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Tax competition and tax base equalization in the presence of multiple tax instruments

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Abstract
The literature on tax competition has argued that tax base equalization, which reduces regional disparities in tax bases, can serve as a means of internalizing horizontal and vertical fiscal externalities. This argument assumes that each government relies on a single tax base (a regional tax on mobile capital and a federal tax on savings). This paper considers the case in which a distortionary labor tax is also available. Internalizing fiscal externalities requires that while the regional capital tax base is fully equalized, a region's equalization entitlement for the labor tax is positive when its tax base is "larger" than the average tax base of all regions. This efficient tax base equalization system is incompatible with the primary objective of fiscal equalization.

Keywords Tax competition · Fiscal externalities · Fiscal equalization

JEL Classifications H71 · H77 · R50

1 Introduction

In federal countries such as Australia, Canada, Germany, and Switzerland, fiscal equalization is an important intergovernmental policy that intends to reduce regional fiscal disparities. Tax base equalization, known as the representative tax system (RTS), is a system of fiscal equalization designed to measure regional fiscal capacities using regional tax bases. Under this system of fiscal equalization, a region's entitlement is equal to the difference between its tax base and the average tax base of all regions, multiplied by the average tax rate of all regions. Smart (1998, p. 215) argues that tax base equalization induces regional governments to raise their tax rates because the equalization system compensates for the resulting

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loss of tax bases.[1] This policy incentive is beneficial when regional governments engage in inefficient tax competition for mobile business capital (see Wilson, 1986; Zodrow and Mieszkowski, 1986).[2] Tax base equalization can be used to counteract the downward pressure on source-based capital taxes caused by tax competition.

Köthenbürger (2002) formalizes this basic argument and claims that tax base equalization should be fully implemented when regional governments compete for a fixed amount of mobile capital.[3] The distortion of tax competition arises because each region ignores the external impact of its tax policy on other regions; a region's tax increase causes capital outflows and raises other regions' tax revenues. Full tax base equalization internalizes this horizontal fiscal externality by compensating for the loss of the mobile tax base.

Bucovetsky and Smart (2006) analyze tax competition and tax base equalization in the presence of endogenous savings. In addition to the positive externality caused by capital mobility, regional tax policy in this case creates a negative fiscal externality by reducing the total capital stock. Therefore, in comparison with Köthenbürger (2002), each region's equalization entitlement must be reduced to weaken the tax-increasing impact of the equalization system. Bucovetsky and Smart (2006) derives an efficient rate of equalization that depends on the semi-elasticities of capital demand and supply. Kotsogiannis (2010) argues that the efficient rate of equalization further declines when vertical tax competition is also considered. If a federal capital (savings) tax is imposed to finance public expenditure that benefits each region, regional tax policy creates a negative vertical fiscal externality by reducing the federal tax revenue.

In Köthenbürger (2002), Bucovetsky and Smart (2006), and Kotsogiannis (2010), each region's tax instrument is limited to a source-based tax on capital.[4] Kotsogiannis (2010) also assumes that the federal government only taxes capital (savings). Since their seminal works, studies on fiscal equalization in the context of tax competition have incorporated distortions other than fiscal externalities into models of a single tax base. Examples of recent studies include Wrede (2014) for agglomeration externalities, Ogawa and Wang (2016) for repeated asymmetric games, Liesegang

[1] An alternative system of fiscal equalization is tax revenue equalization, under which fiscal capacities are measured by regional tax revenues, rather than regional tax bases. This equalization system has both positive and negative impacts on regional tax rates. The positive impact is similar to that of tax base equalization. The negative impact arises because a region's contribution to the equalization system increases when its tax revenue is raised. There are empirical analyses of whether or not fiscal equalization increases subnational governments' tax rates; see, for example, Dahlby and Warren (2003), Büttner (2006), Smart (2007), Egger et al. (2010), and Rauch and Hummel (2016).

[2] See Wilson (1999) and Fuest et al. (2005) for comprehensive reviews of the tax competition literature.

[3] Köthenbürger (2002) includes an analysis of tax revenue equalization, whereas this paper focuses on tax base equalization. Recently, there have been studies comparing these two equalization systems in the context of tax competition; see, for example, Liesegang and Runkel (2018) and Kikuchi and Tamai (2019).

[4] Köthenbürger (2002, Appendix 2) claims that his argument holds even if a labor tax is also available. However, due to the assumption that the total capital stock is exogenous, his model does not capture the implication of using multiple taxes. In his model, tax base equalization induces regional governments to only rely on the capital tax that is not distortionary from the viewpoint of the entire economy. The labor tax that distorts labor-leisure decision is not used after all.

and Runkel (2018) for ad valorem versus unit taxation, and Kikuchi and Tamai (2019) for unemployment. Unlike the aforementioned studies, this paper provides a tax competition analysis of tax base equalization and multiple taxes.[5]

This analysis is important because there are countries where multiple tax bases are used by regional governments and are included in the calculation of regional capacities in fiscal equalization systems. For example, in Canada, taxes on personal income, corporate income, property, and sales are subject to tax base equalization (see Dafflon, 2007; Smart, 2007; Feehan, 2014).[6] The Swiss system of fiscal equalization measures each canton's capacity by aggregating different bases (income, profits, and wealth) on which cantons levy taxes (see Soguel, 2019).

The present model is built on Bucovetsky and Wilson (1991, Sect. 3), where regional governments impose taxes on capital and labor when savings and labor supply decisions are endogenous. This canonical model of tax competition is extended to include fiscal equalization and federal public policy. The federal government also imposes capital and labor taxes, implying that there are both horizontal and vertical fiscal externalities. In this setting, a system of efficient tax base equalization that internalizes fiscal externalities is examined. The regional capital tax base should be fully equalized even if the total capital stock is variable. However, for the regional labor tax base, a region's equalization entitlement must be positive if its tax base is "larger" than the average tax base of all regions. The resulting "negative" rate of equalization implies that the efficiency-enhancing role of tax base equalization is doubtful because it is incompatible with the primary objective of fiscal equalization.

The remainder of this paper is organized as follows. Section 2 describes the model. Sections 3 derives a system of efficient tax base equalization. This system is interpreted in comparison with Köthenbürger (2002), Bucovetsky and Smart (2006), and Kotsogiannis (2010). Section 4 concludes.

2 The model

This paper focuses on the efficiency properties of tax base equalization under tax competition. Consider a federation consisting of N identical regions. The population of each region is normalized to one. Each resident is endowed with a given amount of endowment (e) and makes consumption, savings, and labor supply decisions in a two-period framework. In the first period, the endowment is divided into current consumption (c) and savings ($s = e - c$). The supply of labor (n) is determined in

[5] Fiscal equalization and multiple taxes have been analyzed in different contexts. See Dahlby and Wilson (1994) and Smart (1998) for optimal commodity taxation and Esteller-Moré et al. (2017) and Holm-Hadaulla (2020) for political economics. Esteller-Moré et al. (2017) consider fiscal equalization when lobby groups influence regional tax policy. In their model, tax base equalization counteracts political downward pressures on regional tax rates. Holm-Hadaulla (2020) examines the impact of fiscal equalization on the mixture of capital and land taxes. Regional tax policy is decided through majority voting.

[6] In Canada, natural resource revenues are also subject to fiscal equalization. However, unlike other taxes, actual revenues are used to measure provincial fiscal capacities. In this sense, the Canadian system of fiscal equalization is a hybrid of tax base and tax revenue equalization programs.

the second period. Labor income and the return from savings are spent on second-period consumption. The lifetime utility function is expressed as follows:

$$U(c) + (1+\rho)(e-c) + \omega n - \phi(n) + \Gamma(g, G), \tag{1}$$

where ρ is the return on savings, ω is the net wage rate, g is the level of regional public expenditure, and G is the level of federal public expenditure per region. The utility of the first-period consumption is given by $U(c)$. Consumption in the second period is equal to $(1+\rho)(e-c)+\omega n$. The disutility of labor is $\phi(n)$. The utility of public expenditure is $\Gamma(g, G)$.[7] $U(c)$ and $\Gamma(g, G)$ are increasing and concave, whereas $\phi(n)$ is increasing and convex. The marginal benefit of g (G) is denoted by Γ_g (Γ_G).[8] Taking market prices and public expenditure as given, each resident maximizes (1) with respect to c and n. This maximization yields the savings and labor supply functions, and the indirect private utility function, denoted by $s(\rho)$, $n(\omega)$, and $V(\omega, \rho)$, respectively. The derivatives of these functions are positive.

$$s'(\rho) > 0,\ n'(\omega) > 0,\ V_\omega = n, \quad \text{and} \quad V_\rho = s. \tag{2}$$

The total utility is given by $V(\omega, \rho) + \Gamma(g, G)$.

Production and taxation occur in the second period. In each region, a numeraire output is produced from labor and capital. The well-behaved regional production function is given by $f(k, n)$, where k is the regional capital stock. The production function exhibits constant returns to scale. The output can be transformed into a private good, g, or G. The government of each region and the federal government impose taxes on labor and capital to finance their public expenditures. Let t^R and T^R (t^F and T^F) denote the regional (federal) capital and labor tax rates, respectively. The regional capital tax is a source-based tax, whereas the federal capital tax is equivalent to a savings tax. In the presence of these taxes, profit maximization implies that

$$f_k(k, n) = \rho + t \quad \text{and} \quad f_n(k, n) = W = \omega + T, \tag{3}$$

where $t = t^R + t^F$, $T = T^R + T^F$, $\rho + t$ is the gross return on capital, and W is the gross wage rate. The zero-profits condition yields W as a function of $\rho + t$, denoted as $W(\rho + t)$. This function has the following features:

$$W'(\rho + t) = -k/n = -\gamma(\rho + t) \quad \text{and} \quad \gamma'(\rho + t) < 0, \tag{4}$$

where γ is the capital–labor ratio. An increase in the gross return on capital causes the gross wage rate to decline. The concavity of the production function implies that $\gamma'(\rho + t) < 0$.

Given that all regions are identical, this paper investigates a symmetric equilibrium in which all regions choose the same tax rates. However, it should be emphasized that this assumption does not imply regional policy coordination. As formalized below, each region non-cooperatively chooses t^R and T^R, taking the tax rates of

[7] The assumption of quasi-linear preference can be relaxed without changing the essence of the present analysis.

[8] In this paper, the subscripts attached to functions represent partial derivatives (e.g., $\partial\Gamma/\partial g = \Gamma_g$).

other regions and the federal government as given. The resulting regional tax rates are inefficient without fiscal equalization.

The regional public good is financed by fiscal equalization transfer, which is denoted by Λ, and capital and labor taxes. Noting from (3) and (4) that $k = \gamma(\rho + t)n(W(\rho + t) - T)$, each region's public budget constraint is given by

$$g = \left[t^R\gamma(\rho + t) + T^R\right]n(W(\rho + t) - T) + \Lambda. \tag{5}$$

In the present model, Λ takes the form of the representative tax system; a region's equalization entitlement is based on a fraction of the difference between its tax base and the average tax base of all regions. This difference is equal to $\overline{k} - k$ for the capital tax and $\overline{n} - n$ for the labor tax, where $\overline{k}$ ($\overline{n}$) is the average capital (labor) supply of all regions. These tax bases are evaluated by the average regional capital and labor tax rates, denoted by $\overline{t}^R$ and $\overline{T}^R$, respectively. Each region's entitlement is equal to

$$\Lambda = \overline{t}^R\alpha\left(\overline{k} - k\right) + \overline{T}^R\beta\left(\overline{n} - n\right), \tag{6}$$

where α and β represent the rates of equalization that characterize the magnitude of fiscal transfer. For example, full equalization of all tax bases means that $\alpha = \beta = 1$.

The tax revenue of the federal government is shared by all regions through the provision of G. Let t^{R*} and T^{R*} denote the capital and labor tax rates in $N - 1$ rival regions, respectively.[9] From the viewpoint of each region, the provision level of G is equal to

$$G = \frac{1}{N}\left\{\left[t^F\gamma(\rho + t) + T^F\right]n(W(\rho + t) - T) + (N - 1)\left[t^F\gamma(\rho + t^*) + T^F\right]n(W(\rho + t^*) - T^*)\right\}, \tag{7}$$

where $t^* = t^{R*} + t^F$ and $T^* = T^{R*} + T^F$ are the consolidated tax rates in the other $N - 1$ regions. Note that the federal tax revenue is only spent on G because the equalization system specified in (6) is a net fiscal transfer among regions.[10]

The net return on capital or savings is determined by equating the aggregate capital demand and supply in the entire economy. Let $b(\rho, t, T)$ be the net capital export function of each region:

$$b(\rho, t, T) = s(\rho) - \gamma(\rho + t)n(W(\rho + t) - T). \tag{8}$$

From (4), the partial derivatives of this function are

$$b_\rho = s' + \gamma^2 n' - \gamma' n > 0, \quad b_t = \gamma^2 n' - \gamma' n > 0, \quad \text{and} \quad b_T = \gamma n' > 0. \tag{9}$$

Using t^* and T^*, the capital market equilibrium can be expressed as:

[9] As far as symmetric allocations among identical regions are concerned, there is no need to distinguish between other regions' tax rates, because they are exogenous when considering non-cooperative regional policy making. One may interpret t^{R*} and T^{R*} as the regional capital and labor tax rates in the symmetric equilibrium.

[10] For this reason, a region's tax policy does not affect the sum of equalization entitlement over all regions. See Kotsogiannis (2010, Appendix) for a formal argument.

$$b(\rho, t, T) + (N-1)b(\rho, t^*, T^*) = 0. \tag{10}$$

This equation gives ρ as a function of the tax rates:

$$\rho = \rho(t, T, t^*, T^*), \tag{11}$$

where

$$\rho_{t^R} = -b_t/\left(Nb_\rho\right) \quad \text{and} \quad \rho_{T^R} = -b_T/\left(Nb_\rho\right). \tag{12}$$

These derivatives are evaluated in the symmetric equilibrium in which $t^R = t^{R*}$ and $T^R = T^{R*}$. According to (12), each region recognizes that its tax policy influences the net return on capital.

Taking t^F, T^F, t^*, and T^* as given, each regional government chooses t^R and T^R to maximize $V(W(\rho + t) - T, \rho) + \Gamma(g, G)$, subject to (5), (6), (7), and (11). The present analysis assumes that non-cooperative regions and the federal government play a Nash game in tax rates. In this game, each region ignores the impact of t^R and T^R on the tax revenue of other regions. The resulting external impact corresponds to horizontal fiscal externalities. Further, although each region sees through the federal public budget and considers the impact of t^R and T^R on G through (7), the welfare impact of the change in federal expenditure on other regions is ignored. This external impact corresponds to vertical fiscal externalities.

The Nash game in tax rates also implies that the federal government considers the impact of t^F and T^F on g in all regions through (5). Thus, the welfare impact of the change in regional expenditure is internalized in federal policy making.[11] Given that the federal tax policy does not cause distortion, the focus of this paper is on the rates of equalization (α and β) that internalize the horizontal and vertical fiscal externalities caused by non-cooperative regional policy making, conditional on the federal tax rates. Following Kotsogiannis (2010, Proposition 2), I assume that t^F and T^F are positive. This assumption is plausible when the Boadway-Keen (1996) type of lump-sum transfers from lower-level to higher-level governments is unavailable, as in the present framework.[12]

[11] See Hoyt (2001) and Keen and Kotsogiannis (2002, 2004).

[12] The essence of this paper holds even if the federal tax rates are endogenous, as long as the federal and regional labor tax rates are positive. Boadway and Keen (1996) argue that if lump-sum fiscal transfers are available, negative federal tax rates and transfers are efficient under vertical tax competition. This argument does not apply to the present analysis of tax base equalization. Indeed, the equalization system stated in (6) can never replicate the Boadway-Keen type of negative lump-sum transfers. Note that Kotsogiannis (2010, Proposition 3) considers a variant of tax base equalization that implicitly assumes lump-sum transfers; the proposition is not directly comparable to the present analysis.

3 Analysis

3.1 Non-cooperative and efficient regional tax policy

When choosing t^R and T^R, each region perceives that its equalization entitlement is affected according to (6). In Appendix, it is shown that

$$\partial\Lambda/\partial t^R = \frac{N-1}{N}\left(\alpha t^R b_t + \beta T^R \gamma n'\right), \tag{13}$$

$$\partial\Lambda/\partial T^R = \frac{N-1}{N}\left(\alpha t^R b_T + \beta T^R n'\right). \tag{14}$$

From (2) and (9), the partial derivatives on the left-hand side of (13) and (14) are positive if t^R and T^R and the rates of equalization are positive. In this case, an increase in a region's tax rates raises its equalization entitlement.

Recognizing (13) and (14), non-cooperative regions maximize $V(W(\rho+t)-T,\rho)+\Gamma(g,G)$. From (5), (7), and (11), the first-order conditions for t^R and T^R that are evaluated in the symmetric equilibrium ($t^R = t^{R*}$ and $T^R = T^{R*}$) are given by[13]

$$\left(t^R\right) \quad \phi + \Gamma_g \zeta \rho_{t^R} + \left(\Gamma_G/N\right)\mathrm{Z}\left(N\rho_{t^R}+1\right) + \Gamma_g\left(\partial\Lambda/\partial t^R\right) = 0, \tag{15}$$

$$\left(T^R\right) \quad \Phi + \Gamma_g \zeta \rho_{T^R} + \left(\Gamma_G/N\right)\left[\mathrm{Z}N\rho_{T^R} - \left(t^F\gamma + T^F\right)n'\right] + \Gamma_g\left(\partial\Lambda/\partial T^R\right) = 0, \tag{16}$$

where

$$\phi = -\gamma n + \Gamma_g(\gamma n + \zeta), \tag{17}$$

$$\Phi = -n + \Gamma_g\left[n - \left(t^R\gamma + T^R\right)n'\right], \tag{18}$$

$$\zeta = t^R\gamma' n - \left(t^R\gamma + T^R\right)\gamma n', \tag{19}$$

$$\mathrm{Z} = t^F\gamma' n - \left(t^F\gamma + T^F\right)\gamma n'. \tag{20}$$

In (15) and (16), ϕ and Φ capture the welfare impact of the regional tax policy, given the levels of G, ρ, and Λ. The second term captures the impact on g through the policy-induced change in the net capital return, whereas the third term represents the impact on G. The last term is the impact through tax base equalization, as described in (13) or (14).

[13] In the symmetric equilibrium, γ and n (and their derivatives) are equal across regions. Moreover, $\gamma n = s$ holds in all regions.

Next, I consider an efficient regional tax policy. Given that symmetric allocations are analyzed, the present analysis defines a constrained efficient regional tax policy as t^R and T^R that maximizes the welfare of a closed region (i.e., $N = 1$), conditional on the federal tax rates.[14] When $N = 1$, there are no horizontal fiscal externalities. Moreover, as long as the impact of t^R and T^R on G is considered, there are no vertical fiscal externalities. Note that in this welfare maximization, the impact of t^R and T^R on the net capital return is derived from $b(\rho, t, T) = 0$. Using (12), the policy-induced changes in ρ can be expressed as $N\rho_{t^R} = -b_t/b_\rho$ and $N\rho_{T^R} = -b_T/b_\rho$. Thus, the first-order conditions for the efficient tax rates are given by

$$\left(t^R\right) \quad \phi + \Gamma_g \zeta N \rho_{t^R} + \Gamma_G \mathrm{Z}\left(N\rho_{t^R} + 1\right) = 0, \tag{21}$$

$$\left(T^R\right) \quad \Phi + \Gamma_g \zeta N \rho_{T^R} + \Gamma_G \left[\mathrm{Z}N\rho_{T^R} - \left(t^F\gamma + T^F\right)n'\right] = 0, \tag{22}$$

where ϕ, Φ, ζ, and Z take the same expressions as those in (17), (18), (19), and (20), respectively.

These equations yield the condition for the mix of t^R and T^R in the efficient allocation. This condition plays an important role in deriving a system of efficient tax base equalization in the present model.

Lemma 1 *Conditional on the federal tax rates, the efficient regional capital and labor taxes satisfy:*

$$\left(\Gamma_g \zeta + \Gamma_G \mathrm{Z}\right) = -\left(t^R\Gamma_g + t^F\Gamma_G\right)b_\rho. \tag{23}$$

Proof Subtracting (22) multiplied by γ from (21) and applying (17), (18), (19) and (20),

$$\left(t^R\Gamma_g + t^F\Gamma_G\right)\gamma' n + \left(\Gamma_g\zeta + \Gamma_G\mathrm{Z}\right)N\left(\rho_{t^R} - \gamma\rho_{T^R}\right) = 0. \tag{24}$$

As (12) implies that $N\left(\rho_{t^R} - \gamma\rho_{T^R}\right) = \gamma' n/b_\rho$, (24) can be reduced to (23). □

Using (9), (12), (19), and (20) and noting that $k = s$ in the symmetric allocation, (23) can be rewritten as:

$$\left(t^R + t^F\frac{\Gamma_G}{\Gamma_g}\right)\frac{s'}{s} = \left(T^R + T^F\frac{\Gamma_G}{\Gamma_g}\right)]\frac{n'}{n}. \tag{25}$$

This equation, which corresponds to the elasticity rule for optimal taxation, shows that the efficient regional tax mix equates the marginal excess burden of capital and labor taxes.

[14] That is, the efficient regional tax rates are the solution of maximizing $V(W(\rho + t) - T, \rho) + \Gamma(g, G)$, subject to $g = \left[t^R\gamma(\rho + t) + T^R\right]n(W(\rho + t) - T)$ and $G = [t^F\gamma(\rho + t) + T^F]n(W(\rho + t) - T)$.

3.2 Efficient tax base equalization

Even if the regional capital and labor tax rates are non-cooperatively chosen according to (15) and (16), they are efficient when α and β are set to meet (21) and (22) simultaneously. By setting the equalization system in this manner, the efficient regional tax policy is implementable.

Subtracting (15) from (21), and (16) from (22) yields the following two equations:

$$\Gamma_g \partial\Lambda/\partial t^R = \frac{N-1}{N}\left[\Gamma_g \zeta N \rho_{t^R} + \Gamma_G Z\left(N\rho_{t^R}+1\right)\right], \tag{26}$$

$$\Gamma_g \partial\Lambda/\partial T^R = \frac{N-1}{N}\left\{\Gamma_g \zeta N \rho_{T^R} + \Gamma_G\left[ZN\rho_{T^R} - \left(t^F\gamma + T^F\right)n'\right]\right\}. \tag{27}$$

The first and second terms on the right-hand side represent the horizontal and vertical fiscal externalities caused by non-cooperative regional policy making, respectively. I explore each of these externalities later. The rates of tax base equalization should be set to equate the marginal change in equalization entitlement and the marginal welfare impact of fiscal externalities. Solving (26) and (27) with respect to α and β leads to the following proposition:

Proposition 1 *In the presence of tax base equalization, the efficient regional tax policy is implementable through non-cooperative policy making when* $\alpha = 1$ *and* $\beta = -\left(T^F/T^R\right)\left(\Gamma_G/\Gamma_g\right)$.

Proof For the right-hand side of (26), Lemma 1, together with (12) and (20), implies that

$$\Gamma_g \zeta N \rho_{t^R} + \Gamma_G Z\left(N\rho_{t^R}+1\right) = t^R b_t \Gamma_g - T^F \gamma n' \Gamma_G. \tag{28}$$

Similarly, for the right-hand side of (27), it can be confirmed that

$$\Gamma_g \zeta N \rho_{T^R} + \Gamma_G\left[ZN\rho_{T^R} - \left(t^F\gamma + T^F\right)\gamma n'\right] = t^R b_T \Gamma_g - T^F n' \Gamma_G. \tag{29}$$

Using (13), (14), (28), and (29), the system of (26) and (27) can be described as:

$$\begin{vmatrix} t^R b_t, & T^R \gamma n' \\ t^R b_T, & T^R n' \end{vmatrix} \begin{vmatrix} \alpha \\ \beta \end{vmatrix} = \begin{vmatrix} t^R b_t - T^F \gamma n' \frac{\Gamma_G}{\Gamma_g} \\ t^R b_T - T^F n' \frac{\Gamma_G}{\Gamma_g} \end{vmatrix}. \tag{30}$$

The desired result immediately follows from (30). □

Proposition 1 shows that mobile and immobile tax bases are treated differently for efficiency. While the regional capital tax base should be fully equalized, the rate of equalization for the regional labor tax base must be negative as long as the federal and regional labor tax rates are positive. If α and β are constrained to be non-negative, tax base equalization cannot support efficiency. This analytical result implies that internalizing fiscal externalities is incompatible with the primary objective of

fiscal equalization. Although the present model of identical regions only focuses on efficiency, it highlights a potential trade-off between regional equality and efficiency in a striking manner. This trade-off can also be illustrated by noting the inefficiency of full equalization of all tax bases ($\alpha = \beta = 1$). As efficiency requires that $\alpha = 1$ and $\beta < 0$, full tax-base equalization will lead to excessive taxation because of the positive impact of the equalization system on regional tax rates.[15]

To gain insight into how tax base equalization works in the present model, I consider the external impact of non-cooperative regional tax policy on other regions and the federal government. A region's increase in t^R or T^R creates horizontal and vertical fiscal externalities by:

(i) raising the capital tax revenue of other regions through interregional capital movements;
(ii) decreasing savings, thereby reducing the capital tax revenue of other regions and the federal government;
(iii) raising the labor tax revenue of other regions through interregional capital movements; and
(iv) (iv) decreasing the total labor supply, thereby reducing the federal labor tax revenue.

The positive horizontal externality in (i) captures an increase in the capital tax base of other regions when the total capital stock is hypothetically fixed. When a region raises its tax rates, mobile capital moves to other regions with relatively lower tax rates. The negative horizontal and vertical externalities in (ii) are due to the negative impact of capital and labor taxes on ρ, which decreases the supply of capital in each region. The positive horizontal externality in (iii) arises because the policy-induced capital movements increase the demand for labor in other regions, as capital and labor are complements in production.[16] However, as (iv) indicates, the total labor supply in the entire economy declines because the decrease in the labor supply in the region with higher tax rates dominates the increase in other regions.[17] The resulting negative impact on the federal labor tax revenue represents a negative vertical externality.

Köthenbürger (2002, Proposition 2) argues that when only capital is taxed, tax base equalization should be fully implemented to internalize the externality in (i)

[15] This argument is closely related to the empirical analyses of Smart (2007, p.1210) and Dahlby and Ferede (2012, p.875) regarding the Canadian equalization system in which full equalization of multiple tax bases is an institutional feature (with the proviso stated in footnote 6). They point out the possibility that the Canadian system leads to excessive taxation. Although full tax-base equalization contributes to reducing regional inequality, it is accompanied by an efficiency cost.

[16] Bucovetsky and Wilson (1991, Sect. 3) refer to the distortionary impact of this positive externality on non-cooperative regional tax policy without fiscal equalization.

[17] Formally, a region's increase in t^R changes its labor tax base by $n'W'\left(\rho_{t^R}+1\right)$. The change in the labor supply in each of the other $N-1$ regions is equal to $n'W'\rho_{t^R}$. From (4), (9), and (12), the change in the total labor supply is equal to $n'W'\left(N\rho_{t^R}+1\right)=-n'\gamma s'/b_\rho$ in the symmetric equilibrium. Similarly, a region's increase in T^R changes the total labor supply by $n'W'N\rho_{T^R}-n'=-n'\gamma\left(s'-\gamma' n\right)/b_\rho$ in the symmetric equilibrium.

($\alpha = 1$ in terms of the present notation). Bucovetsky and Smart (2006, Proposition 2) and Kotsogiannis (2010, Proposition 2) show that when savings decisions are endogenous, the rate of equalization must be less than one ($\alpha < 1$) to internalize the externalities in (i) and (ii) simultaneously. In addition to these externalities, the externalities in (iii) and (iv) are relevant when both capital and labor taxes are available.

However, in the present model, tax base equalization does not need to internalize all of the externalities stated in (i)–(iv). The negative externality in (ii) offsets the positive one in (iii) when the regional tax rates are set according to Lemma 1. The externality in (iv) is also partially offset. More precisely, the change in the total labor supply for this externality can be decomposed into the impact of the policy-induced change in ρ (i.e., ρ_{t^R} or ρ_{T^R}) and the direct impact of t^R or T^R (see footnote 17). The impact through the change in ρ, as well as the externalities in (ii) and (iii), is neutralized in the efficient allocation. Consequently, the remaining externalities that must be internalized by tax base equalization are the positive externality in (i) and the part of the externality in (iv) that corresponds to the direct impact of t^R or T^R on n.[18] On the right-hand side of (28) and (29), the first and second terms capture these externalities, respectively. In Proposition 1, α is equal to one to internalize the externality in (i), whereas β is negative to internalize the externality in (iv). Thus, for the regional capital tax base, Köthenbürger's (2002) equalization formula is valid even if the total capital stock is variable. The negative rate of equalization for the regional labor tax base is due to overlapping federal and regional tax bases under which regional taxation must be discouraged to achieve efficiency.

This argument illustrates that the trade-off between regional equality and efficiency is particularly prominent when vertical tax competition is considered. Indeed, if the federal public sector was absent in the present model, the system of efficient tax base equalization would be such that $\alpha = 1$ and $\beta = 0$. Horizontal fiscal externalities can be internalized even if the rates of equalization are constrained to be non-negative. Note that a similar scenario may occur when only capital is taxed. In Kotsogiannis (2010, Proposition 2), the efficient rate of equalization for the regional capital tax base may be negative depending on the relative magnitude of federal and regional public expenditures. By contrast, this rate is positive in Bucovetsky and Smart (2006, Proposition 2), where the federal public sector is not modeled. Note, however, that in the present model of multiple taxes, the trade-off between regional equality and efficiency is "inevitable" because of the negativity of β. Overlapping immobile tax bases casts doubt on the claim that tax base equalization can be used to internalize fiscal externalities.

[18] The direct impact of t^R or T^R on n, which is equal to $-\gamma n'$ or $-n'$, occurs in the region with higher tax rates. This impact changes federal expenditure per region by $-T^F \gamma n'/N$ or $-T^F n'/N$.

4 Concluding remarks

The present analysis has considered a system of efficient tax base equalization that internalizes horizontal and vertical fiscal externalities. This system depends on the set of available tax instruments. When the federal and regional governments use capital and labor taxes, the regional capital tax base should be fully equalized, regardless of whether or not the total capital stock is variable. However, the rate of equalization for the regional labor tax base, which has not been investigated in the context of tax competition, must be negative for efficiency.

The result for the regional labor tax base shows that the efficiency-enhancing role of tax base equalization is not as useful as previously claimed. To simultaneously pursue regional equality and efficiency, tax base equalization may be used together with other policy instruments such as matching grants. As Dahlby (1996) and Hoyt (2001) argue, matching revenue grants can cope with horizontal and vertical fiscal externalities. To investigate how different fiscal transfers are mixed to achieve regional equality and efficiency, asymmetric tax competition among heterogeneous regions should be analyzed.

Apart from this extension, it is interesting to examine how allowing for economic and/or institutional distortions other than fiscal externalities, which have been analyzed in the previous studies on fiscal equalization (see Sect. 1), affects the present analytical results for tax base equalization and multiple tax bases. Combining other distortions into a single theoretical framework will yield more profound insight into the influence of fiscal equalization on regional public policies.

Appendix

The derivation procedures for (13) and (14) are described below. Differentiating (6) yields

$$\partial\Lambda/\partial t^R = \alpha t^R\left(\partial\overline{k}/\partial t^R - \partial k/\partial t^R\right) + \beta T^R\left(\partial\overline{n}/\partial t^R - \partial n/\partial t^R\right), \tag{A.1}$$

$$\partial\Lambda/\partial T^R = \alpha t\left(\partial\overline{k}/\partial T^R - \partial k/\partial T^R\right) + \beta T^R\left(\partial\overline{n}/\partial T^R - \partial n/\partial T^R\right). \tag{A.2}$$

Note that $\overline{k} = k$, $\overline{n} = n$, $\overline{t}^R = t^R$, and $\overline{T}^R = T^R$ hold in the symmetric equilibrium. Thus, the changes in $\overline{t}^R$ and $\overline{T}^R$ are irrelevant to the derivations of (13) and (14).

For the regional capital tax base, noting that $\overline{k} = \frac{Ns(\rho)}{N} = s(\rho)$, the difference between $\overline{k}$ and k is equal to

$$\overline{k} - k = s(\rho) - \gamma(\rho + t)n(W(\rho + t) - T). \tag{A.3}$$

Differentiating (A.3) and applying (4), (9), and (12) yields

$$\partial\overline{k}/\partial t^R - \partial k/\partial t^R = s'\rho_{t^R} - \left(\gamma' n - \gamma^2 n'\right)\left(\rho_{t^R} + 1\right) = b_\rho\rho_{t^R} + b_t = \frac{N-1}{N}b_t, \tag{A.4}$$

$$\partial\overline{k}/\partial T^R - \partial k/\partial T^R = s'\rho_{T^R} - \left(\gamma' n - \gamma^2 n'\right)\rho_{T^R} + \gamma n' = b_\rho \rho_{T^R} + b_T = \frac{N-1}{N} b_T. \tag{A.5}$$

For the regional labor tax base, the difference between $\overline{n}$ and n is equal to

$$\overline{n} - n = \frac{1}{N}\left[n(W(\rho + t) - T) + (N-1)n(W(\rho + t^*) - T^*)\right] - n(W(\rho + t) - T). \tag{A.6}$$

Differentiating (A.6) and evaluating the outcome in the symmetric equilibrium yields

$$\partial\overline{n}/\partial t^R - \partial n/\partial t^R = \frac{N-1}{N}\gamma n', \tag{A.7}$$

$$\partial\overline{n}/\partial T^R - \partial n/\partial T^R = \frac{N-1}{N} n'. \tag{A.8}$$

Equation (13) is derived by substituting (A.4) and (A.7) in (A.1). Equation (14) is derived by substituting (A.5) and (A.8) in (A.2).

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