials established by unilateral changes in a state's tax policy.

The second effect in (10) is the vertical externality, reflecting the fact that, as noted above, each state bears only $(1/N)$-th of the cost of the reduction in the federal tax base—national savings NS— that it induces by raising its own tax rate. The extent of this depends on the interest-sensitivity of savings: the greater is S', the greater is the reduction in the federal tax base consequent upon the net interest rate cut that follows when any state raises its tax rate.

The third effect is a horizontal externality operating through the taxation of rents by the states.[9] This captures effects on both private consumption and public revenues. The former follows from the effect of the state rent tax in implying—equating S and K in (2)—that in equilibrium each individual is harmed by a reduction in the net interest rate (the reduced return on their savings being less than fully offset by reduced rental payments on the capital they employ). Thus each state ignores the harm that it does to citizens of other states when by raising its tax rate it reduces the net interest rate throughout the federation. This tends towards state taxes being too high. On the other hand, each state also ignores the benefit that it confers on others by raising its tax rate and thereby increasing the capital employed, and hence the rent taxes collected, in those other states. This tends towards state taxes being too low. Which of these effects dominates depends on the relative valuations of private consumption and state spending, $1 - \Gamma_g$.

All three effects in (10) vanish, so that the non-cooperative equilibrium is second-best efficient, in two circumstances. The first, trivially, is that in which there is only one state: there is then no other state to be harmed by a horizontal outflow of capital, and none to share the reduction in federal expenditure induced by an increase in the state tax rate. The second is that in which[10] $K' = 0$, and so also $p' = 0$. In this case the horizontal externalities vanish because there are again no horizontal movements of capital; and the vertical externality also vanishes because the equilibrium level of savings is tied down by the demand for capital, so is in this case also wholly unresponsive to state tax rates. Notice that it is not enough for all externalities vanish that the supply of savings be fixed: that still leaves scope for horizontal competition for capital. It is only if the demand for capital is fixed that the coordination issue disappears.

It is clear from (10) that whether it is the horizontal or the vertical externality that dominates depends, in general, on the relative elasticities of the supply of savings and the demand for capital (which determine p') and on the extent to which the states tax rents. To see the relevant considerations more clearly, consider in turn the cases in which rents are untaxed ($\theta = 0$) and in which they are fully taxed ($\theta = 1$).

Setting $\theta = 0$ in (10), multiplying by $K = S$ and recalling (5), (6) and (7), the vertical externality dominates ($W_t < 0$) iff

$$|p'| < \frac{\Gamma_G G}{\Gamma_G G + \Gamma_g g} . \tag{11}$$

That is, the vertical externality dominates iff the responsiveness of the net interest rate to a federation-wide increase in the consolidated tax rate is smaller in absolute value than the share of federal in total spending (with federal and state spending valued by

their marginal worth to consumers). Intuitively, a low value for $|p'|$ means that the interest elasticity of the supply of savings is high relative to the interest elasticity of the demand for capital; so the effect of state tax changes on the federal tax base (the supply of savings), which determines the vertical externality, is large relative to the sensitivity of capital movements with respect to the interest rate, which shapes the horizontal externality.

The condition in (11) points clearly to circumstances in which either horizontal or vertical externality will dominate. If savings are completely inelastic, then[11] $|p'| = 1$ and (11) fails. The horizontal externality then dominates: inelastic saving means an inelastic federal tax base, so that there are no vertical effects from state taxes. At the other extreme—or rather, just short of it, since we have seen that both externalities vanish once it is reached—as $p' \to 0$ so both g^* and G^* tend to their first-best values;[12] assuming both of these to be strictly positive, the inequality in (11) must then hold for small enough p'. Thus the vertical externality is sure to dominate if, loosely speaking, the interest elasticity of savings is large enough relative to the demand for capital. The intuition is the converse of that given above.

Summarizing:

PROPOSITION 1: *When rents are untaxed ($\theta = 0$):*

(a) The horizontal externality dominates if the supply of savings is independent of the net interest rate;

(b) The vertical externality dominates if the interest responsiveness of savings is sufficiently high relative to that of the demand for capital; and

(c) Both externalities vanish if and only if the demand for capital is unaffected by the cost of capital.

The theoretical possibilities are thus clear. The condition in (11) also enables one to derive some sense of the likely practical importance of the points at issue. In particular, is it at all plausible that (11) might hold, and state taxes consequently be too high in equilibrium?

Take, as an example, the United States. Federal spending is about twice state (plus local) spending from own sources.[13] Assuming that federal and state spending have the same marginal social value, the right of (11) is then about two-thirds. Supposing too a tax-inclusive consolidated tax rate τ/ρ of 20 percent—broadly in line with the effective marginal and average tax rates for the US calculated by Lucy Chennells and Rachel Griffith (1997)[14]—and taking the recent estimate of Robert S. Chirinko *et al* (1999) that the elasticity of the capital stock with respect to the user cost of capital is about 0.25, the inequality (11) will then hold so long as the interest elasticity of savings is 0.1 or more. This is a relatively low figure:[15] much lower, for instance, than the much-cited estimate by Michael J. Boskin (1978) of an interest elasticity of 0.4. Thus a dominant vertical externality does not necessarily require an implausibly high savings elasticity. Taking a higher figure of 0.75 for the elasticity of the capital stock, (11) continues to point to over-taxation at state level for any savings elasticity above 0.31. These calculations

are of course no more than illustrative,[16] but suggest that the possibility of a dominant vertical externality is more than a theoretical curiosum.

Consider now the opposite extreme, in which rents are fully taxed by the states (so that $\theta = 1$). Suppose too, for the case to be interesting, that the associated revenues are insufficient to finance all worthwhile public expenditure, so that $t^* > 0$. This is an important benchmark case, as it corresponds precisely to the standard prescription that lower-level jurisdictions tax immobile bases before turning to mobile ones. Setting $\theta = 1$ in (9), solving for $\Gamma_G TS'$ and substituting into (10) gives

$$W_t = (1 - N)\Gamma_g t^* K' . \tag{12}$$

In this case the balance of effects is therefore clear-cut:

PROPOSITION 2: *The horizontal externality dominates if the states fully tax rents ($\theta = 1$).*

This provides a new rationale for an old view: if states have fully exploited immobile tax bases, as conventional wisdom would have them do, then, even in the presence of tax base overlap with a federal government, the presumption is that equilibrium state taxes will be too low.[17]

B. *When is the federal tax rate too high?*

The results above characterizing the potential inefficiency in state taxes require no particular assumption on the way in which the benevolent federal policy-maker sets the federal tax T. This does, however, have powerful implications for the potential distortion of the federal tax rate induced by the interplay between vertical and horizontal externalities.

One possibility is that the federal government, like state policy-makers, plays Nash, taking all state taxes as given. It will then set $W_T = 0$: the federal tax is set at the level that is optimal given the equilibrium state tax.

The more interesting case—and in many cases the more plausible—is that in which the federal government moves first. Recognizing the impact that T has on the equilibrium state tax, it will then typically deviate from rule $W_T = 0$ in order to induce a favorable shift in the state tax. Will this strategic consideration lead to 'under-taxation' at the federal level, in the sense that $W_T > 0$ in equilibrium,[18] or will it lead to federal 'over-taxation'?

With the equilibrium state tax implicitly defined by (8) as a function $t(T)$ of the federal tax, the federal government chooses T to maximize $W(t(T), T)$. The necessary condition for this gives:

PROPOSITION 3: *There is over-taxation at the federal level if and only if W_t and t' have opposite signs.*

Thus the direction of inefficiency in the level of the federal tax depends on: first, whether the horizontal or vertical externality dominates in the setting of state taxes; and second, whether state and federal taxes are strategic substitutes (in the sense that $t' < 0$) or complements ($t' > 0$). The reason for this straightforward. If, for example, the horizontal externality dominates, so that the state tax t is set too low, then the

federal government will wish to set T so as to induce a higher t (the first-order gain from the change in t more than offsetting the second-order loss from moving T away from its conditionally optimal level); which requires setting T above its otherwise optimal level if the two taxes are strategic complements, and below it if they are strategic substitutes.

It would be dull to catalogue the possibilities. But take, for instance, the case in which rents are fully taxed by the states. Proposition 2, recall shows that there is then sure to be under-taxation at state level. From Proposition 3, it follows that there is under- (respectively, over-) taxation at the federal level if state and federal taxes are strategic substitutes (complements). Strategic substitutability, for instance, will thus mean that in the circumstances of the proposition taxes will be set too low at both levels of government: a coordinated increase in both federal and state taxes would be welfare-improving.

The question is then whether strategic substitutability or complementarity is the more likely. As is evident from contemplating comparative statics on (8), the issue is analytically involved: some of the considerations that arise are discussed by Timothy Besley and Harvey S. Rosen (1998), Michael J. Keen (1998), and Timothy J. Goodspeed (2000), though in contexts without horizontal mobility of the tax base. The important point for present purposes, however, is that the sign of t' is theoretically ambiguous.[19] Recent empirical work on business taxes in Canada by Masayoshi Hayashi and Robin Boadway (1999) finds it to be negative: higher federal taxes seem to reduce provincial taxes. If so, and if the federal government acts as a Stackelberg leader (which their results also suggest to be the case) then Proposition 3 implies that inefficiencies in tax setting will have the same sign as both levels of government: if horizontal externalities dominate in state taxation, for instance, then the equilibrium federal tax will also be too low.

III. Summary and Conclusions

The relative strengths of vertical and horizontal tax externalities turns on the balance between the interest responsiveness of the supply of savings and demand for capital, the extent to which immobile factors are taxed by the states, and the strength of preferences between federal and state expenditures. Roughly speaking, the vertical externality will dominate if the aggregate tax base of the federation is sufficiently responsive to the state tax instrument. In this case, and contrary to conventional wisdom, state taxes are actually too high in equilibrium. The horizontal externality will dominate, on the other hand, if the inter-state mobility of the tax base is great enough.

In one important case, however, the balance of effects is clear-cut. If conventional advice is followed in the allocation of tax powers—so that the states tax immobile bases before they tax horizontally mobile ones—then the horizontal externality dominates. In this sense the standard view that has emerged from models of federations without federal governments—that state tax rates are likely to be too low in equilibrium—survives a more realistic view of federal tax architecture.

The conclusions drawn here thus to some degree affirm those familiar from models without a federal presence. But the additional perspective that comes from recognizing the vertical externalities inherent in federal systems requires, at the very least, that this conventional wisdom be re-interpreted. Tax interactions in federations are more complex than has often been supposed.

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Notes

[1]Though small, the literature on vertical externalities is now growing: partial surveys are in Michael J. Keen (1998), and John D. Wilson (1999). Important early treatments by James H. Cassing and Ayre L. Hillman (1982), and Marilyn R. Flowers (1988) first drew attention to the potential implications of vertical externalities for overall levels of taxation, but did so on the assumption that policy makers are Leviathans and without formally integrating them with familiar horizontal externalities.

[2]This is a central theme, for instance, of John D. Wilson (1986), George R. Zodrow and Peter Mieszkowski (1986), and David E. Wildasin (1989). There are cases, however, in which tax exporting can leave equilibrium taxes too high: see, for example, Jack Mintz and Henry Tulkens (1986).

[3]Michael J. Keen (1995), Matthias Wrede (1996), and Michael J. Keen and Christos Kotsogiannis (2000) address the same issues for the case in which policy-makers are revenue-maximizing Leviathans.

[4]State taxes are often deductible or creditable against federal taxes, but modeling this would distract from the effects arising from the behavior of the private sector that we seek to emphasize: see Bev Dahlby, Jack Mintz and Sam L. Wilson (1999).

[5]Derivatives are indicated by a prime for functions of a single variable, and—except where there is risk of confusion with subscripts used to identify states—by subscripts for functions of several.

[6]Since N is taken as fixed, this is equivalent to (but proves expositionally more convenient than) having the federal government provide some good public to the federation as a whole. Note too that the fixed allocation of federal expenditure across states precludes the common pool problem analyzed by V.V Chari, Larry E. Jones and Ramon Marimon (1997).

[7]Robin Boadway and Michael Keen (1996), and Bev Dahlby (1996) consider some of the implications of vertical externalities for the design of inter-governmental transfers.

[8]There is some abuse of language here: first, because W may not be concave in t; second, because, as will be seen, there are in general two horizontal externalities at work, one of them ambiguous in sign. But the terminology is convenient and evocative.

[9]Vertical effects would evidently also arise if the federal government taxed rents: see below.

[10]We avoid a simple limiting argument by briefly departing from the assumption that $K' < 0$.

[11]This also holds in the limit as $K' \to \infty$. So long as the right of (11) is bounded away from unity, the same conclusion also applies: the horizontal externality dominates, in this case because of the great sensitivity of horizontal capital flows to tax differentials.

[12]The argument here is incomplete in that—so as to focus upon it later—we have not specified the precise way in which the federal government sets T, and so have not fully described the equilibrium. All that is needed here, however, is that the first-best be attained when, in effect, all taxes are lump-sum. This will be true under any appealing view of benevolent policy-making, and is certainly true under either of the two characterizations in subsection B below.

[13]See for example Table 15.2 of the Historical Tables in *Budget of the United States Government, Fiscal Year 2001* (US Government Printing Office, Washington DC 2000).

[14]See also Julie H. Collins and Douglas A. Shackelford (1995).

[15]Views on the interest sensitivity of savings continue to vary widely: see for instance the review of estimates of the intertemporal elasticity of substitution in Douglas W. Elmendorf (1996).

[16]The relative marginal valuations of state and federal expenditures, for instance, will themselves reflect whether state taxes are too high or too low. When the federal government plays Nash, it is

straightforward to show that there is over-taxation in the sense of $W_t < 0$ if and only if $\Gamma_g < \Gamma_G$. Suppose then that there is under-taxation at state level to the extent that $\Gamma_G = (1.1)\Gamma_g$. For the first set of parameter values in the text, such under-taxation can only occur if the interest elasticity of savings is greater than only 0.09.

[17]One might conjecture that, conversely, the vertical externality will necessarily dominate if rents are fully taxed by the federal government. This is not so. A federal rent tax certainly points towards excessively high state taxes: when considering raising its tax rate, each state bears only $1/N$th of the cost of the reduction in federal rent receipts induced by the consequent shrinking of the national tax base. Nevertheless, one can show that even if the federal government taxes rents at 100 percent, then—as in Proposition 1—the horizontal externality will still dominate if the interest elasticity of savings is sufficiently low.

[18]Of course this is 'under-taxation' only in the sense that a federal tax increase would raise welfare if—contrary to the presumption underlying federal policy—the state tax were to remain unchanged.

[19]To see this, consider the very special case in which rents are untaxed and the marginal valuation of public expenditure is so high that policy-makers properly act as revenue-maximizers; and suppose further that $S' \to \infty$ (so that the net return to capital is fixed). Keen and Kotsogiannis (2000) show that then $t' > 0$ iff $E > 1$, where $E \equiv KK''/(K')^2$ denotes the elasticity of the slope of the marginal product of capital schedule. If $F(\cdot)$ is quadratic, for instance, $E = 0$ and the two taxes are strategic substitutes; if on the other hand F is Cobb-Douglas with exponent $\alpha \in (0,1)$, then $E - 1 = 1 - \alpha > 0$ and they are strategic complements.

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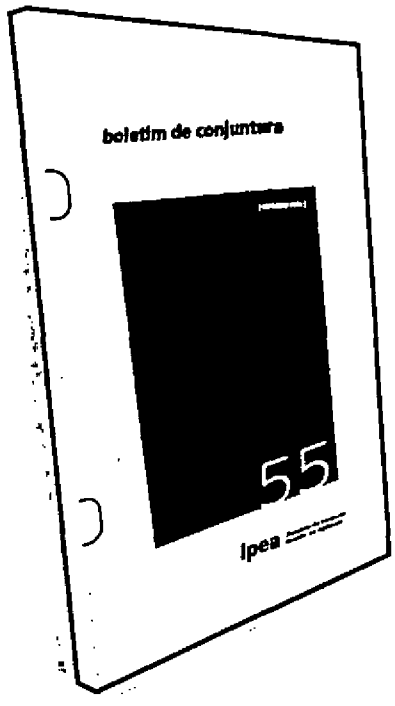

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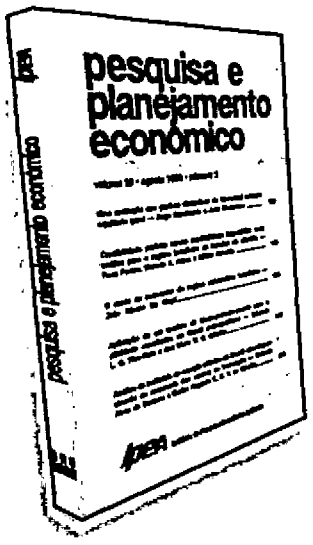

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