Equalizing Tax Bases or Tax Revenues under Tax Competition? The Role of Formula Apportionment*

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Abstract: This paper contributes to the literature on fiscal equalization and corporate tax competition. The innovation is that we explicitly model multinational enterprises and a corporate tax system that is designed according to Formula Apportionment. Two main results are obtained. First, in contrast to previous studies we identify cases where tax revenue equalization is better in mitigating detrimental tax competition than tax base equalization. Second, tax base equalization nevertheless has the advantage that it may render tax rates efficient, depending on the shape of the apportionment formula. A pure payroll formula does not ensure efficiency, but a back-of-the-envelope calibration of our model to Canadian provinces suggests that a pure sales formula may be optimal.

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1 Introduction

Many federations have implemented fiscal equalization schemes among their member countries. Basically two types of equalization schemes can be distinguished. Tax base equalization tries to equalize tax bases or, equivalently, tax capacities of countries. The so-called Representative Tax System (RTS) between Canadian provinces is an example for tax base equalization (Boadway, 2004; Smart, 2007). Another example is fiscal equalization among German municipalities (Büttner, 2006; Egger et al., 2010). An alternative type of equalization is tax revenue equalization which directly redistributes tax revenues. Such a system is implemented, for instance, between German states (Baretti et al., 2002). And even though there is no explicit equalization scheme in the US, implicit redistribution by federal taxes and transfers goes into the direction of tax revenue equalization (Bayoumi and Masson, 1995; Mélitz and Zumer, 2002).

The basic aim of fiscal equalization schemes is a redistributive one. Fiscal resources are reallocated between the countries in order to equalize (at least partially) the standard of living in all parts of the federation. However, the economic literature has emphasized also an efficiency argument in favor of fiscal equalization. It is well-known that the taxation of mobile capital and firms by member countries of a federation leads to inefficient tax competition. Each country tries to attract mobile tax bases and thereby to improve its tax revenues without taking into account the external effects of its tax policy on other countries. It has been shown that fiscal equalization may be a useful instrument to internalize such fiscal externalities in corporate taxation and that tax base equalization is more suitable for this purpose than tax revenue equalization (Köthenbürger, 2002; Bucovetsky and Smart, 2006; Kotsogiannis, 2010).

The present paper contributes to the literature on fiscal equalization and corporate tax competition. The innovation of the paper is that we consider an alternative modeling of firms and corporate taxation. Previous studies suppose firms with a single entity and use capital taxation as a shortcut of corporate taxation. In contrast, we take into account that in practice (i) a large part of firms are multinational enterprises (MNE) with subsidiaries in more than one country and (ii) corporate taxation of such

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enterprises often follows the so-called Formula Apportionment principle. Under Formula Apportionment, governments tax corporate income instead of capital. Moreover, tax bases of all subsidiaries of a MNE are first aggregated to the consolidated tax base and then allocated to the taxing countries according to a formula that equals a linear combination of the relative capital, sales and payroll shares of the firm’s subsidiaries. Interestingly, all above mentioned federations with fiscal equalization schemes (Canada, Germany, US) tax firms according to the Formula Apportionment principle (Weiner, 2005; Böttner et al., 2011), indicating the importance of taking into account this principle when discussing the effects of fiscal equalization on tax competition.

We introduce MNEs and Formula Apportionment in a standard tax competition framework with fiscal equalization. There is one representative MNE with a subsidiary in each member country of a federation. Subsidiaries demand mobile capital and immobile labor in order to produce a consumption good. Each country is populated by a representative household who inelastically supplies capital and labor. The household demands the consumption good and a public good which the local government finances by the receipts of a Formula Apportionment corporate income tax. The governments of the countries play a Nash tax competition game and are connected by either tax base or tax revenue equalization. Within this framework we first characterize the inefficiency of the equilibrium tax rates by identifying pecuniary externalities (effect of a country’s tax rate on the other countries’ welfare via changes in capital, wage and profit income) and fiscal externalities (effect of a country’s tax rate on the other countries’ welfare via changes in the consolidated tax base and the apportionment formula).

We then investigate the capability of fiscal equalization to internalize these externalities and to restore efficiency. Two important results follow from our analysis. The first main result is that, in contrast to the previous literature, we are able to identify cases where equilibrium tax rates are more efficient under tax revenue equalization than under tax base equalization. The intuition is as follows. Both equalization schemes are characterized by pecuniary and fiscal distortions. The pecuniary distortion reflects the fact that the equalization schemes do not internalize pecuniary externalities since they aim at equalizing fiscal resources and not private income. The fiscal distortion means that the schemes also fail to fully internalize the fiscal externalities. We show in detail that under tax revenue equalization the net effect of the two distortions leaves
uncorrected the wage externality, i.e. the effect of a country’s tax rate on wage income in other countries. This externality is positive and causes inefficiently low tax rates under tax revenue equalization. Moreover, it turns out that the fiscal distortion is more severe under tax revenue equalization than under tax base equalization. Hence, the net distortion under tax base equalization is smaller than under tax revenue equalization and it may well become negative, implying inefficiently high tax rates. We then identify cases where the wage externality is so low that undertaxation under tax revenue equalization is less harmful than overtaxation under tax base equalization. In such cases tax revenue equalization becomes superior to tax base equalization.

The second main result nevertheless points to a great advantage of tax base equalization. Tax revenue equalization may be better than tax base equalization, indeed, but tax rates under tax revenue equalization are always inefficiently low. In contrast, under tax base equalization the net effect of the pecuniary and fiscal distortions may be zero, so corporate tax rates may become efficient. We show that this efficiency property heavily relies on the shape of the apportionment formula. To illustrate, we map in our theoretical model the case of German municipalities and Canadian provinces. As mentioned above, both federations employ tax base equalization and Formula Apportionment. Moreover, corporate income taxation of German municipalities employ a pure payroll apportionment formula, while Canadian provinces use a formula with equal weight on payroll and sales (Weiner, 2005; Büttner et al., 2011).

Under a pure payroll formula, we can show that tax base equalization always leads to inefficiently low tax rates. The reason is that with the total formula weight on the payroll factor the wage externality is rather large and overcompensates the governments’ incentive to raise tax rates above their efficient level. Hence, the German system of tax base equalization and Formula Apportionment with a pure payroll formula does not restore efficiency of corporate tax rates. If payroll and sales factors enter the apportionment formula, the analytical complexity prevents clear-cut results for the general specification of our model. We therefore confine ourselves to numerical analysis and conduct a back-of-the-envelope calibration of our model to the Canadian case. It turns out that efficiency is attained with a pure sales formula and that the optimal weight on payroll is approximately zero. Hence, even though the Canadian system puts lower weight on payroll than the German system, this weight is still too large. Every positive
weight on payroll causes a wage externality that dominates all other incentives of the governments and, therefore, causes inefficient undertaxation. We can even generalize this argument against the payroll factor to the case of a general three-factor formula, where the optimal weight on payroll is again zero and the optimal formula is a linear combination of the sales and capital factors only.

There is already a large and steadily growing literature on fiscal equalization and corporate tax competition. Early articles are, for example, Wildasin (1989), DePater and Myers (1994) and Smart (1998). More recent contributions are made by Janeba and Peters (2000), Dahlby and Warren (2003), Büttner (2006), Gaigné and Riou (2007), Smart (2007), Hendriks et al. (2008), Egger et al. (2010), Lui (2014), Wang et al. (2014), Ogawa and Wang (2016) and Silva (2016). Our paper is closest to Köthenbürger (2002), Bucovetsky and Smart (2006), Kotsogiannis (2010), Wrede (2014) and Liesegang and Runkel (2016). These papers show that tax base equalization (RTS) either ensures efficient tax rates under tax competition or at least dominates tax revenue equalization. Hence, in contrast to our analysis, they do not identify cases where tax revenue equalization is superior. The reason for the difference in results is that previous articles do not take into account MNEs and Formula Apportionment. This also explains why previous studies cannot highlight the role of the apportionment formula for efficiency under tax base equalization, which is our second important contribution.

Our paper is also related to the literature on tax competition under Formula Apportionment (e.g. Gordon and Wilson, 1986; Eggert and Schjelderup, 2003; Nielsen et al., 2010) and, in particular, to the question which formula should be used in order to mitigate tax competition. In contrast to our results, Wellisch (2004) shows that the optimal formula is a pure payroll formula. However, in his model the corporate tax is a tax on the fixed factor labor and not on corporate income and he does not take into account fiscal equalization. In line with our results, there are some studies that make the point for the sales factor in the apportionment formula, for example, Anand and Sansing (2000), Pethig and Wagener (2007), Pinto (2007), Riedel and Runkel (2007) and Eichner and Runkel (2008, 2009). Closest to our analysis is Eichner and Runkel (2011). In a model very similar to ours, but without fiscal equalization, they show that Formula Apportionment always yields inefficiently low corporate tax rates, but that this inefficiency is the least pronounced under a pure sales formula. Hence, our
results strengthen their contribution, at least for the Canadian case: If tax base equalization is taken into account, then the pure sales formula not only mitigates inefficient undertaxation the most, it even removes it completely.

The paper is organized as follows. In Section 2 we present the basic model. Sections 3 and 4 investigate the market equilibrium and tax competition between the countries, respectively. In Section 5 we analyze the effects of fiscal equalization on tax competition. Our main results are collected in Section 6. Section 7 summarizes.

2 Basic Framework

Consider an economy with \( n \geq 2 \) identical countries.\(^2\) Country indices are denoted by \( i, j \in \{1, \ldots, n\} \). Each country is populated by a large number of identical households from which we focus on the representative one. This household owns a fixed capital endowment \( \bar{k} \) and a fixed labor endowment \( \bar{l} \). While capital is perfectly mobile, labor is totally immobile. The household in country \( i \) supplies its capital endowment on the world capital market at the world interest rate \( r \) and its labor endowment on the local labor market at the wage rate \( w_i \). Moreover, the household in country \( i \) owns a share \( 1/n \) of a MNE that we describe below. Hence, it receives the share \( 1/n \) of the MNE’s after-tax profits \( \pi \) as profit income. The household uses its total income for a private consumption good. Normalizing the price of this good to one and denoting by \( c_i \) the quantity consumed, the budget constraint of the household in country \( i \) reads

\[
c_i = r \bar{k} + w_i \bar{l} + \pi/n. \tag{1}
\]

In addition to the private consumption good, the household consumes the quantity \( g_i \) of a public consumption good provided by the local government of country \( i \). The utility of the household in country \( i \) is given by the quasi-concave utility function \( U(c_i, g_i) \) with positive marginal utilities \( U_c > 0 \) and \( U_g > 0 \).

There is a large number of MNEs with subsidiaries in each country. We suppose all MNEs are identical and focus on the representative one. This MNE produces the consumption good with the help of capital and labor. Production in country \( i \)

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\(^2\)We deliberately focus on the symmetric case with perfectly identical countries in order to identify the basic mechanism at work in our model. Country asymmetries have already intensively been discussed in the previous literature mentioned in the Introduction.
is modeled by the production function $F(k_i, \ell_i)$ with $k_i$ and $\ell_i$ representing capital and labor input, respectively. We assume $F_k > 0$, $F_{kk} < 0$, $F_\ell > 0$ and $F_{\ell\ell} < 0$, i.e. production is characterized by positive and decreasing marginal returns to both inputs. Capital and labor are complements in the sense of a positive cross derivative $F_{k\ell} = F_{\ell k} > 0$. Since we model corporate taxation as tax on corporate income, it is plausible to assume that the MNE earns some corporate income that can be taxed by governments. In our model, this income stems from decreasing returns to scale in production. We suppose the production function is homogeneous of degree $m \in ]0,1[$, i.e. $F(\lambda k_i, \lambda \ell_i) = \lambda^m F(k_i, \ell_i)$ for all $\lambda > 0$. Thus, there is a fixed third production factor like e.g. land or entrepreneurial capabilities that generates pure economic rents.

Beside decreasing returns to scale, a second factor that renders the tax base of the MNE positive is partial deductibility of capital costs. In most real-world corporate tax systems, restricted depreciation allowances and the asymmetric treatment of debt and equity costs limit the share of tax-deductible capital costs. We therefore assume that the MNE may deduct only the share $\rho \in [0,1]$ of capital costs. In contrast, labor costs are fully tax-deductible. Formally, the MNE’s tax base in country $i$ is defined as

$$\phi_i = F(k_i, \ell_i) - \rho r_k k_i - w_i \ell_i.$$  \hspace{1cm} (2)

It equals sales less deductible capital costs and payroll. Note that the deductibility parameter $\rho$ is exogenously given and the same for all countries. This is a realistic assumption for many Formula Apportionment systems, like the one in Germany and Canada, since these systems use a common tax base definition.\(^3\)

We assume that corporate taxation follows the Formula Apportionment principle. The MNE’s tax bases from all subsidiaries are first consolidated and then allocated to the countries according to a certain formula. Consolidation yields the MNE’s consolidated tax base $\sum_{j=1}^n \phi_j$. The apportionment formula is a general three-factor formula and, thus, contains the capital, sales and payroll shares. Denoting the weights attached to these factors by $\gamma$, $\sigma$ and $\varphi$ with $(\gamma, \sigma, \varphi) \in [0,1]^3$ and $\gamma + \sigma + \varphi = 1$, the share of the consolidated tax base allocated to country $i$ can be written as

$$A_i(k_i, k_{-i}, \ell_i, \ell_{-i}, w_i, w_{-i}) = \gamma \frac{k_i}{\sum_{j=1}^n k_j} + \sigma \frac{F(k_i, \ell_i)}{\sum_{j=1}^n F(k_j, \ell_j)} + \varphi \frac{w_i \ell_i}{\sum_{j=1}^n w_j \ell_j},$$ \hspace{1cm} (3)

\(^3\)An exception is Formula Apportionment in the US where each state uses its own tax base definition. But even in this system the definitions are not that different (e.g. Weiner, 2005).
where $x_{-i} := (x_1, ..., x_{i-1}, x_{i+1}, ..., x_n)$ for $x \in \{k, \ell, w\}$. The MNE’s tax liability in country $i$ is $t_i A^i(\cdot)\sum_{j=1}^{n}\phi_j$ and its after-tax profits read

$$\pi = (1 - \tau)\sum_{j=1}^{n}\phi_j - (1 - \rho)r\sum_{j=1}^{n}k_j,$$

with

$$\tau = \sum_{j=1}^{n}t_j A^j = t_i + \sum_{j \neq i}(t_j - t_i)A^j.$$  

The expression in (5) is the MNE’s effective tax rate and equals the weighted average of all national tax rates, the weights being equal to the apportionment shares.

We consider a general equilibrium model where all relevant prices are determined endogenously. The model is therefore closed by the market equilibrium conditions. The world capital market is in equilibrium if

$$\sum_{j=1}^{n}k_j = n\bar{k}.$$  

This condition requires that the MNE’s capital demand equals the households’ capital supply. The equilibrium condition for the local labor market in country $i$ reads

$$\ell_i = \bar{l}.$$  

Hence, labor demand of the MNE in country $i$ has to be equal to labor supply of the household in country $i$. As we will see below, capital and labor demand of the MNE depend on the factor prices and, thus, the equilibrium conditions (6) and (7) endogenously determine the interest rate $r$ and the wage rates $w_i$ for $i \in \{1, \ldots, n\}$.

### 3 Market Equilibrium

In order to characterize the properties of the market equilibrium, we have to derive the MNE’s capital and labor demand. The MNE sets capital and labor such that its after-tax profits (4) are maximized. The first-order conditions are given by

$$\sum_{j=1}^{n}\phi_j \cdot \sum_{j \neq i}(t_i - t_j)A^j_{k_i} + (1 - \tau)F_k(k_i, \ell_i) - (1 - \rho \tau)r = 0,$$

$$\sum_{j=1}^{n}\phi_j \cdot \sum_{j \neq i}(t_i - t_j)A^j_{\ell_i} + (1 - \tau)[F_\ell(k_i, \ell_i) - w_i] = 0,$$
for \( i \in \{1, \ldots, n\} \). To understand the rationale of these conditions, initially ignore the terms containing the formula derivatives \( A_{k_i}^j \) and \( A_{\ell_i}^j \). The conditions then have the standard logic of equalizing marginal returns and marginal costs. According to (8), the MNE expands investment in country \( i \) until the after-tax marginal returns to capital, \((1 - \tau)F_k(k_i, \ell_i)\), equal the after-tax marginal costs of capital, \((1 - \rho \tau)r\). Almost the same is true for profit-maximizing labor input determined by (9), except that now the before-tax marginal returns and costs, \(F_\ell(k_i, \ell_i)\) and \(w_i\), are relevant since payroll is fully tax-deductible. Formula Apportionment enters (8) and (9) in two ways. First, since tax bases are consolidated, the returns from country \( i \) are not only taxed in country \( i \) but also in all other countries. Hence, the relevant tax rate is the effective tax rate \( \tau \) instead of the national tax rate \( t_i \). Second, the MNE has additional incentives represented by the terms containing the derivatives \( A_{k_i}^j \) and \( A_{\ell_i}^j \) of the apportionment formula. These terms reflect the MNE’s formula manipulation incentive, i.e. the incentive to increase investment and labor demand in low-tax countries in order to increase the share of the consolidated tax base assigned to these countries.\(^4\)

The first-order conditions (8) and (9) together with the market equilibrium conditions (6) and (7) determine the capital and labor allocation, \( \{k_i\}_{i=1}^n \) and \( \{\ell_i\}_{i=1}^n \), the world interest rate \( r \) and the wage rates \( \{w_i\}_{i=1}^n \) in the market equilibrium as functions of the tax rates \( \{t_i\}_{i=1}^n \). For the subsequent analysis of tax competition and fiscal equalization we need to know the impact of the tax rates on the equilibrium allocation. The focus will be on a symmetric situation where all countries choose the same tax rate \( t_i = t \). Under symmetry, (6)–(9) yield \( k_i = \bar{k} \), \( \ell_i = \bar{\ell} \), \( w_i = w \) and \( \phi_i = \phi \). Moreover, symmetry implies \( A^i = 1/n \) and together with the market equilibrium conditions

\[
A_{k_i}^i = -(n - 1)A_{k_i}^i = \frac{n - 1}{n^2} \left( \frac{\gamma}{\bar{k}} + \frac{\sigma F_k}{F} \right),
\]

\[
A_{\ell_i}^i = -(n - 1)A_{\ell_i}^i = \frac{n - 1}{n^2} \left( \frac{\varphi}{\bar{\ell}} + \frac{\sigma F_\ell}{F} \right),
\]

\[
A_{w_i}^i = -(n - 1)A_{w_i}^i = \frac{n - 1}{n^2} \frac{\varphi}{F_\ell}.
\]

\(^4\)In order to illustrate, consider the case with two countries \( n = 2 \) and assume country \( i \) is the low-tax country \( (t_i < t_j) \). Note that \( A_{k_i}^j < 0 \) and \( A_{\ell_i}^j < 0 \). Hence, the first terms in (8) and (9) are positive and represent marginal benefits of capital and labor in country \( i \). They give the MNE the incentive to raise investment and labor demand in country \( i \), which is the low-tax country.
Totally differentiating (6)–(9) and afterwards applying the symmetry property, the appendix proves the comparative static results

$$\frac{\partial r}{\partial t_i} = -\frac{F_k - \rho r}{n(1 - \rho t)} < 0,$$

(13)

$$\frac{\partial k_i}{\partial t_i} = -(n - 1)\frac{\partial k_j}{\partial t_i} = \frac{(n - 1)\phi}{n(1 - t)F_{kk}} \left( \frac{\gamma k}{F} + \frac{\sigma F_k}{F} \right) < 0,$$

(14)

$$\frac{dw_i}{dt_i} = -(n - 1)\frac{\partial w_j}{\partial t_i} = \frac{(n - 1)\phi}{n(1 - t)F_{kk}} \left( \frac{\gamma F_{kt}}{k} + \frac{\sigma (F_{kt} - F_k F_{kk})}{F} - \frac{\varphi F_{kk}}{\ell} \right) < 0,$$

(15)

for \(i, j \in \{1, \ldots, n\}\) and \(i \neq j\). A reduction of the tax rate in country \(i\) induces the MNE to relocate capital from the other countries to country \(i\), as shown in equation (14). Moreover, the MNE reduces labor demand in all other countries in favor of labor demand in country \(i\). Since labor is totally immobile and fixed in supply, the changes in labor demand translate into corresponding changes in wage rates, as can be seen in equation (15). The rationale of these results goes back to the formula manipulation incentive. If country \(i\) reduces the tax rate, the MNE wants to increase the share \(A_i\) of the consolidated tax base taxed in country \(i\) and to reduce the shares \(A_j\) of the consolidated tax base taxed in all other countries \(j \neq i\). This is reached by investing more capital and demanding more labor in country \(i\) relatively to the other countries. Formally, the intuition is confirmed by the fact that the expressions in (14) and (15) are non-zero only if one of the formula weights \(\gamma\), \(\sigma\) or \(\varphi\) is positive. In addition, the reduction in the tax rate raises the interest rate according to (13). This effect is not caused by the apportionment formula, but merely by the direct effect of tax rate changes on the world interest rate via equation (8); all other effects cancel out.

### 4 Tax Competition

The governments of the countries finance their expenditures for the public good by the receipts from corporate income taxation and by fiscal equalization grants. Public expenditures of country \(i\) amount to \(g_i\). Tax revenues of country \(i\) read \(t_i A_i(\cdot) \sum_{j=1}^n \phi_j\).

The fiscal equalization grant is represented by the function \(T^i(t)\) where \(t := (t_1, \ldots, t_n)\) denotes the vector of statutory tax rates of all countries. A positive value of \(T^i(t)\) indicates a grant that country \(i\) receives, while a negative value of \(T^i(t)\) implies that country \(i\) makes a payment to the equalization system. Fiscal equalization is purely
redistributive, i.e. $$\sum_{j=1}^{n} T^j(t) = 0$$. The public budget constraint of country $$i$$ is

$$g_i = t_i A^i(k_i, k_{-i}, \ell_i, \ell_{-i}, w_i, w_{-i}) \sum_{j=1}^{n} \phi_j + T^i(t). \quad (16)$$

The government of country $$i$$ chooses its tax rate $$t_i$$ in order to maximize its resident’s utility $$U(c_i, g_i)$$ subject to the private and public budget constraints (1) and (16). In doing so, it takes into account the comparative static effects (13)–(15) of its tax policy on the market equilibrium. It takes as given the tax policy of the other countries. We therefore obtain a Nash tax competition game among the $$n$$ countries.

The Nash equilibrium is determined by $$\partial U(c_i, g_i)/\partial t_i = 0$$ for $$i \in \{1, \ldots, n\}$$. As all countries are assumed to be identical, we focus on the symmetric equilibrium with $$t_i = t$$, $$k_i = \bar{k}$$, $$\ell_i = \bar{\ell}$$, $$w_i = w$$, and $$\phi_i = \phi$$. With the help of (2), (4), (5) and (10)–(15), it is straightforward to show that the symmetric Nash equilibrium is characterized by

$$U_g/U_c = \frac{\phi - n \rho t \bar{k} \partial r/\partial t_i + (n - 1)(CE + WE + PE)}{\phi - n \rho t \bar{k} \partial r/\partial t_i - (n - 1)(TE + FE) + T_i^i}, \quad (17)$$

with

$$CE = \bar{k} \partial r/\partial t_i < 0, \quad WE = \bar{\ell} \partial w_j/\partial t_i > 0, \quad PE = \frac{1}{n} \frac{\partial \pi}{\partial t_i} = \frac{1}{n} \left[ -\phi - n(1 - \rho t) \bar{k} \partial r/\partial t_i \right] < 0, \quad (18)$$

$$TE = \frac{t}{n} \sum_{j=1}^{n} \frac{\partial \phi_j}{\partial t_i} = -\rho t \bar{k} \partial r/\partial t_i > 0, \quad (19)$$

$$FE = tn\phi \frac{\partial A^j}{\partial t_i} = t\phi \left[ \left( \frac{\gamma}{\bar{k}} + \frac{\sigma F_k}{F} \right) \frac{\partial k_j}{\partial t_i} + \frac{\varphi w_j}{w \partial t_i} \right] > 0. \quad (20)$$

The expressions in (18) represent pecuniary externalities of corporate taxation. They indicate how changes in the tax rate of one country affect private income of other countries. If country $$i$$ reduces its tax rate, the interest rate goes up according to (13). As consequence, capital income in country $$j \neq i$$ increases (negative capital income externality CE). Profit income goes up since the direct positive effect of the tax reduction on the MNE’s profits overcompensates the indirect negative effect via the increase in the interest rate (negative profit income externality PE). Moreover,

5The sign of PE follows from using symmetry, (9), (13) and the Euler Theorem $$mF = \bar{k} F_k + \bar{\ell} F_{\ell}$$ in the definition of PE in (18). The result is $$PE = -(1 - m)F/n < 0$. 

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the reduction in country $i$’s tax rate lowers the wage rate in country $j \neq i$ according to (15) and, thus, the wage income in country $j \neq i$ (positive wage income externality $WE$). Equations (19) and (20) represent the fiscal externalities of corporate taxation. If country $i$ reduces its tax rate, the consolidated tax base and thereby tax revenues in country $j \neq i$ fall (positive tax base externality $TE$). This effect solely rests on the increase in the interest rate; changes in the capital allocation and wage rates cancel out due to consolidation. Finally, the reduction in country $i$’s tax rate induces the MNE to manipulate the apportionment formula by reducing the share of the consolidated tax base assigned to country $j \neq i$ (positive formula externality $FE$).

In the absence of fiscal equalization, the pecuniary and fiscal externalities reflect the deviation of the equilibrium tax rates from their Pareto-efficient (cooperative) level. Formally, this can be seen by setting all externalities and the marginal equalization grant $T^i_t$ equal to zero in (17). The Nash equilibrium condition of the tax competition game then simplifies to $U_g/U_c = 1$ which is the Samuelson rule for the Pareto-efficient provision of the public good (see the appendix). Due to the complexity of our approach, it is not possible to determine the sign of the sum of externalities $CE + WE + PE + TE + FE$ and, thus, to state whether equilibrium tax rates are inefficiently low or high (positive or negative sign of the sum of externalities). However, the sum of externalities is zero only by accident. The equilibrium tax rates are therefore usually inefficient.

5 Fiscal Equalization

This inefficiency result holds in the absence of fiscal equalization. In contrast, when an equalization scheme is implemented, it may be shaped in such a way that the equilibrium tax rates become efficient. To see this, set

$$T^i_t = (n - 1)(CE + WE + PE + TE + FE).$$

Inserting (21) into (17) implies $U_g/U_c = 1$, i.e. the equilibrium condition coincides with the Samuelson rule and the equilibrium tax rates are efficient. Intuitively, the marginal transfer (21) plays a Pigouvian role. It induces the government of country $i$ to internalize all pecuniary and fiscal externalities of its tax policy and to choose the efficient tax rates. The question is which type of fiscal equalization scheme satisfies the Pigouvian condition (21). We consider tax base and tax revenues equalization.
**Tax Base Equalization.** In practice, tax base equalization is usually implemented as Representative Tax System (RTS). The RTS tries to equalize deviations of the countries’ tax bases from the average tax base. Under Formula Apportionment the corporate tax base of country \(i\) is given by \(\phi_i = A^i \sum_{j=1}^{n} \phi_j\). The average corporate tax base can be written as \(\bar{\phi} = \sum_{j=1}^{n} \phi_j / n = \sum_{j=1}^{n} \phi_j / n\) since \(\sum_{j=1}^{n} A^i = 1\). The equalization transfer of country \(i\) under the RTS then reads

\[
T^{iB}(t) = \bar{t}(\bar{\phi} - \phi_i),
\]

(22)

where \(\bar{t} = \sum_{j=1}^{n} t_j \phi_j / \sum_{j=1}^{n} \phi_j\) is the so-called representative tax rate. Applied to the world tax base, the representative tax rate generates the same tax revenues as the sum of tax revenues from all countries. According to (22), the RTS neutralizes any attempt of country \(i\) to increase the tax base \(\phi_i\) above the average tax base \(\bar{\phi}\).

We first describe the distortions caused by tax base equalization and in the next section check whether this type of equalization satisfies the Pigouvian condition (21). From (2), (14), (15), (19), (20), (22) and \(\partial A^i / \partial t_i = -(n-1)(\partial A^i / \partial t_i)\) it follows

\[
T^{iB}(t) = -\rho t \bar{k} \frac{\partial r}{\partial t_i} - t \frac{\partial \phi_i}{\partial t_i} = (n-1)FE = (n-1)(TE + FE) + (n-1)\rho t \bar{k} \frac{\partial r}{\partial t_i}.
\]

(23)

There are two distortions of tax base equalization. First, it does not internalize the pecuniary externalities since it aims at equalizing tax bases and not private income. Formally, this pecuniary distortion can be seen at (23) which does not contain the pecuniary externalities. Second, tax base equalization even fails to fully internalize the fiscal externalities since \(T^{iB}(t) < (n-1)(TE + FE)\) due to (23). The reason for this fiscal distortion is as follows. Start in a fully symmetric situation and suppose country \(i\) reduces its tax rate. The change in tax revenues is represented by the expression \(-t(\partial \phi_i / \partial t_i)\) in the first part of (23). This expression can be written as

\[
-t \frac{\partial \phi_i}{\partial t_i} = -tn \phi \frac{\partial A^i}{\partial t_i} - t \sum_{j=1}^{n} \frac{\partial \phi_j}{\partial t_i}.
\]

(24)

Hence, the change in country \(i\)’s tax revenues is caused by a change in the apportionment share \(A^i\) and a change in the consolidated tax base \(\sum_{j=1}^{n} \phi_j\). With a constant average tax base \(\bar{\phi}\), the change in country \(i\)’s tax revenues given by (24) would be completely taken away by tax base equalization and used to compensate the other countries for their decline in tax revenues. However, under Formula Apportionment the average
tax base is not constant. Changes in the capital and labor allocation cancel out, indeed, but the reduction in country $i$’s tax rate increases the interest rate and therefore has a negative impact on the average tax base. This effect is reflected by $-\rho k (\partial r / \partial t_i)$ in the first part of (23). It neutralizes the change of country $i$’s tax base via changes in the consolidated tax base, i.e. the part $-t \sum_{j=1}^{n} (\partial \phi_j / \partial t_i) / n$ in (24) which just equals $\rho k (\partial r / \partial t_i)$. What remains is only the change via the apportionment share, i.e. the term $-tn\phi (\partial A^i / \partial t_i)$ in (24). But the size of redistribution is then not large enough to compensate the other countries for their reduction in tax revenues. Hence, tax base equalization reflects the formula externality, but not the tax base externality.$^6$

**Tax Revenue Equalization.** Tax revenue equalization tries to directly equalize differences in the countries’ tax revenues. Country $i$’s tax revenues are given by $t_i \phi_i^c$. Average tax revenues are $\overline{\phi c} = \sum_{j=1}^{n} t_j \phi_j^c / n$. Country $i$’s fiscal transfer then reads

$$ T_i^R(t) = \overline{\phi c} - t_i \phi_i^c. $$

(25)

Differentiating (25) in the same way as (22) gives

$$ T_i^{Rt} = T_i^{Bt} - \phi \frac{n-1}{n}. $$

(26)

If we compare (26) with (23), we see that the marginal effects of country $i$’s tax rate on the equalization transfer under tax revenue equalization encompass all marginal effects occurring under tax base equalization ($T_i^{Bt}$). Hence, tax revenue equalization is also characterized by the pecuniary and fiscal distortions described above. But under tax revenue equalization there is an additional effect reflected by the term $-\phi(n-1)/n$ in (26). For a given tax base, the decrease in country $i$’s tax rate directly reduces country $i$’s tax revenues by $\phi$. Also the average tax revenues of all countries fall, but due to averaging only by $\phi/n < \phi$. Hence, the additional direct effect under tax revenue equalization further reduces the net transfer that country $i$ pays to the other countries and aggravates the fiscal distortion, i.e. the degree to which the fiscal externality is internalized decreases compared to tax base equalization.

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$^6$This story is also true when the number of countries is large and each country has a negligible impact on the interest rate. For $n \to \infty$, the effect of a single country on the interest rate really converges to zero due to (13). But the number of countries that are affected goes to infinity. Multiplying both effects shows that the net effect is positive even if $n \to \infty$. Formally, inserting (13), (19) and (20) in (23), we see that $T_i^{Bt}$ is proportional to $(n-1)/n$ which goes to one if $n \to \infty$. 

13
6 Results

We now use the insights from the previous sections in order to formulate our main results. We start with the question whether equilibrium tax rates under tax base and tax revenue equalization are inefficiently high or low. Thereafter we compare equilibrium tax rates under the two equalization schemes and finally we take a closer look at the efficiency properties of the equilibrium tax rates under tax base equalization.

**Efficiency Properties of Equalization Schemes.** Using (18)–(20), the marginal transfers (23) and (26) under tax base and tax revenue equalization can be written as

\[
T_{iB}^t = (n - 1)(FE + TE + CE + PE) + \phi \frac{n - 1}{n},
\]

\[
T_{iR}^t = (n - 1)(FE + TE + CE + PE).
\]

Comparing (27) and (28) with (21) it is straightforward to prove

**Proposition 1.** Under tax revenue equalization \([T^i(t) = T^{iR}(t)]\) equilibrium tax rates are inefficiently low. Compared to this, equilibrium tax rates are higher under tax base equalization \([T^i(t) = T^{iB}(t)]\), but still inefficiently low if \(WE > \phi/n\), inefficiently high if \(WE < \phi/n\) and efficient if \(WE = \phi/n\).

The intuition of these results can be explained with the help of (27) and (28). As seen from (28), under tax revenue equalization the net effect of the pecuniary and fiscal distortions is that the wage income externality \((n - 1)WE\) is ignored. According to (18) this externality is positive and, thus, equilibrium tax rates under tax revenue equalization are inefficiently low. Tax base equalization also induces the countries to ignore the wage income externality and to reduce their corporate tax rates below their efficient levels, as becomes obvious from (27). However, the fiscal distortion under tax base equalization is less severe than under tax revenue equalization. The difference is reflected by the term \(\phi(n - 1)/n\) in (26) and (27). This term gives the country an incentive to increase tax rates. Hence, equilibrium tax rates are always higher under tax base equalization than under tax revenue equalization. If the countries’ incentive to raise tax rates according to the term \(\phi(n - 1)/n\) is weaker than their incentive to lower tax rates according to the wage income externality \((n - 1)WE\), the equilibrium tax rates under tax base equalization stay below their efficient level. For \(\phi(n - 1)/n\)
equal to the wage income externality \((n-1)\text{WE}\) both incentives just neutralize each other and equilibrium tax rates under tax base equalization are efficient. If \(\phi(n-1)/n\) is larger than \((n-1)\text{WE}\), then the countries’ incentive to raise tax rates becomes so strong that equilibrium tax rates lie above their efficient levels.

**Comparison of Equalization Schemes.** An immediate question following from Proposition 1 is under which equalization scheme the equilibrium tax rates are more efficient. From the analysis so far it is straightforward to derive

**Proposition 2.** *Equilibrium tax rates are more efficient under tax revenue equalization* \([T^i(t) = T^{iR}(t)]\) *than under tax base equalization* \([T^i(t) = T^{iB}(t)]\) *iff* \(2 \cdot \text{WE} < \phi/n\).

As far as equilibrium tax rates under tax base equalization are inefficiently low, they are higher and thereby more efficient than those under tax revenue equalization according to Proposition 1. Hence, tax revenue equalization may only be superior to tax base equalization if the latter generates inefficiently high corporate tax rates and if this overtaxation is more severe than undertaxation under tax revenue equalization. This is the case if the distortion under tax base equalization is stronger in absolute terms than the distortion under tax revenue equalization. Formally, we obtain \(-\text{WE} + \phi/n > \text{WE}\) or, equivalently, \(2 \cdot \text{WE} < \phi/n\) as stated in Proposition 2.

In stark contrast to the previous literature, we therefore identify a condition under which tax base equalization performs worse in fighting tax competition than tax revenue equalization. In the standard tax competition model with a unit tax on capital, tax base equalization induces governments to implement the efficient levels of tax rates, while tax revenue equalization does not (e.g. Köthenbürger, 2002; Bucovetsky and Smart, 2006; Kotsogiannis, 2010). If the unit tax is replaced by a tax on corporate income, then tax base equalization also fails to restore efficiency in the tax competition game between governments; equilibrium tax rates are inefficiently low. However, in this setting tax revenue equalization performs even worse and further lowers the equilibrium tax rates below their efficient levels (Liesegang and Runkel, 2016). As shown by our analysis, in contrast, when we take into account that in many federations with equalization schemes the corporate tax system follows the Formula Apportionment principle, then tax revenue equalization may become superior to tax base equalization.
In order to show that there are really model specifications satisfying the condition for the superiority of tax rate equalization, we consider an example. Suppose a Cobb-Douglas production technology $F(k_i,\ell_i) = k_i^\alpha \ell_i^\beta$ with $\alpha, \beta \in [0,1]^2$ and $\alpha + \beta < 1$. Moreover, consider a Cobb-Douglas utility function $U(c_i, g_i) = g_i^\xi c_i^{1-\xi}$ with $\xi \in ]0,1[$. Capital costs are not deductible at all, so $\beta = 1$ and $\sigma = \varphi = 0$. In the symmetric case, we obtain $r = (1-t)\alpha \bar{k}^{\alpha-1} \bar{\ell}^\beta$, $w = \beta \bar{k}^{\alpha} \bar{\ell}^{\beta-1}$, $\pi = n(1-t)(1-\alpha-\beta)\bar{k}^{\alpha} \bar{\ell}^\beta$, $g = t\phi = t(1-\beta)\bar{k}^{\alpha} \bar{\ell}^\beta$ and $c = [1-(1-\beta)t]\bar{k}^{\alpha} \bar{\ell}^\beta$.

Using (13)–(15) and (18), the pecuniary externalities can be written as

\[ CE + WE + PE = -\frac{\phi (1-t)(1-\alpha) - \beta}{n (1-t)(1-\alpha)}, \quad CE + PE = -\frac{\phi}{n}. \]  

(29)

Denote the Pareto-optimal tax rate by $t^P$ and the equilibrium tax rate under tax base and tax revenue equalization by $t^B$ and $t^R$, respectively. From $U_g = \varepsilon g^{\xi-1} c^{1-\varepsilon}$ and $U_c = (1-\varepsilon) g^\xi c^{-\varepsilon}$ as well as equations (17), (27) and (28), we obtain

\[ \frac{\varepsilon}{1-\varepsilon} \frac{1-(1-\beta)t^P}{(1-\beta)t^P} = 1, \]  

(30)

\[ \frac{\varepsilon}{1-\varepsilon} \frac{1-(1-\beta)t^B}{(1-\beta)t^B} = \frac{\phi + (n-1)(CE + WE + PE)}{\phi + (n-1)(CE + PE + \phi/n)}, \]  

(31)

\[ \frac{\varepsilon}{1-\varepsilon} \frac{1-(1-\beta)t^R}{(1-\beta)t^R} = \frac{\phi + (n-1)(CE + WE + PE)}{\phi + (n-1)(CE + PE)} \]  

(32)

Inserting (29) and rearranging gives the following (implicit) solutions for the tax rates

\[ t^P = \frac{\varepsilon}{1-\beta}, \]  

(33)

\[ t^B = \frac{\varepsilon}{1-\beta} + \frac{n-1}{n} \frac{(1-\alpha)(1-t^B) - \beta}{(1-\alpha)(1-t^B)} (1-\varepsilon)t^B, \]  

(34)

\[ t^R = \frac{\varepsilon}{1-\beta} - (n-1) \frac{\beta}{(1-\alpha)(1-t^R)} (1-\varepsilon)t^R. \]  

(35)

For $\beta > 0$ it follows from (33)–(35) that $t^R < t^P$ and $t^B \leq t^P$, consistently with Proposition 1. Consider now the extreme case with $\beta \to 0$. We then obtain

\[ t^R \to \varepsilon = t^P, \quad t^B \to \varepsilon + \frac{n-1}{n} (1-\varepsilon)t^B > \varepsilon = t^P, \]  

since $\varepsilon < 1$ and $n \geq 2$. From this, we may deduce\(^7\)

\[ As a numerical example for this corollary, set $\alpha = 0.3$, $\beta = 0.1$, $\varepsilon = 0.05$, $n = 4$, $\bar{k} = 10$ and $\bar{\ell} = 2$. Then, $t^P = 0.056$, $t^B = 0.137$ and $t^R = 0.039$. The welfare levels are $W^P = 1.753$, $W^B = 1.700$ and $W^R = 1.748$, so tax revenue equalization yields higher welfare than tax base equalization.
Corollary 1. Suppose \( F(k, \ell) = k^\alpha \ell^\beta \) with \( \alpha, \beta \in [0,1]^2 \), \( \alpha + \beta < 1 \) and \( U(c, g) = g^\varepsilon c^{1-\varepsilon} \) with \( \varepsilon \in [0,1] \). Moreover, assume \( \rho = 0 \), \( \gamma = 1 \) and \( \sigma = \varphi = 0 \). Then there exists a strictly positive threshold value \( \beta > 0 \) such that equilibrium tax rates are more efficient under tax revenue than under tax base equalization if and only if \( \beta < \bar{\beta} \).

In our example, we have a pure capital apportionment formula, so the wage income externality WE is already rather low. Moreover, WE is the lower, the smaller is the production elasticity of labor, \( \beta \), since for a small \( \beta \) the input labor is not that essential for production. At a certain level of the labor production elasticity, the wage income externality WE becomes smaller than \( \phi/2n \) and, thus, the condition for the superiority of tax revenue over tax base equalization identified in Proposition 2 is satisfied.

Efficiency under Tax Base Equalization. Even though we have shown in the previous paragraph that tax revenue equalization may be better than tax base equalization, there is an important advantage of tax base equalization. In contrast to tax revenue equalization where equilibrium corporate tax rates are always efficiently low, under tax base equalization equilibrium corporate tax rates may be efficient. As shown in Proposition 1 this is the case if \( WE = \phi/n \) or, using (15) and (18), if

\[
\frac{\ell}{(1-tP)F_{kk}} \left( \frac{\gamma F_{kk}}{k} + \frac{\sigma (F_{kF_{kl}} - F_l F_{kk})}{F} - \frac{\varphi F_{kk}}{\ell} \right) = 1, \tag{37}
\]

where we have evaluated the resulting expression at the efficient corporate tax rate \( tP \).

From (37) it becomes obvious that the shape of the apportionment formula is decisive for the efficiency property of tax base equalization.

Consider first a pure payroll formula, i.e. \( \varphi = 1 \) and \( \gamma = \sigma = 0 \). Inserting into (37), we obtain \( 1/(1-tP) = 1 \) and, thus, a contradiction. This means that with a pure payroll formula tax base equalization is not able to restore efficiency. Moreover, inserting \( \varphi = 1 \) and \( \gamma = \sigma = 0 \) into the wage income externality in (18), we get \( WE - \phi/n = t\phi/[n(1-t)] > 0 \). Hence, \( WE > \phi/n \) and Proposition 1 implies

Proposition 3. Suppose Formula Apportionment uses a pure payroll formula (\( \varphi = 1 \), \( \gamma = \sigma = 0 \)). Equilibrium corporate tax rates under tax base equalization \( [T^i(t) = T^{iB}(t)] \) are then inefficiently low.

The intuition of this proposition is straightforward. With a pure payroll formula, the input factor labor receives a high weight in the apportionment of consolidated profits.
Hence, the wage income externality \((n-1)\)WE is relatively large and the corresponding incentive of governments to reduce tax rates is stronger than their incentive to increase tax rates due to the term \((n-1)\phi/n\). The net effect is that governments set their corporate tax rates below their efficient level, as stated in Proposition 3. This insight shows that the German system with tax base equalization and pure payroll Formula Apportionment on the municipality level does not ensure efficient corporate tax rates.

The implication of Proposition 3 for Germany raises the question how tax base equalization among Canadian provinces performs. The Formula Apportionment system in Canada uses an equally weighted sales-payroll formula, i.e. \(\gamma = 0\) and \(\sigma = \phi = 0.5\). For this formula, the complexity of our analysis prevents clear-cut results. We therefore turn to numerical simulations and calibrate the model to the Canadian economy. According to Tsurumi (1970), the substitution elasticity between labor and capital in Canadian industries is pretty close to one. Hence, as a rough approximation we can continue to work with the Cobb-Douglas technology already used in Corollary 1. Inserting this technology together with \(\gamma = 0\) and \(\sigma = 1 - \phi\) into (37) gives

\[
\sigma^P = \frac{1 - \alpha}{1 - \alpha - \beta} t^P, \tag{38}
\]

where \(\sigma^P\) is the efficient weight on sales if the formula uses only sales and payroll. As can be seen from (38), this efficient weight on sales depends on the efficient tax rate \(t^P\). In order to determine \(t^P\) we have to solve the Samuelson rule \(U_g/U_c = 1\).

For Cobb-Douglas production, it follows from (1)–(9) and symmetry that

\[
r = (1 - t)\alpha k^{\alpha - 1} \ell^\beta / (1 - \rho t), \quad \phi = [1 - \alpha - \beta + \alpha(1 - \rho)/(1 - \rho t)]k^{\alpha} \ell^\beta, \quad \pi = n(1 - t)(1 - \alpha - \beta)k^{\alpha} \ell^\beta, \\
g = t[1 - \alpha - \beta + \alpha(1 - \rho)/(1 - \rho t)]k^{\alpha} \ell^\beta \quad \text{and} \quad c = \{1 - t[1 - \alpha - \beta + \alpha(1 - \rho)/(1 - \rho t)]\}k^{\alpha} \ell^\beta.
\]

With the Cobb-Douglas utility function, the Samuelson rule becomes \(\varepsilon c = (1 - \varepsilon)g\). Inserting \(c\) and \(g\) and solving gives the efficient corporate tax rate

\[
t^P = \frac{1 - \alpha - \beta + \alpha(1 - \rho) + \varepsilon \rho}{2\rho(1 - \alpha - \beta)} + \sqrt{\frac{[1 - \alpha - \beta + \alpha(1 - \rho) + \varepsilon \rho]^2}{4\rho^2(1 - \alpha - \beta)^2} - \frac{\varepsilon}{\rho(1 - \alpha - \beta)}}, \tag{39}
\]

where we have excluded a second solution that yields values larger than one.

In order to compute the efficient tax rate (39), we have to use values for the model parameters. The production elasticities can be computed from Tsurumi (1970) as \(\alpha = 0.3302\) and \(\beta = 0.6141\). The deductibility parameter is taken from Riedel and

\[\text{Tsurumi (1970) starts with the CES production function } F(k, \ell) = [\delta k^\nu + (1 - \delta)\ell^\nu]^{-\mu/\nu}. \text{ In Table}\]
Runkel (2007) who obtain $\rho = 0.69$. Finally, we have to determine the preference parameter $\varepsilon$. To the best of our knowledge, there is no estimation of this parameter in the literature. We therefore calibrate our model to the Canadian economy in order to obtain an approximation. For this, consider the equilibrium tax rate $t^B$ under tax base equalization determined by (17) together with (27). Using the Cobb-Douglas specification as well as $\gamma = 0$ and $\varphi = 1 - \sigma$, we obtain after some tedious calculations

$$
\varepsilon \frac{1 - t^B \left[ 1 - \alpha - \beta + \frac{\alpha (1 - \rho)}{1 - \rho t^B} \right]}{1 - \varepsilon \frac{t^B \left[ 1 - \alpha - \beta + \frac{\alpha (1 - \rho)}{1 - \rho t^B} \right]}{1 - \alpha - \beta + \frac{\alpha (1 - \rho)}{1 - \rho t^B}}} = \left[ 1 - \alpha - \beta + \frac{\alpha (1 - \rho)}{1 - \rho t^B} \right] \left[ 1 + \frac{n - 1}{1 - t^B} \left( 1 - \sigma \frac{1 - \alpha - \beta}{1 - \alpha} \right) + \frac{\alpha \rho t^B (1 - \rho)}{(1 - \rho t^B)^2} \right] + n \left[ 1 - \alpha - \beta + \frac{\alpha (1 - \rho)}{1 - \rho t^B} \right] + \frac{\alpha \rho t^B (1 - \rho)}{(1 - \rho t^B)^2}. \tag{40}
$$

We already know $\alpha = 0.3302$, $\beta = 0.6141$ and $\rho = 0.69$. Moreover, in Canada we have $n = 13$ provinces and $\sigma = 0.5$. We then set $\varepsilon$ in (40) such that the resulting tax rate $t^B$ equals the average tax rate of Canadian provinces. This average tax rate is currently around $t^B = 0.08$. Inserting into (40) and solving gives $\varepsilon = 0.0136$.

We are now in the position to compute the optimal corporate tax rate and the optimal formula weight. Inserting $\alpha = 0.3302$, $\beta = 0.6141$, $\rho = 0.69$ and $\varepsilon = 0.0136$ into (38) and (39) gives $t^P = 0.083$ and $\sigma^P = 0.997$. Hence, our simple calibration of the model suggests that the currently employed apportionment formula without capital factor and with equal weight on sales and payroll does not ensure efficiency of tax base equalization among Canadian provinces. Efficiency gains may be realized by switching to a pure sales formula with $\sigma^P \approx 1$. The rationale goes again back to the wage income externality. The apportionment formula in Canada puts lower weight on payroll than the formula in German municipalities, indeed, but the weight is still too large and the corresponding wage income externality too high compared to the term $\phi/n$. Lowering the weight on the payroll factor and putting more weight on sales

1, he estimates $\nu = -0.0001$, $\delta = 0.3497$ and $\mu = 0.9443$. The result $\nu = -0.0001$ means that the substitution elasticity $1/(1 - \nu)$ is approximately one and we obtain the special case of Cobb-Douglas production $F(k, \ell) = k^{\alpha} \ell^\beta$ with $\alpha = \delta \mu = 0.3302$ and $\beta = (1 - \delta) \mu = 0.6141$.

9We here take the average of the general tax rates and the reduced tax rates levied on small business. See www2.deloitte.com/ca/en/pages/tax/articles/canadian-tax-rates-archive.html.
reduces the wage income externality up to the point where WE just equals \( \phi/n \). In the Canadian example, this is the case if sales get all the weight in the formula.

If we consider the general three-factor formula, it can be shown that the above analysis remains completely unchanged except for replacing \( \sigma^P \) by \( \sigma^P + \gamma^P \). Hence, the optimal formula under tax base equalization for Canadian provinces is described by \( \sigma^P + \gamma^P \approx 1 \) and \( \phi^P \approx 0 \). Hence, the pure sales formula is not the only formula that ensures efficiency. For example, the equally weighted capital-sales formula with \( \sigma^P = 0.5 \) and \( \gamma^P = 0.5 \) will do the job, too. Also in this case, payroll should not be included into the formula since it generates a wage income externality that is too high.

## 7 Conclusion

This paper includes the corporate tax principle of Formula Apportionment into the analysis of fiscal equalization and tax competition. A multi-country general equilibrium approach determines the market equilibrium that is influenced by the countries’ tax policy. On this market equilibrium, the countries play a Nash tax competition game where taxation follows Formula Apportionment and countries are connected by a fiscal equalization scheme. In contrast to the previous literature, we show that in such a model equilibrium tax rates may be more efficient under tax revenue than tax base equalization. The latter equalization scheme nevertheless has the advantage over the former that it may yield efficient tax rates. We have shown that this is not the case when payroll enters the apportionment formula, as in Germany and Canada, but that a pure sales formula may be a more efficient formula design.

Of course, there are many options to extend or generalize our analysis. Perhaps most important is to emphasize that our calibration to Canadian provinces is only a back-of-the-envelope exercise and should not yet been seen as a sophisticated tool to derive reliable implications for concrete policy consulting. More suitable for this purposes would be a large scale simulation model that may account for many other real-world features of corporate tax competition and fiscal equalization, for example, country asymmetries, intertemporal issues of the firms’ investment decision or federal corporate income taxes. We nevertheless believe that our simple calibration has an important benefit as a good starting point for such a more complex policy analysis.
Appendix

Proof of equations (13)–(15). Totally differentiating (8) and (9), taking into account $d\ell_i = 0$ from (7) and applying the symmetry property yields

$$n\phi \sum_{j \neq i} (dt_i - dt_j)A^j_{ki} + (1-t)F_{kk}dk_i - (F_k - \rho r)dt - (1-t\rho)dr = 0,$$

(41)

$$n\phi \sum_{j \neq i} (dt_i - dt_j)A^j_{ki} + (1-t)F_{kk}dk_i - (1-t)dw_i = 0.$$  

(42)

Equation (5) and the symmetry assumption imply $d\tau = \sum_{j=1}^n dt_j/n$. Inserting into (41) and solving for $k_i$ gives

$$dk_i = \frac{1}{(1-t)F_{kk}} \left\{ \frac{F_k - \rho r}{n} \sum_{j=1}^n dt_j - n\phi A^j_{ki} \left[ (n-1)dt_i - \sum_{j \neq i}^n dt_j \right] + (1-t\rho)dr \right\}.$$  

(43)

If we sum up (43) over all $i \in \{1, \ldots, n\}$ and take into account $\sum_{i=1}^n dk_i = 0$ from (6) as well as $\sum_{i=1}^n [(n-1)dt_i - \sum_{j \neq i}^n dt_j] = 0$, equation (43) simplifies to

$$dr = -\frac{F_k - \rho r}{n(1-t\rho)} \sum_j dt_j.$$  

(44)

Equation (13) follows from (44), if we set $dt_i \neq 0$ and $dt_j = 0$ for $j \neq i$. Inserting equation (44) back into equation (43) implies

$$\frac{\partial k_i}{\partial t_i} = -(n-1)\frac{\partial k_i}{\partial t_j} = -\frac{n(n-1)\phi A^j_{ki}}{(1-t)F_{kk}}.$$  

(45)

Using (10) proves (14). Finally, from (42) we obtain

$$dw_i = F_{kk}dk_i + \frac{n\phi}{1-t} \sum_{j \neq i} (dt_i - dt_j)A^j_{ki},$$  

(46)

and, thus,

$$\frac{\partial w_i}{\partial t_i} = F_{kl} \frac{\partial k_i}{\partial t_i} + \frac{n(n-1)\phi}{1-t} A^j_{ki}, \quad \frac{\partial w_i}{\partial t_j} = F_{kl} \frac{\partial k_i}{\partial t_j} - \frac{n\phi}{1-t} A^j_{ki}.$$  

(47)

Using (45) and (11) proves (15). □

Pareto-efficient (cooperative) solution. The efficient solution follows from maximizing the countries’ joint welfare given by

$$\sum_{j=1}^n U(c_j, g_j) = \sum_{j=1}^n U \left( r\vec{k} + w_j\vec{\ell} + \frac{\pi}{n}, t_jA^j(\cdot) \sum_{z=1}^n \phi_z \right).$$  

(48)
where $\phi_z$, $\pi$, $r$, $k_j$ and $w_j$ depend on the tax rates according to (2), (4) and (13)–(15). Maximizing the joint welfare (48) with respect to country $i$’s tax rate $t_i$ and applying the symmetry property yields the first-order condition

$$U_c \left( nk \frac{\partial r}{\partial t_i} + \ell \sum_{j=1}^{n} \frac{\partial w_j}{\partial t_i} + \frac{\partial \pi}{\partial t_i} \right) + U_g \left( \phi + tn\phi \sum_{j=1}^{n} \frac{\partial A_j}{\partial t_i} + t \sum_{j=1}^{n} \frac{\partial \phi_j}{\partial t_i} \right) = 0. \tag{49}$$

From (2), (4), (13)–(15) and $\sum_{j=1}^{n} A^j = 1$ we obtain $\sum_{j=1}^{n} \frac{\partial w_j}{\partial t_i} = 0$, $\frac{\partial \pi}{\partial t_i} = -\phi - n(1 - \rho t)\bar{k}(\partial r/\partial t_i)$, $\sum_{j=1}^{n} \frac{\partial A_j}{\partial t_i} = 0$ and $\sum_{j=1}^{n} \frac{\partial \phi_j}{\partial t_i} = -n\rho \bar{k}(\partial r/\partial t_i)$. Inserting into (49) gives

$$U_c \left( -\phi + n\rho t \bar{k} \frac{\partial r}{\partial t_i} \right) + U_g \left( \phi - n\rho t \bar{k} \frac{\partial r}{\partial t_i} \right) = 0, \tag{50}$$

and, thus, the Samuelson rule $U_g/U_c = 1$. ■

References


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