Competing in taxes and investment under fiscal equalization [☆],[☆☆]

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Abstract

The paper considers a model of federation with two heterogeneous regions that try to attract the capital by competing in capital income taxes and public investment that enhance the productivity of capital. Regions' choices determine allocation of capital across the regions and their revenues under a tax sharing scheme. This framework allows for the examination of different approaches to fiscal equalization schemes [Boadway, R., Flatters, F., 1982. Efficiency and equalization payments in a federal system of government: a synthesis and extension of recent results, Canadian Journal of Economics 15, 613–633; Weingast, B.R., 2006. Second Generation Fiscal Federalism: Implication for Decentralized Democratic Governance and Economic Development, Working Paper, Hoover Institution, Stanford University]. We show that tax competition distorts (downwards) public investments and that the equalization grants discourage public investments with a little effect on equilibrium taxes. However, the equalization schemes remain beneficial not only for the federation and, under a low degree of regional asymmetry, also for each region.
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1. Introduction

A large number of federal countries have adopted various equalization schemes that allow central governments to address the issue of fiscal imbalances across jurisdictions. The equalization payments are enshrined in the Canadian constitution and are used in Australia, Denmark and Switzerland, and in many developing countries (see Ahmad and

Thomas, 1997; Shah, 2004). Another example is Germany, where in addition to the transfers from the federal to state governments, there exists a scheme of transfers across states. In the US, the state tax sharing is one of two forms of state intergovernmental aid to local governments (the other consists of categorical grants-in-aid), which is itself the largest element of state expenditures. In fact, in 2000 the average share of state intergovernmental expenditures in states' general revenues was about one third across the US.

The alleged purpose of these scheme is an attempt to correct fiscal imbalances and equalize the citizens access to public services across jurisdictions. Another reason, outlined by Boadway and Flatters (1982), is that fiscal equalization schemes can generate efficiency gains by internalizing the fiscal externality. The Boadway–Flatters result has been later reinforced in a strategic tax setting,[1] where jurisdictions can alter tax rates in response to equalization policies. Then the federal planner can design intergovernmental transfers to implement the efficient tax rates at the local level. Even though there is no guarantee that all jurisdictions benefit from such transfers and would implement it on a voluntary basis, Hindriks and Myles (2003) have shown that jurisdictions can voluntarily agree to share revenue as a strategic device to limit harmful tax competition.

More recently, the optimistic view of fiscal equalization has been challenged by the so-called second generation of fiscal federalism (Weingast, 2006), which suggests that equalization grants may have perverse fiscal incentives. Namely, local governments are more inclined to provide market-enhancing public goods and to raise tax revenue if they capture a large portion of the generated tax revenue.[2] Along these lines Shleifer and Vishny (1998) conclude that "the effect of such fiscal federalism are perverse" (p.249) and used this argument in their comparison of economic reforms in China and Russia.

It is important to point out that the two conflicting views are "asymmetric" in their reliance on taxes and public investments. The issue of public investment incentives is not accounted for by the efficiency argument for equalization grants, whereas the "perverse fiscal incentive argument" ignores the capital mobility. In our attempt to merge both theories, we offer a model with both tax and (factor-augmenting) public investment competition. More specifically, there is an economy with a total stock of capital, to be assigned, subject to a participation constraint, to two different localities (regions). In order to enhance the productivity of capital, the regions commit to local public investments, which attract capital to the region at the expense of its competitor. We use the framework of a two-stage game in which regions choose their public investments before setting taxes. This simple setting shows that flows of capital between localities create a non-market inefficient linkage whereby one region's tax base responds to the other region's policy choices.

An important feature of our model is the tax-public investment interaction: regions that offer a more appealing environment for capital, may be more attractive even if they set a higher tax on capital. We find that in equilibrium there is under-investment and under-taxation.[3] While the latter is a standard consequence of tax competition for a mobile tax base, the under-investment result is less obvious. When the second-stage tax choices are strategic complements, the effect of the first-stage commitment in public investments allows the regions to shift their tax reaction curves inwards and to set a lower tax in response to every tax choice of the other region. Thus, each region under-invests in order to soften tax competition. It is interesting to contrast this observation with the over-provision of public investment versus public goods in the simultaneous moves game examined by Keen and Marchand (1997). The reason for such distortion in the composition of public spending is that public good impacts only residents of the region whereas public investments attract capital away from other regions. Such negative externalities may lead to the over-provision of public investment, but the key message of our analysis is that this result could be reversed when we allow for a strategic effect of investment in a two-stage game. In our model, when regions behave non-cooperatively, they are not able to expropriate rents from the capital owners. This implies that the public investment increases the return to capital, but confers no benefit to the residents who do not own capital. As a result, regions spend excessively on public

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[1] Bird and Slack (1990), Wildasin (1991), Smart (1998), Kothenburger (2002), Bucovetsky and Smart (2006), Figuières et al. (2004).

[2] See the empirical literature on the relationship between intergovernmental transfers and local tax effort: Buettner (2006), Dahlby and Warren (2003), Baretti et al. (2002), Hepp and von Hagen (2001), and a theoretical contribution by Bordignon et al. (2001) who show how intergovernmental transfers affect tax enforcement. Several papers have estimated marginal revenue retention rates between 10 and 30% for Mexico, Russia and India: see Careaga and Weingast (2000) Parikh and Weingast (2003), Zhuravskaya (2000). A somewhat different estimation result is provided by Jin et al. (2005), who argued that on average Chinese provinces retain 90% of locally generated tax revenue.

[3] Matsumoto (1998) considers regions competing in infrastructures funded by capital taxes. In order to increase provision, governments must increase the tax rate, thus inducing capital flight, which, in turn, yields the under-provision. A potential negative effect of mobility on public investments has been emphasized in a somewhat different context by Cai and Treisman (2005), who argue the unattractive region would be unable to compensate for its initial disadvantage and would prefer to divert public funds to regular public goods and politicians' rents.

investments, from the perspective of their own residents, but insufficiently from the point of view of aggregate welfare. Partial cooperation on public investments, if regions cannot negotiate tax rates, is then welfare improving.

We then proceed with the welfare analysis of fiscal equalization schemes (defined as tax sharing arrangements), which have two opposite effects on equilibrium taxes. The positive effect is to internalize the fiscal externalities that lead to sub-optimally low tax rates. The negative effect is the lowering of the marginal retention rate which reduces the returns to taxation. Indeed, by raising its own tax level, a region drives away some capital, causing a reduction in regional output, while the extra fiscal revenue is shared with the other region.

In our setting, the two effects cancel out, and equilibrium taxes are independent of the degree of fiscal equalization. However, in stark contrast to the perverse fiscal incentives argument, the equalization discourages public investments and produces a welfare gain. Even though public investment raises the rent from capital, the perfect mobility of capital does not allow the local governments to fully appropriate the rent. Since they have to bear the full cost of the investments, the regions are trapped in a prisoner's dilemma situation whereby one region invests because the other does. Fiscal equalization helps to resolve the dilemma by reducing the equilibrium level of investment spending. Lastly, we introduce the notion of exogenous regional heterogeneity and show that, when the degree of heterogeneity is not too high, each region can benefit from the introduction a "modest" fiscal equalization scheme.

The paper is organized as follows. The next section presents the basic model and derives the benchmark efficient outcome. Section 3 proceeds with the equilibrium analysis in the absence of fiscal equalization. The latter is introduced in Section 4. Section 5 concludes. The proofs of most of the results are relegated to the Appendix.

2. The model

Consider a federation that consists of two regions $i=1, 2$. In each region the local governments chooses a rate of the source-based unit tax t_i levied on the mobile tax base (capital) and a level of public investment g_i that enhances the productivity of domestic capital. The regions' choices, denoted by $t=(t_1, t_2)$ and $g=(g_1, g_2)$, determine the allocation of capital x_1 and x_2 across regions, the precise mechanism of which will be described below. The production in each region is given by the function $F_i(x_i; g_i)$, which is increasing, twice continuously differentiable and concave in the level of capital x_i for $i=1, 2$. Naturally, the private capital and public investments are complements, so that the cross-derivative is $\frac{\partial^2 F_i}{\partial x_i \partial g_i}$ is positive.[4] The cost of the public investment is given by the convex function $c_i(g_i)$, which, for analytical tractability, is assumed to be quadratic: $c_i(g_i) = g_i^2/2$. The federation implements a fiscal equalization scheme where both regions share a proportion α of their tax revenue.

Even though most of our results can be extended for a larger range of values of α, it make sense to limit our analysis to $0 \le \alpha \le 1/2$.

Under perfect mobility the allocation of capital across the regions must equate its net return in two regions. We then obtain the following equality:

$$f_1(x_1; g_1) - t_1 = f_2(x_2; g_2) - t_2, \tag{1}$$

where f_i is the marginal product of the capital in region i. We will require that the net return of capital in either region must be nonnegative, since otherwise the regions would be unable to attract any capital. Thus, the value of expression in (1) is greater or equal to zero.

We assume that the regions correctly anticipate how their tax and public investment decision will affect the allocation of capital. By normalizing the total stock of capital to 1, the arbitrage condition (1) determines the amount of the capital in each region, $x_1 = x_1(t, g)$ and $x_2(t, g)$. Each region maximizes the welfare function W_i, the sum of the return to the immobile factor and tax revenue, net of the investment costs:

$$W_i^\alpha(t, g) = F_i(x_i; g_i) - f_i(x_i; g_i)x_i + (1 - \alpha)t_ix_i + \alpha t_jx_j - c_i(g_i), \tag{2}$$

where $i \ne j$. That is, we assume that there is no domestic ownership of capital. The reason regions are taxing capital is simply to extract rents from the capital owners.[5]

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[4] In this sense, the public input is factor-augmenting, rather than firm-augmenting (in the terminology of Matsumoto, 1998), for it increases the marginal productivity of the production factor.

[5] We are assuming that the residents get a (lump-sum) transfer if the capital tax revenue, including transfers, exceeds the provision cost, and pay a (lump-sum) tax otherwise.

An important feature of our model is the gap between regions in terms of their ability to attract the capital. More specifically, we assume that region 1 has a superior production technology, and if the regions choose the same tax and the same public investment level, region 1 attracts a larger amount of capital than its counterpart. However this production asymmetry is not irreversible, and it can be mitigated and possibly eliminated by regional public investment choices. Specifically, the production functions are given by

$$F_1(x_1; g_1) = \left(\gamma + g_1 + \frac{\delta\varepsilon}{2}\right)x_1 - \delta\frac{x_1^2}{2}, \quad F_2(x_2; g_2) = \left(\gamma + g_2 - \frac{\delta\varepsilon}{2}\right)x_2 - \delta\frac{x_2^2}{2}, \tag{3}$$

where the parameter $\varepsilon \geq 0$ represents the degree of production asymmetry across regions, and $\delta \geq 1$ is the rate of decline of the marginal product of capital with the amount of capital invested in the region. Thus the regional production functions exhibit decreasing returns in capital and constant returns in investment. The regional payoffs simplify to

$$W_i(t, g) = \delta\frac{x_i^2}{2} + (1 - \alpha)t_i x_i + \alpha t_j x_j - \frac{g_i^2}{2}.$$

The last expression shows that public investments confer no direct benefit to region's residents because they do not own capital. However it produces indirect benefit in attracting capital. Indeed, (1) yields the following levels of capital in each region:

$$x_1 = \frac{1 + \varepsilon}{2} + \frac{(g_1 - g_2) - (t_1 - t_2)}{2\delta}, \quad x_2 = \frac{1 - \varepsilon}{2} - \frac{(g_1 - g_2) - (t_1 - t_2)}{2\delta}. \tag{4}$$

In particular, under equal tax and investments levels ($t_1 = t_2$ and $g_1 = g_2$), region 1 attracts more capital than region 2: $x_1(t, g) > 1/2 > x_2(t, g)$. Note that the elasticity of the regional tax base with respect to its own tax and public investment is inversely related to the value δ. The nice feature of this functional form is to provide a neutral case regarding the two opposite views on fiscal equalization. As will be shown below, with this formulation, the positive externality-correction effect of equalization on taxes is just offset by the negative retention-rate effect, so that equilibrium taxes are unaffected by equalization. This simplification will allow us to concentrate on the strategic interaction between taxes and public investments.

Let us first provide a benchmark by deriving the efficient outcome that maximizes the sum of the two regional welfare levels (from the perspective of the regions' residents)[6]:

Proposition 2.1. *Let* $\delta > \frac{1}{1 - \varepsilon}$. *Then efficiency requires a higher level of investment and capital in region 1:* $g_1^o = x_1^o = \frac{1}{2} + \beta > g_2^o = x_2^o = \frac{1}{2} - \beta$, *where* $\beta = \frac{\delta\varepsilon}{2(\delta - 1)} > 0$, *and equal taxation level* $t_1^o = t_2^o = \gamma - \frac{\delta - 1}{2}$.

Productive efficiency requires allocating capital so as to equate its marginal product across regions. With no capital ownership, the remuneration of the mobile factor is taxed away and redistributed to the regions' residents and thus $t_i = f_i = t^o$. Public investments confer no direct benefit to residents, but by increasing the return of capital, public investments also increase tax revenue. The efficient regional investment from the residents' perspective equal investment's marginal revenue (proportional to the amount of capital) to its marginal cost in either region. Since the more attractive region (region 1) should receive more capital, it also exhibits higher marginal value of investment, and thus should also undertake higher public investments. The condition on δ and ε ensures that both regions get capital. When ε is high, it is efficient to allocate all the capital in region 1 if the rate of productivity decline (i.e., δ) is not too high.[7] If part of the capital were owned domestically, then we should add the net return to capital in the regional welfare function and it would simply scale down taxes and scale up public investments by the extent of the domestic ownership of capital.

3. Equilibrium — no equalization

In this section we turn to the examination of regions' equilibrium choices, where, as a benchmark, we first analyze the case without equalizing transfers, i.e., when $\alpha = 0$. We assume that regions make public investments before tax

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[6] We derive the efficient outcome supposing a common budget constraint across the two regions, thus the level of equalization transfers cancels out from the sum of regional welfare, because it is a pure transfer between the two regions. Obviously, it will be an important factor when regions compete in taxes and public investments.

[7] When regional production functions have increasing returns in public inputs and capital, the efficient solution requires allocating all capital in a single region, see Bucovestsky (2006).

decisions so that public investments have a strategic effect on tax choices and regions can attract capital by investing more or taxing less. Attracting more capital increases not only the tax base but also the returns to the immobile factor. Since investment has a negative externality, while taxes' externality effect is positive, one might expect under-taxation and over-investment in equilibrium as in Keen and Marchand (1997) who assumed simultaneous tax and investment choices. However we will show that investment may have important strategic effect on tax choices.

We solve this game backwards and, given the policy choices t, g, the allocation of capital, which is correctly anticipated by both regions, is given by (4).

3.1. Tax subgame

Given the public investments $g = (g_1, g_2)$, each region i anticipates the allocation of capital and independently chooses its tax t_i so as to maximize $W_i(t, g)$. It is easy to verify that the welfare function is concave in taxes, yielding the following single-valued tax response functions,

$$\tau_1(t_2) = \delta\left(\frac{1+\varepsilon}{3} + \frac{g_1 - g_2}{3\delta}\right) + \frac{t_2}{3}, \quad \tau_2(t_1) = \delta\left(\frac{1-\varepsilon}{3} - \frac{g_1 - g_2}{3\delta}\right) + \frac{t_1}{3}. \tag{5}$$

Since the best-response functions are upward sloping, taxes are strategic complements. Note also that the slope is less than one, which ensures the stability of the equilibrium. By solving the system of equations (5), we derive the Nash equilibrium of the tax subgame:

$$\tilde{t}_1(g) = \frac{\delta(2+\varepsilon) + (g_1 - g_2)}{4}, \quad \tilde{t}_2(g) = \frac{\delta(2-\varepsilon) - (g_1 - g_2)}{4}. \tag{6}$$

Thus, there is a negative effect of one region's investment on the other region's second-stage tax choice: $\frac{\partial \tilde{t}_2}{\partial g_1} = \frac{\partial \tilde{t}_1}{\partial g_2} < 0$. Combined with the positive tax externality, investment has a negative strategic effect $\frac{\partial W_i}{\partial \tilde{t}_j} \frac{\partial \tilde{t}}{\partial g_i} < 0$ for $i \neq j$.

3.2. Public investment

The incentive to invest stems both from the direct effect of investment on regional welfare and its strategic effect on the other region's tax rate.[8] Even though the latter is negative for both regions, that does not imply that both regions will necessarily reduce their level of investment. Indeed both regions make investment decisions g_1 and g_2 in the first-stage and a region may invest more since a low level of investment by the other region raises the marginal value of the former region's investment.

The further examination of the equilibrium allows us to state our next result:

Proposition 3.1. *Let $\underline{\delta} = 3/8$. Then under regional asymmetry ($\varepsilon > 0$), $\delta > \underline{\delta}$ and $\gamma > \delta - \underline{\delta}$, there exists a unique asymmetric equilibrium, where the public investments, tax levels and allocation of capital in both regions $i = 1, 2$ are given by:*

$$g_1^* = \underline{\delta} + \frac{\delta\underline{\delta}\varepsilon}{2\left(\delta - \underline{\delta}\right)}, \quad g_2^* = \underline{\delta} - \frac{\delta\underline{\delta}\varepsilon}{2\left(\delta - \underline{\delta}\right)},$$

$$t_1^* = \delta\left(\frac{1}{2} + \frac{\delta\varepsilon}{4\left(\delta - \underline{\delta}\right)}\right), \quad t_2^* = \delta\left(\frac{1}{2} - \frac{\delta\varepsilon}{4\left(\delta - \underline{\delta}\right)}\right), \tag{7}$$

$$x_1^* = \frac{1}{2} + \frac{\delta\varepsilon}{4\left(\delta - \underline{\delta}\right)}, \quad x_2^* = \frac{1}{2} - \frac{\delta\varepsilon}{4\left(\delta - \underline{\delta}\right)}.$$

Region 1 taxes more, invests more and attracts more capital than region 2. Compared to the optimal allocation, there is too little capital and a suboptimal public investment in the more attractive region, and under-taxation in the less attractive region.

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[8] By an envelope argument, there is no effect through own tax rate.

The reason for lower level of capital and investment in region 1 is that region 2 will under-cut its more attractive rival by under-taxing. This in turn shrinks the amount of capital located in region 1, lowers the marginal value of its investment and reduces it to a suboptimal level.

It is interesting to compare the equilibrium outcome and the optimal allocation in the case of symmetric regions ($\varepsilon = 0$). Indeed, (7) implies that $t^* = \delta/2$ and $g^* = \underline{\delta}$ are the symmetric baseline equilibrium in taxes and public investments. Comparing with the optimal tax $t^o = \gamma - (\underline{\delta} - 1)/2$ in Proposition 2.1, it is immediate to verify that there is under-taxation for $\gamma > \delta - \underline{\delta}$. Moreover, since $g^* < g^o = 1/2$, there is always under-investment. Thus we have the following result:

Proposition 3.2. *Under regional symmetry, $\delta > \underline{\delta}$, and $\gamma > \delta - \underline{\delta}$, there is a unique symmetric equilibrium involving under-investment and under-taxation in either region.*

In equilibrium regions under-cut their public investment levels to soften tax competition between them. However, these strategic investment choices are not enough to correct for the classical under-taxation of capital. This is because, when the investment decision is made, each region has still an incentive to under-cut its rival's tax rate. Either region is left with too little taxation and too little public investment. Both regions will gain by increasing jointly their tax rates and public investment levels. Of course the tax increase would be at the expense of outside capital owners. It is important to highlight that the under-investment result is due to the strategic effect of (first stage) investment levels on (second stage) tax levels, and is robust to changing a number of our modeling options. For instance, it is not difficult to see that partial domestic ownership of capital (say $\overline{x}_i < 1/2$ in region $i = 1, 2$) would not change the under-investment result. Indeed, with capital ownership, it is a straightforward exercise to show that equilibrium taxes are given by $t_i = \delta(x_i - \overline{x}_i)$, $i = 1, 2$.[9] Thus domestic ownership simply scales down tax rates by a constant without changing the negative strategic effect of public investments $\left(\frac{\partial t_i}{\partial g_j} < 0 \text{ for } i \neq j \right)$ so that the under-investment result is unchanged.[10] If, on the other hand, one eliminates the sequentiality of decisions, so that taxes and investment levels are chosen simultaneously as in Keen and Marchand (1997), the strategic effect of public investments on tax choices would disappear. In our model we would get under-taxation $t_i = \delta/2$ but efficient investment levels $g_i = 1/2$ in the symmetric equilibrium. This is different from the over-provision result of Keen and Marchand (1997) because we do not have a public good in our model and thus tax competition cannot distort the balance of public good and public investments.[11] Lastly we can compare our non-cooperative equilibrium with partial cooperation on public investments. Because regions cannot negotiate tax rates, they will spend too much on public investment, with too little taxation of capital, from the perspective of their residents. Here regions bear the full cost of public investments, but cannot expropriate the resulting rents from the capital owners. If regions cooperate on public investments in the first stage, and then compete in taxes in the second, they will choose no public investment.[12]

Note that fiscal equalization can be a substitute for partial cooperation, as it can prompt regions to refrain from engaging in wasteful investment when they compete in taxes in the second stage.

4. Equilibrium with equalization

Let us consider the model with equalization ($\alpha > 0$). As in the case without fiscal equalization, we must impose restrictions on the parameters such that the interior equilibrium is stable and the reservation price of capital is respected. The results in this section are valid for $\delta > \underline{\delta}^\alpha$ and $\gamma > \underline{\gamma}^\alpha$, as defined in the Appendix. Equilibrium tax and investment levels are also given in the Appendix.

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[9] Choosing sufficiently low capital ownership $\overline{x}_i$, $i = 1, 2$, one can ensure positive tax rates in both regions. Interestingly enough, thanks to the double asymmetry among regions (capital ownership and productivity), regions may end up with a zero net exporting position in the capital market even if they have asymmetric capital endowments. In such a case, equilibrium taxes are driven down to zero. We thank a referee for calling our attention to this point.

[10] Equilibrium investment levels are $g_i = (\overline{x}_i + 3x_i)/4$: as one would expect, capital ownership fosters investment. Obviously, if $\overline{x}_1 + \overline{x}_2 = 1$, one region will tax and the other will subsidize capital in equilibrium. However the strategic effect of investments on tax rates is independent of their sign and thus of the pattern of capital ownership.

[11] There are other differences between our model and Keen and Marchand (1997). Regions do not own capital and can influence the net return of capital. The former assumption does not change the under-investment result, while relaxing the latter assumption would lead to zero tax rates in our model because there is no public good and the international capital supply is infinitely elastic (see Hindriks and Myles, 2006, chapter 18, p. 570–571).

[12] Calculations relating to the discussion in this paragraph are available upon request.

We start with symmetric regions where the redistributive effect of fiscal equalization is ruled out. In this case, there are uniform taxes and investment levels, with efficient capital allocation. Equilibrium taxes are independent of the equalization grants (externality internalization effect is just offset by the reduction in the retention rate) but, due to the common pool effect, the equilibrium investment levels decrease with the fiscal equalization, and both regions benefit from fiscal equalization. As we indicated in the previous section, in the absence of the equalization scheme, there is under-taxation and under-investment in equilibrium. However, since taxes are independent of fiscal equalization, the entire marginal benefit of investment is assigned to the mobile factor whereas the immobile factor bears the full investment cost. This is in contrast to the efficient solution where taxation reduces the mobile factor's return to its reservation value of zero, so that the government recovers the benefit of public investments through taxation.

Proposition 4.1. *Suppose $\delta > \underline{\delta}^{\alpha}$ and $\gamma > \underline{\gamma}^{\alpha}$. When regions are symmetric, there is under-taxation and under-investment. Fiscal equalization, which does not affect equilibrium taxes, reduces equilibrium investment levels and generates a welfare improvement for both regions.*

This finding supports the second-best analysis view that a reduction in the number of distortions is not necessarily beneficial. In our model equalization affects the investment but not the tax distortion. So we have a somewhat paradoxical result that with under-taxation and under-investment (relative to efficient level), a joint tax-preserving reduction of investment may be welfare improving. Indeed, when the capital is mobile, the regions cannot tax the full marginal value of investment while incurring its full cost. In equilibrium the regions' investment is a purely defensive device (i.e., each region invests because the other does). Thus, equalization is useful in getting them out of this prisoners' dilemma.

In the case of asymmetric regions, the welfare-improving reduction on average investment levels remains. On the other hand, fiscal equalization induces reallocation of capital from the poor to the rich region, which increases the total remuneration of the fixed factor. It is a trivial exercise to show that the total return to the fixed factor is maximized under a corner solution in which one region gets all the capital. Hence, having a more asymmetric capital allocation is good from the total welfare viewpoint. Fiscal equalization also changes total fiscal revenue and the spreading of public investment levels, which can be positive or negative, depending on parameter values. However, it is possible to show that the two positive effects dominate and, as in the asymmetric case, fiscal equalization produces a federation-wide welfare gain.

Proposition 4.2. *Suppose $\delta > \underline{\delta}^{\alpha}$ and $\gamma > \underline{\gamma}^{\alpha}$. When regions are asymmetric, fiscal equalization raises the total welfare of the federation.*

Finally, we address an interesting question which is whether the more attractive (rich) region could gain from fiscal equalization and the resulting redistribution. We show that the introduction of a "modest" level of fiscal equalization has a positive welfare effect on both regions:

Proposition 4.3. *Suppose $\delta > \underline{\delta}^{\alpha}$ and $\gamma > \underline{\gamma}^{\alpha}$. The more attractive region gains from the introduction of a marginal fiscal equalization scheme if either the degree of regional asymmetry ε or the value of δ is sufficiently small.*

The intuition for this result is that when regional asymmetry is low, taxes and capital allocation remain almost unchanged under fiscal equalization, and the reduction in public investment raises welfare. Under regional asymmetry, fiscal equalization is beneficial because it raises the share of capital in the more attractive region. However, this comes at the expense of a transfer of resources to the poor region, which could be substantial if regional asymmetry is sufficiently high. Finally, in our framework the impact of the regional asymmetry ε is amplified by δ.

5. Conclusion

This paper examines the issue of equalization grants among heterogeneous regions competing in taxes and (market-fostering) public investments under the perfect mobility of capital. In our framework, equalization grants have three effects. Two are efficiency-related (the internalization of the fiscal externality and the incentives for public investments) and the third one is redistributive. We show that equalization is desirable in a variety of settings, both for the federation as a whole as for each region. Interestingly, it could be true even for the region which is a net contributor, provided a "modest" degree of the regional asymmetry.

The key feature of our analysis is the interplay between two widely used policy instruments, market-fostering public investments and capital taxation. They have opposing effects on capital allocation: public investments attract capital while taxes drive it away. In addition, equalization grants can have very different effects on taxes and investments (as indicated above by the discussion between the first and second generation of fiscal federalism models). The joint analysis of these two policy instruments, which are usually treated separately in the existing literature, reveals that tax competition distorts the public investment choices. Our main result is that, even in the absence of equalization, there is strategic under-investment among regions, which is due to the fact public investments raise the stake of tax competition and lead regions to compete more fiercely in taxes. Regarding equalization, it may affect investment choices but not equilibrium taxes. The reason is that the marginal retention rate of fiscal revenue also decreases with equalization which discourages tax-raising efforts. Therefore the classical argument that equalization grants' correction for the tax externality leads to higher taxes does not always hold.

Our analysis could be related to the economic impact of the previous (2004 and 2007) enlargements of the European Union. As the European Economic and Social Committee states[13]

> Western members have expressed fear that the new members may represent too much of a burden for their own economies or the European budget. (…) The public debate now focuses on wage and tax competition, which would be used by new members to attract production facilities and jobs.

Our results suggest that "old" member states may benefit from setting up equalization grants all around if they are concerned by the competition from the "new" member states to attract capital.

Appendix

Proof of Proposition 2.1. To determine a Pareto optimal allocation we have to find

$$\max_{x_i, t_i, g_i} \Lambda = \sum_i W_i(t, g) + v\left[\sum_i x_i - 1\right] + \sum_i \mu_i[t_i - f_i(x_i; g_i)] = \delta\frac{x_1^2}{2} + t_1 x_1 - \frac{g_1^2}{2} + \delta\frac{x_2^2}{2} + t_2 x_2 - \frac{g_2^2}{2}$$
$$+ v\left[\sum_i x_i - 1\right] + \mu_1\left[t_1 - \left(\gamma + g_1 + \frac{\delta\varepsilon}{2} - \delta x_1\right)\right] + \mu_2\left[t_2 - \left(\gamma + g_2 - \frac{\delta\varepsilon}{2} - \delta x_2\right)\right].$$

By the first order condition (FOC) on t_i, $\mu_i = -x_i$ which, using the FOCs on x_i and g_i implies, respectively, that $t_i = v$, i.e., $t_1 = t_2$ and, $g_i = x_i$. Combining the FOCs on t_i and v together with the above identities, we have

$$\gamma + g_1 + \frac{\delta\varepsilon}{2} - \delta g_1 = \gamma + (1 - g_1) - \frac{\delta\varepsilon}{2} - \delta(1 - g_1),$$

and by solving for g_1 and the remaining variables, we obtain

$$t_1^0 = t_2^0 = \gamma - \frac{\delta - 1}{2}, g_1^0 = x_1^0 = \frac{1}{2} + \frac{\delta\varepsilon}{2(\delta - 1)}, g_2^0 = x_2^0 = \frac{1}{2} - \frac{\delta\varepsilon}{2(\delta - 1)}.$$

It can be shown that the second order condition (SOC) is satisfied for $\delta > 1$.   □

Proof of Proposition 3.1. Plugging expressions (4) for equilibrium taxes into (6) we obtain $\tilde{x}_1(g) = \frac{1 + \varepsilon/2}{2} + \frac{g_1 - g_2}{4\delta}$. Since region 1 correctly anticipates the equilibrium of the tax subgame and the capital allocation, to maximize its welfare, it chooses the level of its public investment taking as given the investment choice of region 2. FOC is

$$\frac{dW_1}{dg_1} = \frac{\partial W_1}{\partial g_1} + \frac{\partial W_1}{\partial \tilde{x}_1}\frac{\partial \tilde{x}_1}{\partial g_1} + \frac{\partial W_1}{\partial \tilde{t}_1}\frac{\partial \tilde{t}_1}{\partial g_1} = \frac{\tilde{x}_1}{2} + \frac{\tilde{t}_1}{4\delta} - g_1.$$

The substitution for $\tilde{t}_1$ and $\tilde{x}_1$ yields

$$\frac{dW_1}{dg_1} = \frac{3}{4}\left(\frac{1+\varepsilon/2}{2} + \frac{g_1 - g_2}{4\delta}\right) - g_1 = 0.$$

Note that SOC is given by $\frac{d^2 W_1}{dg_1^2} = -1 + \frac{3}{16\delta} < 0$ and it holds when $\delta > 3/16$. By using similar derivations for region 2, we obtain the expressions for best replies

$$G_1(g_2) = \frac{\delta(2+\varepsilon) - g_2}{(16/3)\delta - 1}, \quad G_2(g_1) = \frac{\delta(2-\varepsilon) - g_1}{(16/3)\delta - 1}. \tag{8}$$

Notice that, for $\delta > 3/16$, the best-response functions are downward sloping, and so public investments are strategic substitutes. Moreover, the stability of the public investment equilibrium requires that $\delta > \underline{\delta} \equiv 3/8$. Assume hereafter that $\delta > \underline{\delta}$ and $\gamma > \delta - \underline{\delta}$. The solution of the system of equations (8) yields the equilibrium investment levels

$$g_1^* = \underline{\delta} + \frac{\delta\underline{\delta}\varepsilon}{2(\delta - \underline{\delta})}, \quad g_2^* = \underline{\delta} - \frac{\delta\underline{\delta}\varepsilon}{2(\delta - \underline{\delta})}, \tag{9}$$

and, subsequently, the tax equilibrium

$$t_1^* = \delta\left(\frac{1}{2} + \frac{\delta\varepsilon}{4(\delta - \underline{\delta})}\right), \quad t_2^* = \delta\left(\frac{1}{2} - \frac{\delta\varepsilon}{4(\delta - \underline{\delta})}\right). \tag{10}$$

Therefore $t_1^* - t_2^* > 0$ and $g_1^* - g_2^* > 0$. The equilibrium allocation of capital is $x_1^* = \frac{1}{2} + \frac{\delta\varepsilon}{4(\delta - \underline{\delta})} > x_2^*$. Finally, notice that the reservation price of capital is respected in both jurisdictions for $\gamma > \delta - \underline{\delta} > 0$ since $f_1(x_1^*; g_1^*) - t_1^* = f_2(x_2^*; g_2^*) - t_2^* = \frac{3}{8} + \gamma - \delta$. $\square$

In order to provide the proofs of the results in Section 4, we should first derive an s subgame perfect Nash equilibrium under equalization. First note that fiscal equalization does not change the allocation of capital as a function of policy choices in (4). Solving backwards, we first compute the equilibrium of the tax subgame as a function of investment choices g. Differentiating $W_i^\alpha(t, g)$ in (2) with respect to t_i yields FOC

$$\frac{\partial W_i^\alpha}{\partial t_i} = \left(\frac{1}{2} - \alpha\right)x_i - (1-\alpha)\frac{t_i}{2\delta} + \alpha\frac{t_j}{2\delta} = 0$$

By using (4) to substitute for x_i, we notice that SOC is satisfied: $\frac{\partial^2 W_i^\alpha}{\partial t_i^2} = \frac{4\alpha - 3}{4\delta} < 0$ all $\alpha \in [0, 1/2]$. Thus, we obtain the following tax response functions

$$\tau_1(t_2; \alpha) = K_1 K_2[\delta(1+\varepsilon) + (g_1 - g_2)] + K_2 t_2, \quad \tau_2(t_1; \alpha) = K_1 K_2[\delta(1-\varepsilon) - (g_1 - g_2)] + K_2 t_1,$$

where $K_1 = 1 - 2\alpha$ and $K_2 = (3 - 4\alpha)^{-1}$. It allows us to derive the equilibrium tax levels as functions of g_1 and g_2:

$$\tilde{t}_1(g; \alpha) = \frac{\delta}{2} + \frac{K_1 K_3}{4}(\delta\varepsilon + (g_1 - g_2)), \quad \tilde{t}_2(g; \alpha) = \frac{\delta}{2} - \frac{K_1 K_3}{4}(\delta\varepsilon + (g_1 - g_2)), \tag{11}$$

where $K_3 = (1-\alpha)^{-1}$. Substituting (6) into (4) yields

$$\tilde{x}_1(g, \alpha) = \frac{1}{2} + K_3\left(\frac{\varepsilon}{4} + \frac{g_1 - g_2}{4\delta}\right), \quad \tilde{x}_2(g; \alpha) = \frac{1}{2} - K_3\left(\frac{\varepsilon}{4} + \frac{g_1 - g_2}{4\delta}\right).$$

Anticipating tax choices and capital allocation, each region i chooses its public investment g_i given the choice of the other region g_j, and FOC is

$$\frac{dW_i^\alpha}{dg_1} = \frac{\partial W_i^\alpha}{\partial g_i} + \frac{\partial W_i^\alpha}{\partial \tilde{x}_i}\frac{\partial \tilde{x}_i}{\partial g_i} + \frac{\partial W_i^\alpha}{\partial \tilde{t}_j}\frac{\partial \tilde{t}_j}{\partial g_i} = -g_1 + \frac{\tilde{x}_1}{2} + \frac{\tilde{t}_1}{4\delta} - \alpha K_3\frac{\tilde{t}_2}{4\delta} - \frac{\alpha}{4}K_1 K_3 = 0.$$

(Note that SOC $\frac{d^2 W_i^\alpha}{dg_i^2} = \frac{K_3^2}{16\delta K_2} - 1 < 0$ holds for $\delta > \underline{\delta}^\alpha = \frac{K_3^2}{8K_2}$.

The best replies are

$$G_1^\alpha(g_2) = K_4 + (\delta\varepsilon - g_2)K_5, \quad G_2^\alpha(g_1) = K_4 - (\delta\varepsilon + g_1)K_5,$$

where $K_4 = \delta \frac{2K_3^{-1}(3K_1 + 4\alpha^2)}{16\delta K_3^{-2} - K_2^{-1}}$ and $K_5 = \frac{K_3^{-1}}{16\delta K_3^{-2} - K_2^{-1}}$.

Thus, public investments are strategic substitutes and the Nash equilibrium is stable if $\delta > \underline{\delta}^\alpha$ and $\underline{\delta}^\alpha \in [\underline{\delta}, 1/2]$. It follows that equilibrium taxes and investment levels are given by

$$t_1^*(\alpha) = t^* + \frac{\delta^2}{4}K_3 K_1 \frac{\varepsilon}{\delta - \underline{\delta}^\alpha}, \quad t_2^*(\alpha) = t^* - \frac{\delta^2}{4}K_3 K_1 \frac{\varepsilon}{\delta - \underline{\delta}^\alpha},$$

$$g_1^* = g^*(\alpha) + \frac{K_3^2}{16K_2}\left(\frac{\delta\varepsilon}{\delta - \underline{\delta}^\alpha}\right), \quad g_2^* = g^*(\alpha) - \frac{K_3^2}{16K_2}\left(\frac{\delta\varepsilon}{\delta - \underline{\delta}^\alpha}\right),$$

where the baseline symmetric tax and investment levels are $t^* = \frac{\delta}{2}$ and $g^*(\alpha) = \frac{1}{8}(2K_1 + K_3)$.

This yields the equilibrium capital allocation

$$x_1^*(\alpha) = \frac{1}{2} + \frac{\delta\varepsilon K_3}{4\left(\delta - \underline{\delta}^\alpha\right)}, \quad x_2^*(\alpha) = \frac{1}{2} - \frac{\delta\varepsilon K_3}{4\left(\delta - \underline{\delta}^a\right)}.$$

Hence, for $\delta > \underline{\delta}^\alpha$, there is a stable Nash equilibrium in which the more attractive region invests more in public infrastructures, sets a higher tax rate, and attracts more capital than the less attractive one. Finally, it is straightforward to verify that the reservation price of capital is respected in both jurisdictions for $\gamma > \underline{\gamma}^\alpha = \delta - (K_2^{-1} + \alpha K_3)/8$.

Proof of Proposition 4.1. It is easy to show that

$$\frac{\partial W_1^*}{\partial \alpha} = \delta x_1^* \frac{dx_1^*}{d\alpha} + t_1 \frac{dx_1^*}{d\alpha} + x_1 \frac{dt_1^*}{d\alpha} - g_1^* \frac{dg_1^*}{d\alpha} = -g_1^* \frac{-4 + K_3^2}{8} > 0,$$

where $K_3^2 = (1 - \alpha)^{-2} < 4$ for $0 < \alpha < 1/2$. $\quad \square$

Proof of Proposition 4.2. Straightforward, but tedious, computations yield

$$\frac{d(W_1^{*\alpha} + W_2^{*\alpha})}{d\alpha} = \frac{K_1 K_3^3}{32}\left((K_2^{-1} + 2\alpha)(K_3^{-1}K_2^{-1} + \alpha) + \frac{4\delta^4 \varepsilon^2}{(\delta - \underline{\delta}^\alpha)^3}\right) > 0. \quad \square$$

Proof of Proposition 4.3.

When $\alpha = 0$, the capital in region 1 is given by $x_1^* = \frac{1}{2} + \frac{2\delta\varepsilon}{8\delta - 3}$, which is smaller than 1 if $\varepsilon < \bar{\varepsilon}_0 = (8\delta - 3)/4\delta$. Denote by $Z(\varepsilon)$ the partial derivative (with respect to α) of the welfare of the more attractive region $\frac{\partial W_1^*}{\partial \alpha}$, evaluated at $\alpha = 0$. We shall show that the value of Z is positive under the conditions of the proposition.

We have

$$Z(\varepsilon) = \frac{32\delta^4}{(8\delta - 3)^3}\varepsilon^2 - \frac{3\delta(8\delta - 1)(16\delta - 9)}{16(8\delta - 3)^2}\varepsilon + \frac{9}{64}.$$

Let the two roots of the equation $Z(\varepsilon) = 0$ be denoted by ε_1 and ε_2. It can be verified that both exist if $\delta > \tilde{\delta} \approx 1.0202$. Since $Z(0) > 0$, the straightforward examination yields the following cases: when $\delta < \tilde{\delta}$, $Z(\varepsilon) > 0$ for all $\varepsilon > 0$; when $\tilde{\delta} < \delta < 9/8$, $Z(\varepsilon) > 0$ for $\varepsilon < \varepsilon_1$ and $\varepsilon > \varepsilon_2$; and if $\delta > 9/8$, $Z(\varepsilon) > 0$ for $\varepsilon < \varepsilon_1$. This implies, that $Z(\varepsilon) > 0$ if either $\varepsilon < \varepsilon_1$. or $\delta < \tilde{\delta}$. $\quad \square$

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