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Fiscal equalisation schemes under competition

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Abstract This paper considers optimal fiscal equalisation in a federation that competes with other federations for business tax base. It formalises the argument that, under certain circumstances, federations have an incentive to foster tax competition among their subunits in order to attract tax base from other federations. We show that optimal fiscal equalisation serves the purpose of redistributing income from rich to poor subunits and of choosing an optimal level of tax competition. The latter is chosen as a trade-off between three goals. First, decentralised tax rate setting has positive fiscal externalities within the federation and, thus, tax rates are inefficiently low. Second, in the presence of hold-up problems in investment, tax rates may be inefficiently high. Then, tax competition serves as a commitment device for low future tax rates and is, thus, welfare enhancing. Third, generous fiscal equalisation within the federation is a commitment to not aggressively compete with subunits outside the federation for tax base; as a consequence, with optimal equalisation, equilibrium tax rates are higher within and outside the federation—and even higher than in the case of centralised (i.e. federal level) tax rate setting.

Keywords Business taxation · Fiscal equalisation · Tax competition

JEL Classification H25 · H32 · H87

1 Introduction

Fiscal equalisation schemes have the well-known side effect of mitigating tax competition within federations (see e.g. Wildasin 1989; Köthenbürger 2002; Bucovetsky

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and Smart 2006). Less attention has been paid to the fact that federations never comprise the whole world and, thus, are most probably themselves in tax competition with other federations. In this paper, we analyse a federation's optimal choice of fiscal equalisation in the presence of competing federations. We formalise the idea that federations may choose low levels of equalisation and, thus, a high degree of tax competition within the federation in order to attract capital from outside.

We consider a model in which the world is partitioned into a number of federations with a fixed number of subunits. The subunits' governments individually determine the business tax rate. The federal government implements a fiscal equalisation scheme which, if optimally set, serves the purpose of equalising differences in tax bases across subunits and determining an optimal degree of tax competition. The latter trades off three different objectives. First, as the subunits' governments do not take into account that the capital outflow in response to a tax raise increases tax revenue in other subunits, tax rate setting within the federation may be inefficiently low (like in Zodrow and Mieszkowski 1986). By choosing an adequate degree of fiscal equalisation, the federal government may increase the equilibrium tax rate and, thus, internalise the fiscal externalities. Second, and in contrast to the first objective, tax rates within the federation may be inefficiently high when part of the production in the subunits is prone to a hold-up problem since investment is less flexible than tax rate setting (i.e. some firms have to make their investment decision before the tax rate is revealed). This may call for a low fiscal equalisation rate since tax competition serves as a commitment device for low future tax rates and, thus, solves the hold-up problem (like in Kehoe 1989). Third, fiscal equalisation may not only mitigate tax competition within the federation but also the competition with subunits outside the federation's borders. By choosing a high equalisation rate, the federation commits to not aggressively compete with outside subunits and, thus, increases equilibrium tax rates.

Our model may thus rationalise observable differences between real-world equalisation schemes. Most importantly, outside competition decreases equalisation rates, whereas inside competition increases them. An implication might be that if trade, capital or labour mobility across federations increase, fiscal equalisation may decline. Production technology is of key importance; if capital becomes locked-in after investment, equalisation rates may respond to the resulting hold-up problem by ensuring an adequate degree of tax competition in order to credibly hold tax rates down. The sometimes low degree of equalisation (or the absence of successful tax harmonisation) may therefore be explained as a response to competition from outside the federation. In the equilibrium with optimised equalisation, tax rates are still inefficiently low from a global point of view. However, tax rates are higher (and public goods provision is more efficient) than with centralised tax rate setting, even if subunits are perfectly homogeneous.

By accounting for inflexible capital, our model synthesises both main views on tax competition: the '*race to the bottom*' view formalised in Zodrow and Mieszkowski (1986) which builds on Oates (1972) and others; and the '*taming the Leviathan*' view formalised in Kehoe (1989) building on von Hayek (1948), Brennan and Buchanan

(1980) and others.[1] Depending on the view, fiscal equalisation is welcomed or rejected. If fiscal externalities make tax competition among benevolent governments inefficient, fiscal equalisation helps mitigating the problem by internalising the externalities. Seen from the other perspective, tax competition serves as a commitment device for the government not to expropriate businesses (or households) in the future and, thus, increases economic activity and welfare (Weingast 1995; Qian and Weingast 1997).[2] Our model contributes to this literature by showing that the equalisation scheme may be used to cope with hold-up problems. Using low or even negative equalisation rates (turning the system into an 'unequalisation scheme') fosters tax competition and, under certain circumstances, welfare.[3]

This paper adds to the (so far) small literature on optimal fiscal decentralisation in competing federations, see e.g. Grazzini and Petretto (2007) as well as Janeba and Wilson (2011).[4] It is closely related to Wilson and Janeba (2005) who argue that decentralising public goods provision within a federation may be welfare improving if federations compete with each other. This result is similar to ours (since low equalisation rates are an equivalent to decentralised public goods provision), but it is attained through a different mechanism. Wilson and Janeba (2005) start from the Keen and Kotsogiannis (2002) finding that, if both the federal and the state level levy taxes, vertical externalities may yield overtaxation.[5] By optimally choosing the degree of decentralisation, Wilson and Janeba (2005) show that positive horizontal externalities (across subunits) and negative vertical externalities (across federal and subunit levels) may be balanced such that the reaction functions in tax competition are altered and welfare is improved. In our model, decentralisation (in the form of less equalisation) may be welfare improving because regions otherwise overtax locked-in capital. Decentralised tax rate setting serves as a commitment to low future tax rates which is an advantage for a federation under competition.

Decentralisation as a commitment device is also proposed in Hatfield and Padró i Miquel (2012) who offer a political economy model, building on Besley and Coate (2003). In their paper, the median voter desires high capital taxes when capital is unequally distributed across citizens. This generates the classical time inconsistency problem leading to insufficient capital supply. Decentralisation creates tax competition; thus, taxation of capital is more expensive and therefore lower. In our approach, governments are not restricted by political economy constraints and maximise the representative household's utility. Most importantly, our paper differs in considering

[1] As Kehoe (1989) shows, even benevolent governments may expropriate their citizens. The '*taming the Leviathan*' view is therefore not necessarily incompatible with assuming that governments maximise the representative household's utility. The system of fiscal equalisation may be seen as part of the fiscal constitution that effectively prevents the subunits' governments from (benevolently) exploiting their citizens.

[2] See Eaton and Gersovitz (1983, 1984), Janeba (2000), Konrad and Lommerud (2001), Schnitzer (1999, 2002), Thomas and Worrall (1994).

[3] The federal level itself does not levy business taxes. Thus, there are no vertical externalities as in Keen (1998), Keen and Kotsogiannis (2002), Kessing et al. (2009). With vertical externalities, decentralised policy-making in a federation may be a disadvantage in attracting mobile capital.

[4] Agrawal (2016) provides empirical evidence for inter-federation tax competition. See Brueckner (2004) for a survey on fiscal decentralisation.

[5] See also Hayashi and Boadway (2001).

tax competition between federations (and not just within a single federation). Therefore, next to the hold-up problem, tax policy in our model has horizontal externalities which, even if the degree of decentralisation is optimised, yield inefficiently low tax rates.

The idea that the properties of tax competition may be affected by a prior change in institutions and/or investment has been explored by at least two studies before. Hindricks et al. (2008) show that (first stage) underinvestment in public capital may soften (second stage) tax competition. Becker and Fuest (2012) demonstrate that lenient transfer pricing policies mitigate tax competition.

Fiscal equalisation schemes exist in most developed federations, including Germany, Canada, Australia and others. These schemes differ, of course, in institutional details but have some common features. Most importantly, an increase in tax base in one state is partially absorbed by the redistribution scheme (sometimes via the federal level); equivalently, a decrease in tax base is partially compensated.[6] This increases the state's incentive to raise its tax rate. To see this, recall that optimal tax rate setting is a trade-off between raising revenue and losing tax base. The equalisation scheme only affects one part of the trade-off by mitigating the loss in tax base. In other words, fiscal equalisation reduces the marginal cost of taxation while leaving the marginal benefit unaffected (Boadway 2004). As a consequence, optimal tax rates are higher. Empirical studies find robust evidence for this effect of equalisation schemes (see Büttner 2003, 2006; Egger et al. 2010 for German municipalities, Smart 2007 for Canadian provinces and Dahlby and Warren 2003 for Australia).[7] In this paper, we offer a theory of why real-world fiscal equalisation schemes differ in their incentive effects.

In the next section, the model is presented and analysed. Section 3 concludes.

2 Model analysis

2.1 Setup

Assume a world with m federations, indexed by j, each of which consists of n subunits, indexed by i. The federation index j will be suppressed until misunderstandings may arise.

In each subunit, there is a continuum of firms with mass of unity. Firms are active in either of two different sectors. The first sector has a mass of $\lambda_i \in (0, 1)$ and a production function $f(k)$, where k is a capital input good. The second sector has a mass of $1 - \lambda_i$ and a production technology $g(\kappa)$ where κ is another capital input

[6] The absorption rate on the state's income can be economically substantial. For instance, the marginal absorption rate on a German state (Land) varies between 70 and 92% (Baretti et al. 2002). For Canadian provinces (Smart 2007) and Australian states (Dahlby and Warren 2003), the absorption rates are significantly smaller, in other federations (most importantly, the EU) a fiscal equalisation scheme is entirely missing.

[7] For evidence for tax effects on capital investment across subnational entities, see e.g. Becker et al. (2012).

good.[8] Capital goods k and κ differ since k can be resold at no cost, whereas κ is sunk after investment. Thus, k can be thought of as a flexible input which is mobile at any time and κ as a long-term investment; then, parameter λ_i measures the degree of flexibility of production within a subunit. We assume that $f', g' > 0 > f'', g''$ and $f'(0) = g'(0) = \infty$.

Aggregate firm profits π in subunit i are given by

$$\pi_i = \lambda_i \left[f(k_i) - (r + t_i) k_i\right] + (1 - \lambda_i)\left[g(\kappa_i) - (\rho + t_i)\kappa_i\right] \tag{1}$$

where r and ρ are the interest rates for capital inputs k and κ, and $t_i \geq 0$ is the unit tax on capital levied by subunit i.[9] A crucial assumption is that tax rates cannot be differentiated by sector. This may be justified by constitutional or supranational bounds on policy measures (e.g. within the EU) or just by missing information. In the latter case, it is helpful not to think of distinct sectors but of different types of firms within a sector which the government cannot differentiate.

In each subunit, there is a representative household which is endowed with capital $\bar{K}_i$ which can be transformed into k and κ everywhere in the world. Furthermore, the household is the owner of the firms in its subunit. The household has a utility function $u(x_i, g_i)$ where x_i is private consumption and g_i is the amount of the public good offered by the government in subunit i. We assume that $u_x, u_g > 0 > u_{xx}, u_{gg}$ as well as $u_g(x_i, 0) = u_x(0, g_i) = \infty$. Private consumption is given by

$$x_i = \pi_i + r\bar{k}_i + \rho\bar{\kappa}_i \tag{2}$$

with $\bar{k}_i$ and $\bar{\kappa}_i$ denoting the shares of capital invested in k and κ and $\bar{k}_i + \bar{\kappa}_i = \bar{K}_i$.

Each subunit's government is assumed to be benevolent, i.e. it sets t_i to maximise the representative household's utility. The public good g_i is entirely financed by revenue from the unit tax on capital. A fiscal equalisation scheme redistributes income within a federation. It works as follows: The local tax base is multiplied by a standardised (though fictitious) tax rate[10] $\bar{t}_j$ which is equal for all subunits in a given federation j. A fraction γ_j of this standardised tax revenue is given into a common pool. Each subunit i receives a payment of $1/n$ of this common pool. The government's budget constraint is thus given by

$$T_i = \left(t_i - \frac{n-1}{n}\gamma_j \bar{t}_j\right) K_i + \frac{1}{n}\sum_{-i}\gamma_j \bar{t}_j K_{-i} \equiv g_i \tag{3}$$

where $K_i = \lambda_i k_i + (1 - \lambda_i)\kappa_i$ is the aggregate capital invested in i, i.e. the local tax base. As the variation of γ_j is equivalent to a variation in $\bar{t}_j$, we set $\bar{t}_j = 1$ for presentational ease. γ_j is determined by the federal government.

[8] The production functions may include some fixed input factor (e.g. entrepreneurship, land) which makes them effectively have constant returns to scale. We oppress this fixed factor for simplicity of notation.

[9] Liesegang and Runkel (2016) analyse tax competition with fiscal equalisation with profit taxes instead of unit taxes on capital.

[10] These tax rates are also referred to as 'representative tax rates', see e.g. Boadway (2004).

For purpose of illustration, consider the symmetric case in which all subunits are equal, i.e. $K_i = K_{-i}$. Then, tax revenue is the same as without the equalisation scheme, $T_i = t_i K_i$. Its incentive effect becomes clear when we consider a small increase in t_i.

$$\frac{\mathrm{d}T_i}{\mathrm{d}t_i} = K_i + t_i \frac{\mathrm{d}K_i}{\mathrm{d}t_i} + \gamma_j \frac{n-1}{n} \left(-\frac{\mathrm{d}K_i}{\mathrm{d}t_i} + \frac{\mathrm{d}K_{-i}}{\mathrm{d}t_i} \right) \tag{4}$$

As will be derived below, $\frac{\mathrm{d}K_i}{\mathrm{d}t_i} < 0$ and $\frac{\mathrm{d}K_{-i}}{\mathrm{d}t_i} > 0$. Thus, the equalisation scheme (the third term on the right-hand side) unambiguously increases the effect of a tax rate increase on revenue. The reason is that part of the tax base loss is compensated by lower payments into the common pool and increased payments from the common pool.

Finally, the federation j's government is supposed to be benevolent as well. It sets the equalisation parameter γ_j in order to maximise the sum of household utilities in its subunits. It thus maximises

$$W_j = \sum_i u(x_i, g_i) \tag{5}$$

The timing is as follows. At stage 1, each federation j determines the fiscal equalisation parameter γ_j. At stage 2, firms invest in κ_i. At stage 3, all $m \times n$ subunits' governments set tax rates t_{ij}. At stage 4, firms invest in k_i.[11] Then, pay-offs are realised.

2.2 Equilibrium

The game is solved by backward induction, starting with stage 4. For a given interest rate r, each firm chooses k_i to maximise its profits. Profit-maximising investment is implied by

$$f'(k_i) = r + t_i \tag{6}$$

which yields a capital demand function of $k_i(r, t_i)$.

The interest rate r adjusts such that the capital demand in all $m \times n$ subunits equals capital supply. At stage 2, households have already made investments $\bar{\kappa}_{ij}$ and, thus, the remaining capital supply is $\bar{k} = \sum_j \sum_i \left(\bar{K}_{ij} - \bar{\kappa}_{ij} \right)$. The equilibrium interest rate is implied by

$$\sum_j \sum_i \lambda_{ij} k_{ij} \left(r, t_{ij} \right) = \bar{k} \tag{7}$$

The equilibrium interest rate is thus a function of tax rates and the remaining capital supply, i.e. $r = r(\mathbf{t}, \bar{k})$ where $\mathbf{t}$ denotes the vector of tax rates. An increase in some tax

[11] Note that this does not necessarily imply a chronological order. An equivalent timing would have the firms in the k-sector invest at stage 2 (like the firms in the κ-sector), but adjust their capital stock after taxes have been revealed.

rate, e.g. t_{11} , affects r according to $\frac{dr(\mathbf{t},\bar{k})}{\mathrm{d}t_{11}} = -\frac{\lambda_{11}k'_{11}}{\sum_j \sum_i \lambda_{ij}k'_{ij}}$ which, under symmetry, simplifies to $\frac{dr(\mathbf{t},\bar{k})}{\mathrm{d}t_{11}} = -\frac{1}{mn}$. That is, the effect of an increase in tax rates is inversely related to the number of jurisdictions.

At stage 3, the government in i maximises the representative household's utility taking into account the behavioural consequences of taxation at stage 4, as well as the household's and the government's budget constraints.

$$\max_{t_i} \quad u(x_i, g_i) \quad \text{s.t.} \quad (2) \text{ and } (3) \tag{8}$$

The first-order condition for the optimisation problem in (8) is $\frac{\mathrm{d}u(x_i,g_i)}{\mathrm{d}t_i} = 0$ with $\frac{du(x_i,g_i)}{\mathrm{d}t_i}$ given by

$$\begin{aligned}&\left(u_g^i - u_x^i\right) K_i + u_x^i \left(\bar{k}_i - k_i\right) \frac{\mathrm{d}r(\mathbf{t},\bar{k})}{\mathrm{d}t_i} \\ &+ u_g^i \left(\left(t_i - \frac{n-1}{n}\gamma_j\right)\lambda_i \frac{\mathrm{d}k_i}{\mathrm{d}t_i} + \frac{1}{n}\gamma_j \sum_{-i} \lambda_{-i} \frac{\mathrm{d}k_{-i}}{\mathrm{d}t_i}\right)\end{aligned} \tag{9}$$

u_g^i and u_x^i denote the partial derivatives of $u\,(.)$ with respect to g_i and x_i, and $\frac{\mathrm{d}k_i}{\mathrm{d}t_i} = k_i' + k_i' \frac{\mathrm{d}r(\mathbf{t},\bar{k})}{\mathrm{d}t_i}$ and $\frac{\mathrm{d}k_{-i}}{\mathrm{d}t_i} = k'_{-i} \frac{dr(\mathbf{t},\bar{k})}{\mathrm{d}t_i}$ the tax effects on the capital stocks both directly and indirectly through the interest rate. The first term on the left-hand side represents the welfare effect of transferring funds from the private sector (i.e. firm profits) to the public sector. If $u_g^i > u_x^i$, this effect is positive. The second term depicts the effect of an interest rate change on private income, i.e. on firm profits and the household's interest income. In the symmetric equilibrium, this effect cancels out. The third term captures the tax effect on investment (in subunit i and, due to the equalisation scheme, all other subunits in federation j). A decrease in investment by $\lambda_i \frac{\mathrm{d}k_i}{\mathrm{d}t_i}$ reduces tax revenue but also the (net) payment into the equalisation system (first term in round brackets). Moreover, a tax change in i will affect capital demand in other subunits within the federation (via the interest rate effect) and thus the payment received from the equalisation scheme (second term in round brackets).

In the following, we will focus only on symmetric equilibria. For a symmetric equilibrium to exist, each subunit must have no incentive to deviate from a tax rate that satisfies (9). A reduction in t_i drives up the marginal utility of public funds which, by assumption (see above), eventually becomes infinitely high (note that, due to fiscal equalisation, revenue becomes zero at an above-zero tax rate). With regard to an upward deviation from a situation with symmetric tax rates, note that, since it is a unit tax, there is no natural upper bound on t_i. With regard to the k-sector, there will always be some investment in k_i due to the assumption that $f'(0) = \infty$. However, at $t_i = \frac{g(\kappa)-r\kappa}{\kappa}$, firm profits in the κ-sector are exhausted. To avoid a kink in (9) at $t_i = \frac{g(\kappa)-r\kappa}{\kappa}$, we will assume that firm owners would then have sufficient funds to pay for the additional tax. In this case, the function implied by $\frac{du(x_i,g_i)}{\mathrm{d}t_i}$ can be assumed to be well-behaved with a unique maximum at t implied by (9).[12] In addition, we assume that revenue in the κ-sector is large enough such that the equilibrium tax rate is below $\frac{g(\kappa)-r\kappa}{\kappa}$.

Let t_{ij}^{*} denote the optimal tax rate at stage 3 which solves (8) with (9) equal to zero. Several aspects are noteworthy. First, in the absence of fiscal equalisation, $\gamma_j = 0$, the optimal tax rate is such that there is underprovision of public goods (Zodrow and Mieszkowski 1986).[13] Second, fiscal equalisation increases the optimal tax rate (as has been empirically shown by Büttner 2006 and Egger et al. 2010); the reason is that the equalisation system compensates for the loss of tax base and, thus, reduces the cost of taxation without reducing the benefits.[14] Third, under mild restrictions, tax rates are strategic complements: An increase in a tax rate in some other subunit (be it within the same federation or outside) increases the tax base K_i and thus the gain from taxation. Moreover, it affects the way capital stocks react to taxation, i.e. $\frac{\mathrm{d}k_i}{\mathrm{d}t_i}$ and $\frac{\mathrm{d}k_{-i}}{\mathrm{d}t_i}$. If the latter is quantitatively less important, the optimal tax rate in i increases.[15]

For more interpretation, consider the symmetric case in which $\frac{dr}{\mathrm{d}t_i} = -\frac{1}{mn}$ and the optimal tax rate is

$$t_{ij}^{*} = \left[\frac{u_g^i - u_x^i}{u_g^i} \frac{1}{\left|\eta_{k_i}\right|} \frac{K_i}{\lambda_i k_i} + \gamma_j \frac{n-1}{n} \right] \frac{mn}{mn-1} \tag{10}$$

where $\eta_{k_i} = k_i'/k_i < 0$ is the semi-elasticity of capital. Under symmetry, neither η_{k_i} nor the fraction of 'flexible' production, $\lambda_i k_i / K_i$, depends on the tax rate (i.e. a coordinated increase in tax rates leaves these variables unaffected). Thus, the optimal tax rate depends on the need for public funds[16] (measured by the difference in marginal

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[12] If firm owners cannot, by assumption, pay more than their full profit, the welfare curve would have a kink due to a fall in tax base affected by a marginal tax increase. Then, the tax base would be K_i for $t_i \leq \frac{g(\kappa)-r\kappa}{\kappa}$ and $\lambda_i k_i$ for larger tax rates. Due to the kink, it might be that, in the optimum, the first-order condition for the optimisation problem in (8) is $\frac{du(x_i,g_i)}{\mathrm{d}t_i} > 0$. In the following, we abstract from these complexities since they do not yield new insights.

[13] If $\gamma_j = 0$, (9) reads $\left(u_g^i - u_x^i\right) K_i + u_g^i t_i \lambda_i \frac{\mathrm{d}k_i}{\mathrm{d}t_i} = 0$. With $\frac{\mathrm{d}k_i}{\mathrm{d}t_i} < 0$ and $\lambda_i > 0$, it follows $u_g^i > u_x^i$ (since there is no other source of revenue and $u_g^i > u_x^i$ for $t_i = 0$).

[14] Technically speaking, an increase in γ_j increases the left-hand side of (9). Note that, under symmetry, γ_j does not affect u_g (or u_x) directly as it does not directly affect T_i, see Eq. (3).

[15] In fact, in the literature it is often assumed that strategic complementarity holds although this is not necessarily the case for all model parameters (see Appendix for further discussion). As Keen and Konrad (2013) put it in their Handbook article: *'Intuition might suggest, in particular, that the best response to a reduction in some other country's tax rate will be for i to reduce its own rate too; meaning that tax rates are strategic complements. But this is not, in general, assured (even in the case of symmetric countries)'*. (p. 267) See also Devereux et al. (2008, pp. 1217–19) for a discussion on the assumption of strategic complementarity of tax rates. The evidence supports this assumption. Be it for tax competition between subnational units (Büttner 2001) or between countries (Devereux et al. 2008; Overesch and Rincke 2011), empirical studies typically measure a positive slope of the reaction function, i.e tax rates are strategic complements.

[16] The need for public funds as measured by $\frac{u_g^i - u_x^i}{u_g^i}$ depends on the size of public funds and is thus not independent of t_{ij}. However, since $\frac{u_g^i - u_x^i}{u_g^i}$ can be expected to decrease in the availability of public funds

utilities, $u_g^i - u_x^i$), and decreases in η_{k_i} as well as in $\lambda_i k_i / K_i$. Moreover, the more market power the individual jurisdiction has (measured by the total number of jurisdictions which is inversely related to subunit i's impact on the interest rate, $\frac{dr}{\mathrm{d}t_i}$), the higher is the optimal tax rate. The hold-up problem implicitly shows up in the optimal tax rate as it depends on the semi-elasticity of the k-sector, but not of the κ-sector. The reason is that investment in κ is already sunk, i.e. locked-in, and can be taxed without efficiency costs. However, as we show below, investors will anticipate this and adjust investment in κ to the degree that taxation does not come as a surprise. Note that our assumption of a unique tax rate on k and κ prevents the subunits from fully taxing the κ-sector (as in Kehoe 1989).[17]

At stage 2, the firms invest in κ. For a given interest rate, profit-maximising investment is implied by

$$g'(\kappa_i) = \rho + t_i^e \tag{11}$$

which yields a capital demand function $\kappa_i\left(\rho, t_i^e\right)$ where t_i^e is the expected tax rate set by the subunit i at stage 2.

The interest rate ρ adjusts until capital demand meets capital supply. The latter depends on the interest rate ρ and the expected interest rate r^e. Since the household is a price-taker, it will invest only in κ if $\rho \geq r^e$. The market for κ is in equilibrium when

$$\sum_j \sum_i (1 - \lambda_{ij}) \kappa_{ij}\left(\rho, t_{ij}^e\right) = \sum_j \sum_i \bar{\kappa}_{ij}\left(\rho, r^e\right) \tag{12}$$

Rational expectations yield $r^e = r$ and $t_{ij}^e = t_{ij}$.

In equilibrium, ρ will equal r^e. Otherwise, households would invest their whole endowment $\bar{K}_{ij}$ in either k or κ. With $g'(0) = \infty$ and $f'(0) = \infty$, this cannot be an equilibrium. Therefore, $\rho = r^e$. A change in the expected tax rate changes the equilibrium by changing actual demand for κ and expected demand for k. Due to rational expectations, ρ and r^e are linked through

$$\sum_j \sum_i \left[(1 - \lambda_{ij}) \kappa_{ij}\left(\rho, t_{ij}^e\right) + \lambda_{ij} k_{ij}\left(r^e, t_{ij}^e\right)\right] = \bar{K} \text{ s.t. } \rho = r^e \tag{13}$$

where $\bar{K} = \sum_j \sum_i \bar{K}_{ij}$. This identity defines the functions $\rho(\mathbf{t})$ and $r^e(\mathbf{t})$ which describe the interest rates depending on tax rates (with $r^e(\mathbf{t})$ no more conditioning on investments in κ). A small increase in some tax rate, e.g. t_{11}, affects the expected tax rate $r^e(\mathbf{t})$ and $\rho(\mathbf{t})$ under symmetry according to $\frac{\mathrm{d}r^e(\mathbf{t})}{\mathrm{d}t_{11}} = \frac{\mathrm{d}\rho(\mathbf{t})}{\mathrm{d}t_{11}} = -\frac{1}{mn}$.

Footnote 16 continued
from other sources, the above statement may be rephrased as follows: The optimal tax rate decreases in public funds from other sources.

17 Relaxing this assumption (i.e. allowing for sector specific tax rates) would decrease the optimal tax rate in (10) on the mobile sector to $t_{ij}^* = \left[\frac{u_g^i - u_x^i}{u_g^i} \frac{1}{\left|\eta_{k_i}\right|} + \gamma_j \frac{n-1}{n}\right] \frac{mn}{mn-1}$.

We now turn to stage 1 where the federation determines the equalisation parameter γ_j. The federal government maximises $W_j = \sum_i u(x_i, g_i)$ anticipating the effect of its policy choice on the subunits' tax policies and the firms' and the households' investment decisions. With $r^e(\mathbf{t})$ and $\rho(\mathbf{t})$ only depending on the vector of (expected) tax rates, equilibrium capital stocks can be expressed as a function of the vector $\mathbf{t}$, i.e. $\kappa_{ij} = \kappa_{ij}(\mathbf{t})$ and $k_{ij} = k_{ij}(\mathbf{t})$. Tax rates, however, are shaped by the equalisation schemes in place. To see this, suppose that tax rates are strategic complements. A change in the equalisation scheme, e.g. an increase in γ_j, directly increases the tax rates in federation j. The resulting drop in capital demand decreases the interest rate which, then, leads to an increase in capital demand outside of federation j. As a consequence, tax rates outside j are, in equilibrium, higher. Thus, the vector of equilibrium tax rates, $\mathbf{t}^*$, can be mapped upon the vector of equalisation parameters γ.

Lemma 1 *Let $\mathbf{t}^*(\gamma)$ denote the vector of equilibrium tax rates, and assume that tax rates are strategic complements. Then, we have*

(i) $\frac{dt_{ij}^*(\gamma)}{d\gamma_z} > 0$ *for all* $z = 1, \ldots, m$,

(ii) under symmetry, $\frac{dt_{ij}^*(\gamma)}{d\gamma_j} > \frac{dt_{ij}^*(\gamma)}{d\gamma_z}$ *for* $z \neq j$.

Proof Part (i) follows directly from the assumption that tax rates are strategic complements and the considerations above. Part (ii) can be proven as follows. γ_z affects the tax rates in z directly and tax rates in all subunits indirectly via a change in the interest rate. The interest rate effect on tax rates is, under symmetry, equal for all subunits. Since the direct effect is positive (under symmetry: $\frac{\partial t_{iz}^*(\gamma)}{\partial \gamma_z} = \frac{m(n-1)}{mn-1} > 0$), it follows that $\frac{\mathrm{d}t_{ij}^*(\gamma)}{\mathrm{d}\gamma_j} > \frac{\mathrm{d}t_{ij}^*(\gamma)}{\mathrm{d}\gamma_z}$ for $z \neq j$. □

Now, consider some federation z's optimisation problem given by

$$\max_{\gamma_z} W_z \quad \text{s.t.} \quad (2) \text{ and } (3) \tag{14}$$

The first-order condition is

$$\frac{\mathrm{d}W_z}{\mathrm{d}\gamma_z} = \frac{\partial W_z}{\partial \gamma_z} + \sum_i \frac{\mathrm{d}W_z}{\mathrm{d}t_{iz}^e} \frac{\mathrm{d}t_{iz}^e(\gamma)}{\mathrm{d}\gamma_z} + \sum_{j \neq z} \sum_i \frac{\mathrm{d}W_z}{\mathrm{d}t_{ij}^e} \frac{\mathrm{d}t_{ij}^e(\gamma)}{\mathrm{d}\gamma_z} = 0 \tag{15}$$

With $W_z = \sum_i W_{iz}$ and $W_{iz} = u(x_{iz}, g_{iz})$, the above expression can be written as $\frac{dW_z}{\mathrm{d}\gamma_z} = \sum_i \frac{\mathrm{d}W_{iz}}{\mathrm{d}\gamma_z} = 0$ with

$$
\begin{aligned}
\frac{\mathrm{d}W_{iz}}{\mathrm{d}\gamma_z} = {} & \frac{n-1}{n} u_g^i \left(K_{-iz}^m - K_{iz}\right) \\
& + \left[(u_g^i - u_x^i) K_{iz} + u_g^i t_{iz} K_{iz}' \left(1 + \sum_i \frac{dr^e\,(\mathbf{t})}{\mathrm{d}t_{iz}^e} \right) \right] \frac{\mathrm{d}t_{iz}^e\,(\gamma)}{\mathrm{d}\gamma_z} \\
& + u_g^i t_{iz} K_{iz}' \sum_{j \neq z} \sum_i \frac{dr^e\,(\mathbf{t})}{\mathrm{d}t_{ij}^e} \frac{\mathrm{d}t_{ij}^e\,(\gamma)}{\mathrm{d}\gamma_z}
\end{aligned} \tag{16}
$$

where $K_{-iz}^m = \frac{1}{n-1} \sum_{-iz} K_{-iz}$ is the average capital stock in the other subunits in the federation and $K_{iz}' = \lambda_{iz} k_{iz}' + (1 - \lambda_{iz}) \kappa_{iz}'$ is the total capital stock response to an increase in t_{iz}. The above expression reflects that the choice of γ_z serves the purposes of redistributing income (first term) and affecting tax rate setting within and outside the federation (second and third term). The first term captures the redistributive effect of an increase in γ_z. Subunit i gains from an increase in equalisation if $K_{-iz}^m > K_{iz}$, otherwise it loses. Since u_g^i decreases in g_i, redistribution enhances welfare as soon as subunits differ in g_i. Under symmetry, this effect equals zero since countries receive in sum what they have paid into the common pool. The second term captures the effect of equalisation on tax rate setting within the federation. On the one hand, the choice of γ_z internalises fiscal externalities within the federation; i.e. it accounts for the fact that capital outflows partly remain within the boundaries of the federation (which is reflected by the interest rate change in response to all n tax changes). On the other hand, by determining γ_z, the federation effectively commits its subunits to a certain competitive tax level later on in the game. It can thus solve the hold-up problem that occurs because κ is invested before the tax rates are revealed (technically speaking, it takes account of the elasticity of the whole capital stock instead of just the flexible one's (k_i), see Eq. (9)). The third term represents the effect on tax rates outside federation z. If we assume that tax rates are strategic complements and thus $\frac{\mathrm{d}t_{ij}^e(\gamma)}{\mathrm{d}\gamma_z} > 0$, this effect is unambiguously positive. By committing its own subunits to higher tax rates, the federation acts as a Stackelberg leader and increases the tax rate level outside its own legal reach.

Under symmetry, redistribution within the federation is zero. Then, the above optimality condition implies an optimal tax rate t_{iz}^{E*} (with E for optimal equalisation) given by

$$
t_{iz}^{E*} = \frac{u_g^i - u_x^i}{u_g^i} \frac{1}{\left|\eta_{K_{iz}}\right|} \frac{m}{m-1} \frac{\frac{\mathrm{d}t_{iz}^e}{\mathrm{d}\gamma_z}}{\frac{\mathrm{d}t_{iz}^e}{\mathrm{d}\gamma_z} - \frac{\mathrm{d}t_{-z}^e}{\mathrm{d}\gamma_z}} \tag{17}
$$

with $\eta_{K_{iz}} = \frac{K_{iz}'}{K_{iz}}$. Note that the above equation implies that, even with optimal equalization, public goods provision will not be efficient. The reason is that $u_g^i = u_x^i$ would imply $t_{iz}^{E*} = 0$; this, however, implies $u_g^i = \infty$ which contradicts efficiency (since $u_x^i < \infty$).

Tax rate t_{iz}^{E*} is induced by choosing the equalisation parameter γ_z^* accordingly. Equalising t_{iz}^{E*} with the right-hand side of (10) above allows for stating the following.

Proposition 1 *In the symmetric equilibrium, the equalisation parameter is given by*

$$\gamma_j^* = \frac{u_g^i - u_x^i}{u_g^i} \frac{1}{\left|\eta_{K_i}\right|} \left(\frac{mn-1}{(n-1)(m-1)} \frac{\frac{dt_{iz}^e}{d\gamma_z}}{\frac{dt_{iz}^e}{d\gamma_z} - \frac{dt_{-z}^e}{d\gamma_z}} - \frac{n}{n-1} \left(1 + \frac{\left|\eta_{\kappa_i}\right|}{\left|\eta_{k_i}\right|} \frac{(1-\lambda_i)\,\kappa_{iz}}{\lambda_i k_{iz}}\right)\right) \tag{18}$$

Proof Omitted. □

For illustrative purpose, consider the case of $u(x_i, g_i) = x_i + \beta g_i$, from which follows $\frac{u_g^i - u_x^i}{u_g^i} = \frac{\beta - 1}{\beta}$, and assume that the individual federation ignores its impact on other federations' tax rates, i.e. $\frac{\mathrm{d}t_{-z}^e}{\mathrm{d}\gamma_z} = 0$. Then, the optimal equalisation parameter γ_j^* decreases in the number of federations m and—if profitability does not vary across sectors—in the relative size $\frac{(1-\lambda_{ij})\kappa_{ij}}{\lambda_{ij}k_{ij}}$ and the relative elasticity $\left|\eta_{\kappa_{ij}}\right| / \left|\eta_{k_{ij}}\right|$ of the two sectors. If $\lambda_i = 1$ (no hold-up problem), fiscal equalisation only has the purpose of internalising the fiscal externalities within the federation. With $(1 - \lambda_i) > 0$, the equalisation parameter is decreased, since individual subunits already apply high tax rates due to the locked-in capital in the inflexible sector. Perhaps surprisingly, γ_j^* now may become zero or even negative.[18] This is the case for a sufficiently large and/or a sufficiently elastic 'inflexible' sector. Then, tax competition within the federation is actually not strong enough. The reason is the hold-up problem. If part of the capital is locked-in at the time of tax rate setting, a federation can commit itself to low tax rates by setting low equalisation rates γ_j and, thus, increase overall investment. Accounting for $\frac{\mathrm{d}t_{-z}^e}{\mathrm{d}\gamma_z} > 0$ provides another incentive to increase the equalisation parameter.

We can now further characterise the equilibrium. An important question is whether optimal fiscal equalisation increases or decreases equilibrium tax rates compared to some benchmark case. We already outlined that equilibrium tax rates are higher than in the case without equalisation and $\lambda_i = 1$ (no hold-up problem) because positive fiscal externalities are internalised. With strongly inflexible investment, optimal fiscal equalisation will foster tax competition and thus reduce the tax level. What if the federations were able to set tax rates at stage 1? Would this be equivalent to decentralised tax setting with optimal fiscal equalisation under symmetry?

Proposition 2 *Assume that the federal governments set optimal tax rates at stage 1 for all subunits within the federation. The resulting Nash equilibrium tax rates are lower than the tax rates under decentralised tax setting (on the subunit level) with optimal fiscal equalisation (on the federal level).*

Proof Assume a situation without any fiscal equalisation in which the federal governments set optimal tax rates at stage 1 for all subunits within their jurisdiction. Recall

[18] For instance, if the flexible sector is triple the size of the inflexible one and elasticities are equal, optimal equalisation is zero if $m = n = 3$.

that equalisation in a symmetric situation only affects the individual subunit's incentives to set taxes but, for a given set of tax rates, does not affect the allocation. Consider a symmetric Nash equilibrium in federal tax rate setting. The first-order condition for the tax rate in subunit iz is given in the second term of (16) in square brackets (set equal to zero), and the resulting optimal tax rate is $t^*_{iz} = \frac{u_g - u_x}{u_g} \frac{1}{\left|\eta_{K_{iz}}\right|} \frac{m}{m-1}$. Now, return to federations setting the equalisation parameters γ. Assume a symmetric situation in which the equalisation parameters are set such that the vector of tax rates $\mathbf{t}^*$ is replicated. Evaluated at $\mathbf{t}^*$, we have $\frac{\mathrm{d}W_{iz}}{\mathrm{d}\gamma_z} > 0$ in (16). With $\frac{\mathrm{d}t^e_{-z}}{\mathrm{d}\gamma_z} > 0$, it follows that each individual federation has an incentive to increase γ_z further and, thus, increase tax rates up to $t^{E*}_{iz} > t^*_{iz}$. □

The intuition is as follows. The Nash equilibrium in tax rate setting implies that each federation takes the other federations' choices as given. This is different if the federation sets the fiscal equalisation parameter. Since subunits set the taxes after the equalisation scheme is determined, each federation anticipates the effects of equalisation on *all* subunits' tax policies (not just their own subunits' choices).

Proposition 3 *Starting from the symmetric uncoordinated equilibrium, a small coordinated increase in fiscal equalisation parameters γ_j (and, thus, tax rates) increases efficiency.*

Proof To assess efficiency, consider a coordinated increase of γ_j in all federations, starting from the symmetric uncoordinated equilibrium. A small increase in γ_j does not affect welfare in j. In contrast, a small increase in γ_y in some federation y has the following effect on W_{iz}:

$$\frac{\mathrm{d}W_{iz}}{\mathrm{d}\gamma_y} = \left[(u^i_g - u^i_x) K_{iz} + u^i_g t_{iz} K'_{iz} \left(1 + \sum_i \frac{dr^e(\mathbf{t})}{\mathrm{d}t^e_{iz}} \right) \right] \frac{\mathrm{d}t^e_{iz}(\gamma)}{\mathrm{d}\gamma_y}$$
$$+ u^i_g t_{iz} K'_{iz} \sum_i \frac{dr^e(\mathbf{t})}{\mathrm{d}t^e_{iy}} \frac{\mathrm{d}t^e_{iy}(\gamma)}{\mathrm{d}\gamma_y}$$
$$+ u^i_g t_{iz} K'_{iz} \sum_{j \neq z,y} \sum_i \frac{dr^e(\mathbf{t})}{\mathrm{d}t^e_{ij}} \frac{\mathrm{d}t^e_{ij}(\gamma)}{\mathrm{d}\gamma_y} \tag{19}$$

With $\frac{\mathrm{d}t^e_{iy}(\gamma)}{\mathrm{d}\gamma_y} > \frac{\mathrm{d}t^e_{ij}(\gamma)}{\mathrm{d}\gamma_y}$ and $\frac{\mathrm{d}W_{iz}}{\mathrm{d}\gamma_z} = 0$ under symmetry, it follows that $\frac{\mathrm{d}W_{iz}}{\mathrm{d}\gamma_y} > 0$. Thus, a coordinated increase enhances efficiency. □

It may thus be concluded that fiscal equalisation mitigates tax competition but does not eliminate it if the federation does not comprise the whole world.

3 Discussion

This paper analyses the optimal choice of fiscal equalisation if the federation is in competition for mobile resources with other federations. We model the federation's choice as a trade-off between redistributing income within the federation and affecting decentralised tax rate setting within and outside the federation. In the absence of fiscal equalisation, tax rates may be inefficiently low due to positive fiscal externalities within and outside the federation or inefficiently high because of hold-up problems due to locked-in capital. By manipulating the (perceived) cost of taxation, the equalisation scheme affects the tax rate setting of its subunits and may, thus, account for these inefficiencies. With optimal fiscal equalisation, externalities and hold-up problems can be solved and tax competition with outside subunits can be mitigated (although externalities are not perfectly internalised). Equilibrium tax rates are higher, and public goods provision is more efficient than with centralised tax rate setting.

The optimal rate of fiscal equalisation is a trade-off between these objectives. Depending on their relative importance, equalisation may be high, low, inexistent or even negative. Thus, our model might shed some light on why observable equalisation schemes are the way they are. It offers a complementary argument why fiscal equalisation schemes are not much more prevalent and why, in general, harmonisation of tax rates is rare. The claim that governments willingly forego opportunities to mitigate tax competition and increase tax rates might seem unrealistic at first. However, there is growing awareness that decentralised tax rate setting may actually yield inefficiently high tax rates. For instance, Chen and Mintz (2013) claim that '*Canada's fading advantage is the result of recent anti-competitive provincial tax policies that increased the cost of investment.*' (p. 1). Similarly, Keuschnigg and Loretz (2015) suggest that '*Austria is a high-tax country* [...]. *The challenge is to reduce the tax burden* [...] *one way of doing this is local autonomy and fiscal competition.*' (p. 7). This mirrors our theoretical finding that, in some cases, the federal government wants to induce the subunits to lower tax rates. It might also add to understanding why initiatives of corporate tax rate harmonisation within the EU have so far been without success. If the EU sets out to be a competitive environment to be attractive as a location for non-EU capital investment, non-harmonised business taxes may be an effective instrument to reach these goals.

To conclude, fiscal equalisation may be used to foster tax competition as well as to mitigate it. If tax competition is perceived to be inefficient, the model demonstrates that fiscal equalisation may not only be efficiency enhancing but also be superior to centralised tax rate setting—even if the subunits are perfectly homogeneous and set equal tax rates in equilibrium. The reason is that fiscal equalisation offers a credible commitment to not compete too aggressively and, thus, mitigates tax competition.

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Appendix

This appendix demonstrates under which circumstances tax rates are strategic complements in the model framework used above. For this purpose, consider an exogenous increase in some tax rate, e.g. t_1, and its effect on the tax rate setting in subunit $i \neq 1$. If an increase in t_1 increases t_i when optimally chosen, we will call these two policy instruments strategic complements.

We start from a symmetric situation (which simplifies the analysis and refers to the situation in the model). The first-order condition in Eq. (9) then reads:

$$\left(u_g^i - u_x^i\right) K_i + u_g^i \left(\left(t_i - \frac{n-1}{n}\gamma_j\right)\lambda_i \frac{\mathrm{d}k_i}{\mathrm{d}t_i} + \frac{1}{n}\gamma_j \sum_{-i} \lambda_{-i} \frac{\mathrm{d}k_{-i}}{\mathrm{d}t_i}\right) = 0$$

Differentiate (9) with respect to t_i and t_1 such that

$$\frac{d^2 u\left(x_i, g_i\right)}{\mathrm{d}t_i^2}\mathrm{d}t_i + \frac{d^2 u\left(x_i, g_i\right)}{\mathrm{d}t_i \mathrm{d}t_1}\mathrm{d}t_1 = 0$$

Strategic complementarity is thus given if

$$\frac{\mathrm{d}t_i}{\mathrm{d}t_1} = -\frac{\frac{d^2 u(x_i, g_i)}{\mathrm{d}t_i \mathrm{d}t_1}}{\frac{d^2 u(x_i, g_i)}{\mathrm{d}t_i^2}} > 0,$$

i.e. if $\frac{d^2 u(x_i, g_i)}{\mathrm{d}t_i \mathrm{d}t_1} > 0$ since $\frac{d^2 u(x_i, g_i)}{\mathrm{d}t_i^2}$ is negative (Eq. (9) describes a maximum). It turns out that, without further assumption on the shape of the utility function and the production function, no general statement on the sign of $\frac{d^2 u(x_i, g_i)}{\mathrm{d}t_i^2}$ can be made.

Therefore, to further simplify matters, assume that $u_g = \beta > 1$ and $u_x = 1$ (as in the example in the main text). Note that t_1 does not directly influence the tax rate setting in i. It does, however, increase K_i and reduce K_1. The expression above then becomes

$$\frac{d^2 u\left(x_i, g_i\right)}{\mathrm{d}t_i \mathrm{d}t_1} = (\beta - 1)\frac{\mathrm{d}K_i}{\mathrm{d}t_1} + \beta\left(t_i - \frac{n-1}{n}\gamma_j\right)\lambda_i \frac{d^2 k_i}{\mathrm{d}t_i \mathrm{d}t_1} + \beta \frac{1}{n}\gamma_j \sum_{-i} \lambda_{-i} \frac{d^2 k_{-i}}{\mathrm{d}t_i \mathrm{d}t_1}$$

The first term on the right-hand side is unambiguously positive; an increase in t_1 reduces the world interest rate and, thus, drives up demand for capital in i. The next two terms capture the effect how much an increase in t_1 affects the response of capital demand in different subunits to an increase in t_i. With $\frac{\mathrm{d}k_i}{\mathrm{d}t_i} = k_i' + k_i' \frac{\mathrm{d}r(\mathbf{t}, \bar{k})}{\mathrm{d}t_i}$ and $\frac{\mathrm{d}k_{-i}}{\mathrm{d}t_i} = k_{-i}' \frac{\mathrm{d}r(\mathbf{t}, \bar{k})}{\mathrm{d}t_i}$ as well as $\frac{\mathrm{d}k_i}{\mathrm{d}t_i} = \frac{1}{f''(k_i)}$ and $\frac{\mathrm{d}r(\mathbf{t}, \bar{k})}{\mathrm{d}t_i} = -\frac{\lambda_{ij} \frac{1}{f''(k_i)}}{\sum_j \sum_i \lambda_{ij} \frac{1}{f''\left(k_{ij}\right)}}$, it follows that the sign and the size of the second and third term above depend on the shape of the production function $f\,(.)$.

As an example, consider a quadratic production function, $f(k) = \alpha k - \beta k^2$, with $\alpha, \beta > 0$ and where $f' = \alpha - 2\beta k$ and $f'' = -2\beta$. The expression above now reads

$$\frac{d^2 u\,(x_i, g_i)}{\mathrm{d}t_i \mathrm{d}t_1} = -\left(\beta - 1\right) 2\beta \left(-\frac{1}{mn}\right) > 0$$

which indicates that tax rates are strategic complements.

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