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Abstract

Recent work has shown that a system of equalization grants can limit tax competition among lower-level governments. The structure of such models, however, does not allow for the federal to be an active player but its role is being limited in the administration of the equalization grants. The implication of this is that potentially important, for the efficiency properties of lower-level government taxation, vertical fiscal externalities are ignored. This paper introduces equalization grants into a standard federal capital tax competition model in which fiscal externalities arise not only horizontally, between jurisdictions, but also vertically between the levels of government. It is shown that, even in the presence of vertical fiscal inefficiencies, efficiency in the level of lower-level government taxation can be achieved by a modifying version of a standard equalization grant formula.

Keywords: Federal tax competition; fiscal externalities; equalization grants

JEL: H41; H71; H77

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1 Introduction

Until quite recently the theory of tax competition in federal economies (meaning ones in which there is tax-setting autonomy at more than one level of policy-decision making) has focused on the welfare consequences of horizontal externalities arising from the mobility of tax bases between jurisdictions.[1] The central conclusion from this work has been that horizontal externalities tend to leave equilibrium lower-level government taxes too low: Each jurisdiction ignores the benefit it confers on other jurisdictions by raising its tax rate and so inducing outward movement of its tax base.

More recently, attention has turned to the key feature of the fiscal architecture of federal systems that tax bases are co-occupied by both federal and lower-level governments. This tax base co-occupation gives rise to vertical externalities between federal and lower-level governments,[2] which tend to leave equilibrium lower-level government taxes too high. This is because each lower-level government ignores the harm it does others by raising its tax rate, insofar as the induced contraction in the federal tax base leads to a reduction in federal spending that harms other lower-level governments too. With horizontal and vertical externalities pointing to opposite directions the level of equilibrium lower-level government taxation will depend on the balance of these externalities.[3]

Another important feature of federal fiscal arrangements is equalization grants.[4] The principle underlying equalization grants is that the federal government has the responsibility to ensure that each jurisdiction has adequate revenues to provide a minimum level of public service without recourse to exceptionally high levels of taxation.[5] The

[1]Contributions to the literature on horizontal externalities, among others, include Zodrow and Mieszkowski (1986), Wilson (1986), Wildasin (1989), Hoyt (1991), Dahlby (1996), and Keen and Marchand (1997).

[2]Contributions to this literature include Cassing and Hillman (1982), Flowers (1988), Johnson (1988), Boadway and Keen (1996), Wrede (1996), Wrede (2000), Boadway, Marchand and Vigneault (1998), Keen and Kotsogiannis (2002), and Dahlby and Wilson (2003). Keen (1998) surveys vertical tax externalities, while Wilson (1999) provides a thorough review of the tax competition literature.

[3]For an analysis of this see Keen and Kotsogiannis (2002) who show that this balance depends on the elasticities of the demand for capital and the supply of savings. More recently, this comparison has been taken to commodity taxation with cross border shopping (Rizzo (*forthcoming*), and Devereux, Lockwood and Redoano (2007)) and to imperfectly competitive commodity markets (Karakosta and Kotsogiannis (2006)).

[4]There is a wide range of policy reforms suitable of internalizing fiscal externalities. For an early discussion see Wildasin (1989). See also Dahlby (1994), and Büttner, Hauptmeier and Schwager (2006).

[5]Such grants is common practice in many, the structure of which typically differs between them, countries. A system of equalization grants is a particular system of revenue sharing and is already

typical equalization system sets the per capita transfer to each jurisdiction equal to the difference between its fiscal capacity and the average fiscal capacity of the federation, multiplied by a standard tax rate that is usually equal to the average of jurisdictions' tax rates. The fiscal capacity of a jurisdiction is measured by the observed per capita tax base of that jurisdiction. Hence, the equalization system aims to equalize difference in tax revenues, but implements transfers through an indirect formula that is based on differences in observed tax bases.

It is well understood that equalization grants distort fiscal policy incentives of the receiving jurisdictions and, thus, they have efficiency consequences for the level of lower-level government taxation. The reason for this is that equalization grants compensate jurisdictions for the adverse effect of an increased tax rate on their tax bases thereby inducing them to raise taxes higher than it is desirable from a national point of view.[6] To put it somewhat differently, a tax increase by a single lower-level government causes an outflow of tax base from that jurisdiction (and so a reduction in its tax revenues) and an increase in the tax base of all other jurisdictions. But the reduction in the tax base of that jurisdiction, relative to the average tax base of the federation, increases its entitlement under an equalization formula. This additional increment in equalization entitlement compensates the deviating jurisdictions for the adverse effect of the increased tax rate on their tax base and induces them to set taxes higher than would be chosen by a social planner.

An issue that has attracted attention recently is the extent to which an equalization grant system of the type described above can exactly offset the horizontal fiscal externalities, thereby making lower-level governments willing to implement the tax policies that would be chosen by a unitary government. A contribution by Bucovetsky and Smart (2006) has shown that it can. And this conclusion holds, with simple and intuitive adjustments to the grant system, under a wide range of assumptions about the fundamentals of the economy.

Though the contribution of Bucovetsky and Smart (2006) provides us with a number of

employed in a number of countries, including Canada, Denmark, Sweden and Switzerland. How these grants are computed need not concern us here. For the analysis that follows it suffices to describe the general principle underlying the definition of these grants. We turn to this in the next Section.

[6]The incentive affects are analyzed in, among others, Smart (1998), Köthenbürger (2002), and Bucovetsky and Smart (2006). Empirical evidence for the impact of equalization on the tax setting behavior of lower level jurisdictions is provided by Karkalakos and Kotsogiannis (*forthcoming*), and Smart (*forthcoming*) for Canada, Büttner (2006), and Büttner, Hauptmeier and Schwager (2006) for Germany.

insights regarding the incentive effects of equalization grants, it pays no attention to the fact that lower-level tax setting behavior creates also vertical fiscal externalities. This is because the federal government does not have an active role but is introduced when needed, as a *deus ex machina*, to derive the unitary level of lower-level government taxes. In reality, however, federal governments do play an active role, both in financing and administering equalization grant systems. Equalization grants typically do not involve wealthy jurisdictions making payments to poor jurisdictions; rather, they are *transfers* from the *federal* to the *lower-level* governments that make up the difference between actual lower-level taxes or revenues and some measure of the highest, average, or representative levels of the same taxes or revenues.[7] Since these federal transfers are payments (to the lower-level government) raised by distortionary taxes, they naturally come out of the federal budget.[8]

A related, but distinctively different, contribution to the present is the one by Büttner, Hauptmeier and Schwager (2006) who explore the conditions under which local grant mechanisms enforced by the state governments will enhance efficiency of local taxation. Like us, they do recognize the possibility that the fiscal equalization system impacts on federal and lower-level governments through sharing of revenues, but unlike us they do not model vertical fiscal externalities.

It is the recognition of this federal budget for the level of lower-level government taxation that is central to this paper. More specifically, this paper by explicitly recognizing that (a) lower-level government taxation causes vertical fiscal externalities, and (b) it is the federal government's responsibility to provide these equalization grants, with these payments being paid from the use of distorting[9] capital taxes asks: Can a equalization grant system decentralize the unitary lower-level government taxes? and, if not, how does this equalization grant formula need to be modified to account for the fiscal inefficiencies

[7]These transfers are, thus, distinctively different to those that make appearance in the literature that discusses the issue of fiscal gap in federal economies. See, for instance, Boadway and Keen (1996), and Kotsogiannis and Martínez (2007).

[8]One, of course, may argue (as the existing literature implicitly does) that the required federal revenues for the implementation of an equalization grant system can be raised from the lower-level governments using lump sum taxation. This, however, raises the issue of why such lump sum taxation is not available at the lower-level government level. If one accepts the usual arguments behind the infeasibility (for both levels of government) of lump sum taxes then both levels of government must raise revenues by distortionary means. It is the implication of the use of such taxes for the level of lower-level government taxation that is the focus of this paper.

[9]The use of lump sum taxation for raising revenues for the implementation of the equalization grant system is ruled out for the reason explained in footnote 8.

that are present in the level of lower-level government taxation?

With respect to the first question, it is shown that the standard equalization grant system does eliminate the two types of fiscal externalities identified above, except in the case in which savings are responsive to taxation. If savings do respond to taxes, it is shown that the standard equalization grant can be straightforwardly modified to account for both the horizontal inefficiencies (as in Bucovetsky and Smart (2006)) and the vertical ones; all it requires is that the equalization formula is modified by a factor that accounts both for the sensitivity of demand for, and supply of, capital but also for the size of the vertical externality.

The paper is organized as follows. Section 2 describes a simple model of federal tax arrangements, a central feature of which is that equalization grants are paid to jurisdictions out of federal resources. Section 3 presents the results, while Section 4 concludes.

2 Description of the model

The structure of the model is similar to that of Keen and Kotsogiannis (2002); the departure from that framework being in the explicit recognition of equalization grants paid out of the federal budget.

The model features a federal economy that consists of $m > 1$ jurisdictions indexed by $i = 1 \dots m$. In each jurisdiction i a competitive firm produces output using a strictly concave technology $f_i(k_i)$, with[10]

$$f_i'(k_i) > 0 > f_i''(k_i) \,, \tag{1}$$

where k_i denotes capital employed in jurisdiction i.[11] The government of jurisdiction i levies a source-based unit tax t_i while the federal government levies a source-based unit tax T, common to all jurisdictions. Consolidated capital tax in jurisdiction i is, then, $\tau_i \equiv t_i + T$. Capital is costlessly and freely mobile across jurisdictions and so relocates until it earns the same post-tax return ρ in each jurisdiction given by

$$f_i'(k_i) - t_i - T = \rho \,, \tag{2}$$

[10] Derivatives of functions of one variable are indicated by primes.

[11] A second input, land, is fixed in supply and so it can be (and has been) suppressed.

which implicitly defines $k_i(\rho + \tau_i)$ with

$$k_i'(\rho + \tau_i) = 1/f_i''(k_i) < 0 \ . \tag{3}$$

Capital is paid its marginal product and so profits are given by[12]

$$\pi_i(k_i) = f(k_i) - f_i'(k_i)k_i \ , \tag{4}$$

with, in particular, following from (3),

$$\pi_i'(\rho + \tau_i) = -k_i(\rho + \tau_i) \ . \tag{5}$$

A citizen resides[13] in each jurisdiction i and has quasilinear preferences defined over first- and second-period private consumption, c_1 and c_2, the level g_i of a local public good provided by the local government in which they reside and the level G of the federal public good. The resident in jurisdiction i has endowment e of first period income and in the second period consumes the principal and interest on the first-period savings plus the profits earned in their jurisdiction. Utility is then given by $u(c_1) + c_{i2} + \Gamma_i(g_i, G)$, where both $u(\cdot)$ and $\Gamma_i(\cdot)$ are strictly increasing and concave. Utility maximization gives savings $s(\rho)$, with $s' > 0$, and indirect utility

$$U(\rho, \tau_i) \equiv u(e - s(\rho)) + (1 + \rho)s(\rho) + \pi_i(\rho + \tau_i) \ . \tag{6}$$

It is also the case—following as an envelope property and (5), respectively—that

$$\frac{\partial U}{\partial \rho} = s - k_i \quad ; \quad \frac{\partial U}{\partial \tau_i} = -k_i < 0 \ . \tag{7}$$

Denoting aggregate savings in the federation by $S(\rho) = ms(\rho)$, equilibrium in the capital market implies that

$$S(\rho) = \Sigma_i k_i(\rho + \tau_i) \ . \tag{8}$$

Equation (8) implicitly defines $\rho(\vec{\tau})$, where $\vec{\tau} = (\tau_1, \ldots, \tau_m)$, with in particular

$$\frac{\partial \rho}{\partial t_i} = \frac{k_i'(\rho + \tau_i)}{S'(\rho) - \Sigma_j k_j'(\rho + \tau_j)} \in (-1, 0) \ , \tag{9}$$

[12]Profits accrue, fully, to the households and are not taxable by the governments. An earlier version of this paper has considered the possibility of resource taxation. Adding this to the present framework is possible but it would add extra complications without adding further insights to the issue at the heart of this analysis.

[13]The emphasis of this paper is not on the efficiency properties of lower-level government taxation in the presence of equalization grants when there is heterogeneity of consumers within and across jurisdictions. It is, therefore, assumed that only one consumer resides in each jurisdiction.

and

$$\frac{\partial \rho}{\partial \tau} = \frac{\Sigma_i k_i'(\rho + \tau_i)}{S'(\rho) - \Sigma_j k_j'(\rho + \tau_j)} \in (-1, 0) \ , \tag{10}$$

and thus the return to savings is decreasing in the level of taxation, lower-level government, federal and, hence, consolidated. Notice also, following from (3) and (8), (abusing notation somewhat), that

$$\frac{\partial k_i}{\partial t_i} = k_i'(\rho + \tau_i) \left(1 + \frac{\partial \rho}{\partial t_i}\right) < 0, \ \text{ for all } \ i \ , \tag{11}$$

and

$$\frac{\partial k_j}{\partial t_i} = k_j'(\rho + \tau_j) \frac{\partial \rho}{\partial t_i} > 0, \ \text{ for all } \ j \neq i \ , \tag{12}$$

and thus an increase in the tax of jurisdiction i reduces capital, following (11), in that jurisdiction but increases capital, following (12), in jurisdiction j.

In this paper we are interested in the efficiency properties of a particular equalization grant mechanism, hence the analysis will confine attention to an economy in which consumers have identical preferences for the public good, in the sense that $\Gamma_i(g_i, G) = \Gamma(g, G)$ for all $i = 1 \ldots m$, firms have access to symmetric technologies $f_i = f$ for all $i = 1 \ldots m$, and so to a symmetric equilibrium $\tau_i = \tau$ and $g_i = g$, for all $i = 1 \ldots m$. Of course, in such an equilibrium no equalization payments are paid but their presence does influence the tax setting behavior of the local governments, since a deviation by any lower-level government from the optimal tax rate would be inducing a change in equalization transfers. We turn to this shortly below.

It suffices, however, for the moment to notice, and for later use, that in such equilibrium (9) and (10) become, respectively

$$\frac{\partial \rho}{\partial t_i} = \frac{k'}{m\,(s' - k')} \in (-1, 0) \ , \tag{13}$$

$$p'(\tau) = \frac{k'}{s' - k'} \in (-1, 0) \ , \tag{14}$$

and so, upon making use (14), (13) becomes

$$\frac{\partial \rho}{\partial t_i} = \frac{1}{m} p' \ . \tag{15}$$

We turn now to a detailed description of a standard equalization mechanism and then continue with the maximization problem faced by the lower-level governments.

2.1 Equalization grants and the federal government

As noted in the introductory Section, an equalization system is a particular from of transfers. It sets the per capita transfer to each jurisdiction equal to the difference between its capacity and the average fiscal capacity of the federation, multiplied by a standard tax rate usually equal to the average of jurisdictions' tax rates. Equalization grant to jurisdiction $i = 1 \dots m$,[14] denoted by ω_i, is thus given by[15]

$$\omega_i = \bar{t}\left(\bar{k} - k_i\right) \ , \tag{16}$$

where

$$\bar{t} \equiv \frac{\sum_i t_i k_i}{\sum_i k_i} \ ,$$

is the average lower-level government tax rate, and

$$\bar{k} \equiv \frac{\sum_i k_i}{m} \ ,$$

is the federal ('national') average tax base. Notice, something we turn to shortly, that the cost to the federal government of the equalization grant system in (16) is given by $\Sigma_j \omega_j$.

As already noted, the departure of this paper from the existing contributions dealing with the efficiency properties of equalization grants is in the incorporation of the possibility that uncoordinated lower-level government tax behavior causes vertical tax inefficiencies. The institutional set up considered here is one that considers the equalization grant formula to be predetermined and any required equalization revenues paid out of the federal budget:[16] We do not, thus, consider why an equalization grant system has the particular structure it has, but simply explore its consequences for the efficient level of lower-level government taxation.

The federal government, given the predetermined equalization formula, taxes capital in the federation, meets the required expenditure on the equalization grants, and distributes

[14]These grants are also called 'full' equalization grants. This is because if all receiving jurisdictions do set the national average tax rates, then their revenues after equalization will indeed be equal.

[15]Notice that in (16), the equalization payments cannot be negative. If $\omega_i < 0$, because the fiscal capacity in jurisdiction i exceeds that of the average fiscal capacity of the federation, in the sense that $\bar{k} - k_i < 0$, then in this case $\omega_i = 0$.

[16]Arguably, this is a realistic assumption. In most federations the equalization system is embedded in the federal constitution, changes fairly infrequently and is rarely determined by the federal government alone but it is the product of intensive negotiations between the levels of government.

the residual federal revenues to the lower-level governments uniformly.[17] This amounts to per-jurisdiction spending

$$G = \frac{1}{m}\left(T\Sigma_j k_j(\rho + \tau_j) - \Sigma_j \omega_j(\vec{\tau})\right) \ , \tag{17}$$

where in (17) we have explicitly denoted the dependence of ω_j on the vector of taxes $\vec{\tau}$.

With respect to the type of the federal public good considered here two issues arise. Firstly, it is conceivable that the expenditure on the equalization grants is larger than the federal capital tax revenues that can be collected and as a consequence, for a positive level of federal public good provision, some form of borrowing on the part of the federal government will be required. Though this is, in general, a possibility in the equilibrium analyzed such an issue will not arise since no actual equalization grants are paid to the jurisdictions. Secondly, one may wonder why the federal government provides a quasi-public good whose benefit is shared equally between the jurisdictions instead of a pure public good that is, one whose benefit does not diminish with the number of jurisdictions (as, for example, with expenditure on national defence). The reason for this is analytical convenience. As will be shown later on, the main result of this paper generalizes, straightforwardly, to the latter type of public good.

Notice also, for later use, following from (16), that

$$\frac{\partial \omega_i}{\partial t_i} = \frac{\partial \bar{t}}{\partial t_i}\left(\bar{k} - k_i\right) + \bar{t}\left(\frac{\partial \bar{k}}{\partial t_i} - \frac{\partial k_i}{\partial t_i}\right) \ . \tag{18}$$

(18) simply states that an increase in t_i affects equalization entitlements via two channels; the first one is through the change in the average lower-level government tax rate (for given fiscal capacities), while the second through the change in the fiscal capacities (for given average lower-level government tax rate).

Before proceeding to the determination of the equilibrium lower-level government tax rates, notice that in a symmetric equilibrium (18) becomes

$$\frac{\partial \omega_i}{\partial t_i} = -\left(\frac{m-1}{m}\right)\bar{t}k' > 0 \ , \tag{19}$$

and so jurisdiction i perceives that an increase in its tax rate increases the equalization payment received by that jurisdiction (the inequality follows from equation (3)). This is

[17] Arguably, there are many federal public goods that fit this description, as, as for example, expenditure on highways or education.

simply because jurisdiction i perceives its tax base to be more elastic than the average tax base of the federation. To see this, first notice that, since the average tax base in the federation $\bar{k}$ is equal to the tax base in a typical jurisdiction k_i, the first term in (18) is zero. What is left, therefore, is the difference between two effects arising from the change in t_i; one relating to the change of the federation average tax base, $\partial\bar{k}/\partial t_i$, and given, in symmetric equilibrium, by $k'(1+p')/m < 0$, and the other relating to the change in the own tax base $\partial k_i/\partial t_i$ given, also in symmetric equilibrium, by $k'(1+(1/m)p') < 0$. Since the change in federal average tax base is (in absolute terms) smaller than the (absolute value of the) lower-level government one, jurisdiction i perceives that by changing t_i it will receive equalization payment equal to that given by equation (19). To put this somewhat differently: The change in the average federation fiscal capacity due to the change in the net price of capital is exactly offset by the average lower-level government fiscal capacity in the sense that $k'p'/m = k'(1/m)p'$. What is left is the change in the federation fiscal capacity due to t_i and the lower-level government fiscal capacity due to t_i, that is $k'/m - k'$. Multiplying the latter by $-\bar{t}$ one arrives at the marginal equalization grant in (19).

We turn now to the maximization problem of the typical jurisdiction i.

2.2 Maximization problem of a typical lower-level government

Public good in jurisdiction i is financed with revenues from two sources; taxation on capital and equalization grants received by the federal government. Public good in jurisdiction i is, therefore, given by

$$g_i = t_i k_i(\rho + \tau_i) + \omega_i(\vec{\tau}) \; . \tag{20}$$

Consider now the problem that the typical lower-level government i faces. It maximizes welfare, given by

$$W_i(\rho, \tau_i, g_i, G) = U(\rho + \tau_i) + \Gamma_i(g_i, G) \; , \tag{21}$$

subject to (17) and (20),[18] holding Nash conjectures against all other lower-level government taxes as well as the federal tax. This maximization problem, evaluated at a symmetric equilibrium gives—after using (7), (8), (13) and (14), and the fact that in such an equilibrium $\bar{t} = t$—the necessary condition

$$\frac{\partial W_i\left(t_i, T, \vec{\tau}\right)}{\partial t_i} = -k + \Gamma_g\left[k + tk'\left(1 + \frac{1}{m}p'\right) + \frac{\partial \omega_i}{\partial t_i}\right] + \Gamma_G \frac{1}{m} T k'\left(1 + p'\right) = 0 \; . \tag{22}$$

[18]The lower-level governments, thus, recognize the change in federal spending, in (17), due to their tax setting behavior but the cost of their action is not accounted fully. See below.

The first term in (22), $-k$, reflect the utility loss associated with a loss in second period consumption due to the change in the price of capital.[19] The terms involving Γ_g reflects the utility impact of t_i, through the change in the lower-level government tax revenues (an impact that depends, of course, on the existence of the marginal equalization grant, given by $\partial\omega_i/\partial t_i$). Finally, the term involving Γ_G reflects the utility impact of t_i through the federal budget constraint. Notice that this latter term does not contain terms involving equalization payments. This is because the change in the federation per capita tax base due to the local tax t_i is exactly offset by the change in all lower-level government tax bases due to t_i.[20] So a change in t_i has no revenue impact (and so no vertical externalities) on utility through equalization grants.

3 (In)efficiency of lower-level government taxes

To investigate the (in)efficient level of taxation at the lower-level of government write aggregate welfare in a symmetric equilibrium as

$$W(t,T,\tau) \equiv v\left[p(\tau), \tau, tk(\tau + p(\tau)), Tk(\tau + p(\tau))\right] , \tag{23}$$

and differentiate with respect to the common t (and for given federal tax T) to find, after making use of (7) and the market equilibrium in (8),

$$\frac{\partial W(t,T,\tau)}{\partial t} = -k + \Gamma_g\left[k + tk'(1+p')\right] + \Gamma_G Tk'(1+p') . \tag{24}$$

For the identification of the externalities, it is the sign of (24) that is of interest.[21] One perspective on the sign of (24) is given by comparing this with the necessary condition of the typical government (excluding equalization grants) in (23) to find

$$\frac{\partial W(t,T)}{\partial t} = \left(\frac{m-1}{m}\right)\left[\Gamma_g tk'p' + \Gamma_G Tk'(1+p')\right] . \tag{25}$$

The term $[(m-1)/m]\Gamma_g tk'p' > 0$ in (25) gives the horizontal externalities that relate to the impact that jurisdiction i's tax decision has on all other $m-1$ jurisdictions: Each jurisdiction ignores the benefit it confers on other jurisdictions by raising its tax rate and so inducing outward movement of its tax base. This externality tends to leave local tax

[19] In such an equilibrium, following (7), $s = k$ and so the terms of trade externality (familial from DePater and Myers (1994)) does not make appearance.

[20] This claim is shown in the Appendix.

[21] Notice that (24) involves no equalization payments. This is because (24) involves perturbation in the common t and thus all effects through equalization payments are accounted for.

rates too low, from an equilibrium point of view. The term $[(m-1)/m]\Gamma_G T k'(1+p') < 0$ in (25) gives the vertical externality between federal and lower-level governments: Each lower-level government ignores the harm it does on all other $m-1$ jurisdictions from the induced contraction of the common tax base caused by raising its tax rate. This externality points towards lower-level government taxes that are too high, from an equilibrium point of view. It is, thus, the case that horizontal and vertical externalities point towards opposite directions and thus the level of equilibrium lower-level government taxation will depend on the balance of these externalities.[22]

It is the externalities identified in the preceding paragraph that an efficient equalization grant formula should internalize. Notice that as $p' \to -1$ (something that holds if, following from (14), savings become inelastic in the sense that $s' \to 0$) then, following from (25), the vertical externality $\Gamma_G T k'(1+p') \to 0$ and so the federal tax base tends to be unresponsive to lower-level government taxation.[23] The reason for this is intuitive: With inelastic savings there is no contraction of the federal tax base, given by $Tk(p+\tau) = Ts(p)$, and hence no vertical externalities. In this case the marginal equalization grant that implements the unitary optimum will not feature any vertical externalities. We turn to this shortly.

One could also see equation (24)—with appropriately setting it equal to zero—as the first order condition with respect to the appropriate choice of $t_1, \ldots, t_m$ where $t_1 = t_2 \ldots = t_m$, of the social planner's maximization problem (a social planner overseeing both levels of government), conditional on the federal tax T. Seen that way, equation (24) implicitly defines the unitary optimum for the lower-level governments, conditional on the federal tax T. To make some progress on identifying whether the equalization grant formula in (16) decentralizes the unitary outcome it is this perspective we now take.

Substituting equation (22), with equalization grants, into equation (24) (holding as equality) one obtains the marginal equalization grant that internalizes both types of externalities. This is given by

$$\frac{\partial \hat{\omega}_i}{\partial t_i} = \left(\frac{m-1}{m}\right) \frac{1}{\Gamma_g} \left[\Gamma_g t k' p' + \Gamma_G T k'(1+p')\right] . \tag{26}$$

Inspection of (26) reveals (allowing for the limiting case $p' = -1$) that if savings are inelastic, then it readily reduces to the marginal equalization grant in (19). Consequently

[22] For an analysis of this balance see Keen and Kotsogiannis (2002).

[23] This would be the case in the canonical model of tax competition of Zodrow and Mieszkowski (1986).

the equalization grant system in (16) can decentralize the unitary lower-level government taxes. To emphasize this:

Proposition 1 *In the presence of a federal government and with symmetric jurisdictions and savings being inelastic, the unitary optimum can be decentralized with a system of equalization grants that takes the form of that given in (16) that is,* $\omega_i = \bar{t}\left(\bar{k} - k_i\right)$.

The result that the equalization grant system $\omega_i = \bar{t}\left(\bar{k} - k_i\right)$ can decentralize the unitary lower-level government taxes when savings are inelastic has not gone unnoticed,[24] what has gone unnoticed, however, is that it does so even in the presence of federal public spending. The intuition behind this is straightforward. As already noted, with savings being inelastic there is no contraction of the federal tax base and, hence, no vertical externalities caused by lower-level government taxation. A deviation by any lower-level government from the optimal tax rate then would induce a change in transfers that exactly offsets the horizontal fiscal externality of such deviation given by $[(m-1)/m]tk'$. This implies that each lower-level government behaves as though its tax base were independent of the tax rate.[25]

Seen differently, Proposition 1 also suggests that if savings are elastic, and so $p' \neq -1$, then the equalization grant in (16) will not replicate the unitary optimum, independently of whether there is a federal government, and so vertical externalities, or not. The reason for this is that the equalization grant system in (16) does not fully account for the horizontal externalities and ignores completely the vertical ones.

With respect to the horizontal externalities, one can show that if savings are responsive to its price the equalization grant system in (16) overcompensates lower-level governments for the induced loss in the tax base due to an increase in the lower-level government tax rates. To see this, suppose for the moment that there is no federal government and so $T = 0$. Combining now equations (22) and (24), upon making use of the marginal equalization in (19), one arrives at

$$\frac{\partial W(t,T)}{\partial t} = [(m-1)/m]\Gamma_g tk'(1+p') < 0\ . \tag{27}$$

It is so the case that the unitary optimum level of taxes is lower that the non-cooperative one, if savings are elastic, since a coordinated reduction in all lower-level government non-

[24] See, for instance, Köthenbürger (2002), and Bucovetsky and Smart (2006).

[25] Under any equalization grant system considered here public good provision provided by each lower-level government in given by $g = tk$ and, thus, there is full equalization of revenues.

cooperative taxes increases welfare. To achieve second-best efficiency, in this case, it is easy to verify, from (26), that the marginal equalization grant must satisfy

$$\frac{\partial \hat{\omega}_i}{\partial t_i} = -p' \frac{\partial \omega_i}{\partial t_i} , \tag{28}$$

$$= \frac{e_d}{e_d + e_s} \frac{\partial \omega_i}{\partial t_i} , \tag{29}$$

where the second equality follows from equation (14), with

$$e_d \equiv -k'/k > 0 ,$$

$$e_s \equiv s'/s > 0 ,$$

denoting the semi-elasticities of demand and supply of capital, respectively. This confirms the result, for the symmetric case, of Bucovetsky and Smart (2006).

Since the vertical externalities that make appearance in the marginal equalization grant in (26) also depend on the elasticity of savings, one might expect that they, too, can be corrected with a similar adjustment in the equalization grant system in (16). This is indeed the case, but here the adjustment is somewhat different and contains a measure of the size of the vertical fiscal externality that needs to be corrected, given in utility terms by $[(m-1)/m]\Gamma_G T k'(1+p')$, relative to the size (valued at the margin by Γ_g) of the lower-level government public sector. This is required so the size of the vertical fiscal externality, valued at the margin by Γ_G, is incorporate into the lower-level government budget constraint, the public good of which is valued by Γ_g. All in all, following from (26), the vertical externality is corrected by a marginal equalization grant given by

$$\frac{\partial \tilde{\omega}_i}{\partial t_i} = -\left(\frac{m-1}{m}\right) \frac{\Gamma_G G}{\Gamma_g} \frac{e_d e_s}{e_d + e_s} , \tag{30}$$

$$= \frac{\partial \omega_i}{\partial t_i} \left[-\frac{\Gamma_G G}{\Gamma_g g} \frac{e_s}{e_d + e_s} \right] , \tag{31}$$

where in equation (30) equations (14) and (17) have been used, whereas in (31) use of equations (19) and (20) has been made. With (29) and (31) correcting for horizontal and vertical inefficiencies at the lower-level of government taxation, respectively, it is clear that the marginal equalization grant

$$\frac{\check{\omega}_i}{\partial t_i} = \frac{\hat{\omega}_i}{\partial t_i} + \frac{\tilde{\omega}_i}{\partial t_i} , \tag{32}$$

$$= z \frac{\partial \omega_i}{\partial t_i} , \tag{33}$$

where

$$z = \left[\frac{e_d}{e_d + e_s} - \frac{\Gamma_G G}{\Gamma_g g} \frac{e_s}{e_d + e_s} \right] . \tag{34}$$

decentralizes the unitary level of taxes at the lower-level of government. Consequently, if lower-level governments face the equalization grant mechanism $\breve{\omega}_i = z\omega_i$, where ω_i is given by (16), then they would choose the unitary level of lower-level government taxes. The intuition behind this is straightforward. A deviation by any lower-level government from the optimal tax rate would induce a change in transfers that exactly offsets the horizontal fiscal externality of such deviation, given by $[(m-1)/m]\Gamma_g tk'p'$, and the vertical one, given by $[(m-1)/m]\Gamma_G Ts'p'$. This implies that each lower-level government behaves as though its tax base, and that of the federation, were independent of the tax rate. Summarizing:

Proposition 2 *In the presence of vertical fiscal externalities, and with jurisdictions being symmetric, the unitary optimum can be decentralized with a system of equalization grants in the form of* $\breve{\omega}_i \equiv z\,\omega_i$ *where* ω_i *is given by (16) and* z *is given by (34).*

Proposition 2 offers a key result. It shows that in the presence of vertical fiscal externalities the popular equalization grant mechanism in (16) (that is, $\omega_i = \bar{t}\left(\bar{k} - k_i\right)$), once adjusted by a factor that accounts for the elasticity of savings and the size of the vertical fiscal externality, decentralizes the unitary level of lower-level government taxation.

Of course, the system of equalization grants of Proposition 2 requires a precise knowledge of the marginal utilities of the public goods, in additional to information on the fiscal capacities (and the elasticities of the supply of and demand) for capital required by the equalization grant system that internalizes only the horizontal externalities (as of that in Proposition 1). One may argue that such information requirement restricts the implementation of such equalization mechanism, since such variables are private information of the lower-level governments. While this might be true (and this is also true for the equalization scheme in (16), that is based on fiscal capacities)[26] what Proposition 2 also emphasizes is the direction of the adjustment of the equalization system in (16): The equalization system should be adjusted *positively* so it corrects the horizontal fiscal externalities and *negatively* so it corrects the vertical fiscal externalities.

[26]Even the determination of fiscal capacity is a difficult task. Recent work has started addressing the consequences for electoral choices of the complexity of the equalization grant systems, Kotsogiannis and Schwager (2006).

Suppose now—to return to one of the issues regarding the federal public good raised in section 2—that the federal public good is of the form

$$G = T\Sigma_j k_j(\rho + \tau_j) - \Sigma_j \omega_j(\vec{\tau}) \ . \tag{35}$$

Then, in this case, the first order condition of the typical government, evaluated at a symmetric equilibrium—and after using (7), (8), (13) and (14)—becomes

$$\frac{\partial W_i\left(t_i, T, \vec{\tau}\right)}{\partial t_i} = -k + \Gamma_g \left[k + tk'\left(1 + \frac{1}{m}p'\right) + \frac{\partial \omega_i}{\partial t_i}\right] + \Gamma_G T k'\left(1 + p'\right) = 0 \ . \tag{36}$$

To investigate in this case the (in)efficient level of taxation at the lower-level of government write aggregate welfare in a symmetric equilibrium as

$$W\left(t, T, \tau\right) \equiv v\left[p\left(\tau\right), \tau, tk\left(\tau + p\left(\tau\right)\right), mTk\left(\tau + p\left(\tau\right)\right)\right] \ , \tag{37}$$

and differentiate with respect to the common t (and for given federal tax T) to find,

$$\frac{\partial W\left(t, T, \tau\right)}{\partial t} = -k + \Gamma_g\left[k + tk'\left(1 + p'\right)\right] + \Gamma_G m T k'\left(1 + p'\right) \ . \tag{38}$$

Substituting (36) into (38) gives

$$\frac{\partial W}{\partial t} = \left(\frac{m-1}{m}\right)\Gamma_g t k' p' + (m-1)\Gamma_G T k'(1+p') - \Gamma_g \frac{\partial \omega_i}{\partial t_i} \ . \tag{39}$$

(39) reveals that the marginal transfer that decentralizes the unitary outcome (the transfer that is, that sets $\partial W/\partial t = 0$ in (39)) is given by

$$\frac{\partial \omega_i}{\partial t_i} = \frac{1}{\Gamma_g}\left[\left(\frac{m-1}{m}\right)\Gamma_g t k' p' + (m-1)\Gamma_G T k'(1+p')\right] \ . \tag{40}$$

The marginal equalization grant here, too, should internalize horizontal and vertical externalities. The horizontal externality is the one identified previously, and still present here in undiminished force. It is the vertical externality—arising again from the impact that the lower-level government's tax has of the federal tax base, an impact that is given by $(m-1)Tk'(1+p')$—that takes a new form. One, however, can straightforwardly verify that the marginal equalization grant in (40) reduces to the same marginal transfer of that given in Proposition 2. To emphasize:

Corollary 1 *If the federal government provides a pure public good, and jurisdictions are symmetric, then the unitary optimum can be decentralized with the system of equalization grants of that given in Proposition 2.*

It is, thus, the case that even if the federal government provides a pure public good the popular equalization grant mechanism in (16) (that is, $\omega_i = \bar{t}\left(\bar{k} - k_i\right)$), once adjusted by a factor that accounts for the elasticity of savings and the size of the vertical fiscal externality, decentralizes the unitary level of lower-level government taxation.

4 Concluding remarks

The purpose of this paper has not been to develop a complete theory of equalization grants that corrects fiscal externalities in federal economies. Its purpose has been to point out that in genuine federal systems—where horizontal fiscal externalities (that arise because of uncoordinated behavior of lower-level governments) work alongside vertical ones (that arise because lower-level government ignore the cost of their action on the federal budget constraint)—a standard equalization grant system, that is based on equalizing tax revenues by observing fiscal capacity, works well in delivering the decentralized level of lower-level government taxes, once it is appropriately adjusted.

The analysis is in many respects incomplete. The roles of technology and population heterogeneity (eloquently analyzed by Bucovetsky and Smart (2006) for the case of horizontal externalities only) have not been investigated. Intuition, however, suggests that the present results (with the additional use of lump-sum transfers) will go through once the trade-off between equity and efficiency is accounted for.

Appendix

Proof of claim that the effect of t_i has no effect on federal expenditure on equalization grants that is, $\Sigma_j \partial\omega_j/\partial t_i = 0$.

Take

$$\sum_j \omega_j = \sum_j \bar{t}\left(\bar{k} - k_j\right) \ , \tag{A.1}$$

which upon differentiation, with respect to t_i, becomes

$$\sum_j \frac{\partial \omega_j}{\partial t_i} = \left\{ \frac{\partial \bar{t}}{\partial t_i}\left(\bar{k} - k_i\right) + \bar{t}\left(\frac{\partial \bar{k}}{\partial t_i} - \frac{\partial k_i}{\partial t_i}\right)\right\} + \sum_{j \neq i}\left\{ \frac{\partial \bar{t}}{\partial t_i}\left(\bar{k} - k_j\right) + \bar{t}\left(\frac{\partial \bar{k}}{\partial t_i} - \frac{\partial k_j}{\partial t_i}\right)\right\}. \tag{A.2}$$

Take now the average fiscal capacity of the federation defined in text to be

$$\bar{k} = \frac{\sum k_i}{m} \ . \tag{A.3}$$

Differentiating (A.3) with respect to t_i one obtains

$$\frac{\partial \bar{k}}{\partial t_i} = \frac{k_i'\left(1 + \frac{\partial \rho}{\partial t_i}\right) + \sum_{j \neq i} k_j' \frac{\partial \rho}{\partial t_i}}{m} \ , \tag{A.4}$$

which upon evaluation at the symmetric equilibrium, using (13) and (14), becomes

$$\frac{\partial \bar{k}}{\partial t_i} = \frac{k'\left(1 + p'\right)}{m}. \tag{A.5}$$

In a symmetric equilibrium $\bar{k} = k_i$ for all $i = 1, \ldots m$, and thus $\partial \bar{t}/\partial t_i \left(\bar{k} - k_i\right) = 0$. It is thus the case that (A.2) becomes

$$\begin{aligned}
\sum_j \frac{\partial \omega_j}{\partial t_i} &= \bar{t} \sum_j \left(\frac{\partial \bar{k}}{\partial t_i} - \frac{\partial k_j}{\partial t_i}\right) \ , && \text{(A.6)} \\
&= \bar{t}\left\{ k_i'\left(1 + \frac{\partial \rho}{\partial t_i}\right) + \sum_{j \neq i} k_j' \frac{\partial \rho}{\partial t_i} - k_i'\left(1 + \frac{\partial \rho}{\partial t_i}\right) - \sum_{j \neq i} k_j' \frac{\partial \rho}{\partial t_i}\right\} \ , && \text{(A.7)} \\
&= \bar{t} \cdot 0 \ . && \text{(A.8)}
\end{aligned}$$

where the second equality follows from (A.4) and (12), whereas the third equality follows upon evaluating (A.7) at the symmetric equilibrium. □

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