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ABSTRACT: This paper analyzes the impact of fiscal equalization on asymmetric tax competition when positive agglomeration externalities are present. It shows that equalization of standardized tax revenue improves the spatial allocation of capital provided that agglomeration externalities are sufficiently strong.

JEL Codes: R12, H71, H73

Keywords: Agglomeration, tax competition, fiscal equalization

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1 Introduction

Whether or not the outcome of capital tax competition is efficient, has mainly been considered as a matter of instruments. If only source based taxes are available, taxes are too low and the equilibrium is inefficient (see, e.g., Zodrow and Mieszkowski (1986)), if, in contrast, also residence based taxes are at hand, efficiency can be restored (see Bucovetsky and Wilson (1991)). However, the analysis was restricted to a linearly homogeneous production function which requires capital intensity to be equalized across regions. Furthermore, the focus was mainly on symmetric equilibria of identical regions. Even if the assumption of perfect symmetry was relaxed, identical per-capita endowments typically remained (see Bucovetsky (1991) and Wilson (1991)). The recent spatial economics literature deviates from these assumptions: When technology exhibits increasing returns to scale, core-periphery pattern are likely to emerge. Tax competition has also been studied within the framework of the New Economic Geography (NEG) and many results of the standard competition literature (see the survey by Wilson (1999)) have been reversed: Core regions may very well tax agglomeration rents without affecting the location of capital. Furthermore, instead of inducing a monotonic race to the bottom, trade integration first increases tax rates and later reduces them (see, e.g., Andersson and Forslid (2003), Baldwin and Krugman (2004), and Borck and Pflüger (2006)). Although these results are remarkable, the tax competition literature within the NEG framework has two main shortcomings: First, it relies on the very special assumptions of this strand of literature and there is good reason to doubt the universal validity of the results. Second, there is no smooth transition to the standard tax competition model. Neither is the standard model embedded in the NEG model nor is it the other way round. Especially, for empirical purposes this is truly unsatisfactory. However, there exists a type of model which exhibits the standard features of the NEG model, while at the same time has the standard model as a special case. Assuming that real externalities like knowledge spillovers are the main agglomeration forces, a model with perfect competition and increasing aggregate returns to scale can be built which comprises both strands of literature (see, e.g. Michel et al. (1996) and Abdel-Rahman and Anas (2004)). Burbidge and Cuff (2005) have analyzed tax competition with source and residence based taxes within this framework. They have

shown that asymmetric equilibria with increasing returns to scale are inefficient even if source and residence based taxes are available. Furthermore, larger regions may be better off in equilibrium.[1]

This paper reconsiders the inefficiency result of Burbidge and Cuff (2005) and shows that asymmetry and not increasing returns is the main source of inefficiency. Furthermore, it analyzes whether fiscal equalization schemes provide correcting devices. Since fiscal equalization is common in federations – either explicitly or implicitly via vertical grants (see, e.g., Boadway and Watts (2004)) – this analysis is of high policy relevance. Within the standard model of source based capital tax competition it has been shown by Köthenbürger (2002) and Bucovetsky and Smart (2006) that fiscal equalization schemes – correctly designed – increase efficiency if regions are only sufficiently symmetric. This paper shows that agglomeration externalities may very well amplify the positive impact of a (partial) fiscal equalization scheme.

The following section describes the model and derives the results. Afterwards, a final section concludes.

2 Model

The country consists of two regions. In order to simplify the analysis, it is assumed that total output generates localized positive externalities.[2] Output is produced with two inputs, capital and labor. Capital is interregional mobile, labor is immobile. The output price is normalized to one.

The production function $x_{ij} = X_i^{\epsilon} G(K_{ij}, N_{ij})$, with $0 \leq \epsilon < 1$, characterizes production of firm j in region i. Here, x_{ij} denotes output, K_{ij} and N_{ij}, indicate capital and labor, respectively. Aggregate output in region i, X_i, raises output, but is considered as exogenous by each firm. ϵ is a measure of agglomeration externalities. The "internal" production

[1] A somewhat similar model is used by Boadway et al. (2004).

[2] This is standard in trade theory, see, e.g., Choi and Yu (2002). In regional economics, the mobile input is usually considered as source of agglomeration externalities (see, e.g., Fujita and Thisse (2002)). However, as long as the "internal" production function is Cobb-Douglas, both approaches yield the same results.

function $G(K,N)$ is linearly homogeneous, with $G_{KK} < 0 < G_K$ and $G_{NN} < 0 < G_N$.[3] Both inputs are essential: $G(0,N) = G(K,0) = 0$. Due to constant returns to scale at the firm level, inputs are paid according to their marginal product, profits are zero, and the number of firms is irrelevant. Hence, regional output can be written as $X_i = X_i^{\epsilon} G(K_i, N_i)$, where K_i and N_i denote capital and labor at the regional level. Solving for X_i, yields

$$X_i = F(K_i, N_i) := G(K_i, N_i)^{1/(1-\epsilon)} \tag{1}$$

and hence

$$r_i = (1-\epsilon) F_K(K_i, N_i) \quad \text{and} \quad w_i = (1-\epsilon) F_N(K_i, N_i), \tag{2}$$

where r_i and w_i is the interest rate and the wage in region i, respectively. Aggregate output is homogenous of degree $1/(1-\epsilon)$. Were $\epsilon = 0$, returns to scale would be constant, otherwise, they are increasing. It is assumed that agglomeration externalities are not too strong: $F_{KK}(K,N) < 0$.[4]

N_i persons live in region i and supply inelastically one unit of labor each. Per-capita capital endowment in region i is $\overline{K_i}$. Total capital and labor is denoted by $\overline{K} := \overline{K_1} + \overline{K_2} = K_1 + K_2$ and $\overline{N} := N_1 + N_2$, respectively.

Spatially efficient production Total output is maximized if the marginal product of mobile capital is equalized across regions:

$$F_K(K_1, N_1) = F_K(K_2, N_2). \tag{3}$$

Hence, spatial efficiency requires a uniform return to capital (since the return to capital is proportional to the marginal product of capital). In regions of equal size, i.e., $N_1 = N_2$, capital should be allocated symmetrically. Using (3), it becomes clear that, starting at a symmetric allocation of labor and capital, shifting workers from region j to region i should induce capital movement from region 2 to region i according to

$$\frac{\partial K_i}{\partial N_i} = -\frac{F_{KN}(K_1, N_1) + F_{KN}(K_2, N_2)}{F_{KK}(K_1, N_1) + F_{KK}(K_2, N_2)} = \frac{\overline{K}}{\overline{N}} - \frac{2\epsilon F_K(\overline{K}/2, \overline{N}/2)}{(1-\epsilon)\overline{N} F_{KK}(\overline{K}/2, \overline{N}/2)} > 0,\ i = 1, 2. \tag{4}$$

[3] Partial derivatives are indicated by subscripts.

[4] Krogstrup (2008) analyzes the core-periphery outcome implied by $F_{KK}(K,N) > 0$.

If there were no agglomeration externalities, the capital intensity should stay constant; in the presence of agglomeration externalities the capital intensity in the larger (and, therefore, more productive) region should increase.

Inefficient tax competition Regional governments levy capital taxes according to the source principle and redistribute tax revenue lump-sum. Capital taxes may be negative, and (residence based) lump-sum taxes are available. The source based capital tax rate in region i is denoted by t_i. An interior equilibrium of the capital market equalizes the return to capital net of taxes across regions:

$$r_1 - t_1 = r_2 - t_2, \quad \text{i.e.,} \quad (1-\epsilon)F_K(K_1, N_1) - t_1 = (1-\epsilon)F_K(K_2, N_2) - t_2. \tag{5}$$

Using this equilibrium condition and $K_1 + K_2 = \overline{K}$, capital in region i can be written as a function of tax rates: $K_i(t_1, t_2)$, where

$$\frac{\partial K_i}{\partial t_i} = \frac{1}{\frac{dr_1}{dK_1} + \frac{dr_2}{dK_2}} = \frac{1}{(1-\epsilon)[F_{KK}(K_1, N_1) + F_{KK}(K_2, N_2)]} = -\frac{\partial K_i}{\partial t_j}, \quad i, j = 1, 2,\ j \neq i. \tag{6}$$

An increase in the agglomeration externality strengthens the impact of tax rates on the spatial allocation of capital. Since public goods are neglected, governments maximize regional income, namely the sum of labor income, capital income, and tax revenue. At the market equilibrium, regional income is

$$Y_i \;=\; w_i N_i + (r_i - t_i)\overline{K_i} + t_i K_i = F(K_i, N_i) - (r_i - t_i)(K_i - \overline{K_i}), \quad i = 1, 2. \tag{7}$$

The first-order conditions[5] read

$$\frac{\partial Y_i}{\partial t_i} \;=\; K_i - \overline{K_i} + \left[\epsilon F_K(K_i, N_i) + t_i - \frac{dr_i}{dK_i}(K_i - \overline{K_i})\right]\frac{\partial K_i}{\partial t_i} = 0, \quad i = 1, 2. \tag{8}$$

Hence, tax rates at the Nash equilibrium when regional governments determine tax rates simultaneously are:

$$t_i = -\epsilon F_K(K_i, N_i) - (K_i - \overline{K_i})\frac{dr_j}{dK_j}, \quad i = 1, 2, j \neq i. \tag{9}$$

[5]It is assumed that these conditions are also sufficient.

If there are neither capital flows nor agglomeration externalities, tax rates are zero. While capital importing regions tax capital and, thus, reduce the return to capital, capital exporting regions subsidize capital in order to increase the return to capital (due to the pecuniary externality identified by DePater and Myers (1994)). Agglomeration externalities offer incentives for regional governments to subsidize capital, since the subsidy is an internalization device.

From the equilibrium tax rates follows:

$$r_i - t_i = F_K(K_i, N_i) + (K_i - \overline{K_i})\frac{dr_j}{dK_j}, \quad i = 1, 2, j \neq i. \tag{10}$$

As a consequence, in the presence of tax competition, capital flows across the border imply diverging net returns to capital and, therefore, spatial inefficiency. Using the efficiency condition (3), yields $\partial\overline{K_i}/\partial N_i > 0$ for a given total population and a given total capital endowment, which leads immediately to the following proposition.[6]

Proposition 1 *The Nash equilibrium of tax competition is spatially efficient if and only if under autarky marginal products of capital are equalized across regions. The allocation of labor must be accompanied by a unique allocation of capital endowment defined by* $F_K(\overline{K_1}, N_1) = F_K(\overline{K} - \overline{K_1}, \overline{N} - N_1)$.

If regions are identical ex ante in terms of labor and capital endowment, the tax competition equilibrium is efficient. Otherwise, the equilibrium is generically inefficient, since for every allocation of the total population, only one single allocation of capital endowment allows for spatial efficiency. Without agglomeration externalities per-capita capital endowment should be equalized across regions; with agglomeration externalities, the larger region has to have a larger per-capita endowment of capital.

Tax competition, asymmetry, and fiscal equalization In the following, it will be analyzed whether a fiscal equalization scheme which partially redistributes tax bases and standardized tax revenue mitigates or aggravates spatial inefficiency. The transfer to region i is calculated as

$$Z_i = (\alpha\bar{t} + \beta)\left(\frac{\overline{K}}{\overline{N}} - \frac{K_i}{N_i}\right)N_i, \quad i = 1, 2. \tag{11}$$

[6]See for n regions without agglomeration externalities, Peralta and van Ypersele (2005).

Here, $\bar{t} = (t_1K_1 + t_2K_2)/\overline{K}$ is the average tax rate, α, with $0 \leq \alpha < 1$, is the degree of equalization with respect to standardized tax revenue and β, with $\beta \geq 0$, denotes the degree of equalization with respect to the tax base. Hence, regional income is $Y_i = F(K_i, N_i) - (r_i - t_i)(K_i - \overline{K_i}) + Z_i$. Nash equilibrium first-order conditions become

$$\begin{aligned}\frac{\partial Y_i}{\partial t_i} &= K_i - \overline{K_i} + \alpha K_i \left(\frac{N_i}{\overline{N}} - \frac{K_i}{\overline{K}}\right) + \Bigg[\epsilon F_K(K_i, N_i) + t_i - \frac{dr_i}{dK_i}(K_i - \overline{K_i}) \\ &\quad + \alpha(t_i - t_j)\left(\frac{N_i}{\overline{N}} - \frac{K_i}{\overline{K}}\right) - \alpha\bar{t} - \beta\Bigg]\frac{\partial K_i}{\partial t_i} = 0, \quad i = 1, 2, j \neq i,\end{aligned} \tag{12}$$

when regional governments take the impact of their tax policy on the average tax rate into account. Hence, in a symmetrical equilibrium of identical regions tax rates are

$$t_1 = t_2 = \frac{\beta - \epsilon F_K(\overline{K}/2, \overline{N}/2)}{1 - \alpha}. \tag{13}$$

Equalization of standardized tax revenue increases the equilibrium tax rates if $\beta > \epsilon$ $F_K(\overline{K}/2, \overline{N}/2)$. An increase in a region's tax rate leads to capital outflow. This implies a higher transfer provided that tax rates are positive and/or tax base equalization is strong. Using the first-order conditions (12) and the capital market condition (5), yields

$$\begin{aligned}&F_K(K_1, N_1) - F_K(K_2, N_2) + \left(\frac{dr_1}{dK_1} + \frac{dr_2}{dK_2}\right) \times \\ &\left\{K_1 - \overline{K_1} + \alpha\left[K_1\left(\frac{N_1}{\overline{N}} - \frac{K_1}{\overline{K}}\right) - K_2\left(\frac{N_2}{\overline{N}} - \frac{K_2}{\overline{K}}\right)\right]\right\} = 0.\end{aligned} \tag{14}$$

This equation reveals the relationship between the distortion of tax competition and the fiscal equalization scheme. Without fiscal equalization, i.e. if $\alpha = 0$, the capital-importing region levys a too high capital tax (subsidizes too little), and, therefore, attracts too little capital. As a consequence, the marginal product of capital is too high in this region. Due to the fiscal equalization scheme, an increase in the average tax rate $\bar{t}$ pays off for a particular region if the capital intensity is rather low. Hence, if the region with the lower capital intensity imports capital, fiscal equalization aggravates spatial distortions. Otherwise, it might improve efficiency.

Defining

$$\Delta := \frac{2 - \epsilon - \alpha(1 - \epsilon)}{1 - \epsilon}\left(\frac{dr_1}{dK_1} + \frac{dr_2}{dK_2}\right) < 0, \tag{15}$$

and using (14), starting at a symmetrical equilibrium of identical regions the impact of (exogenously determined) relocation of workers from region 2 to region 1 on the allocation of capital can be written as

$$\frac{\partial K_1}{\partial N_1} = -\frac{F_{KN}(K_1, N_1) + F_{KN}(K_2, N_2) + \alpha\frac{\overline{K}}{\overline{N}}\left(\frac{dr_1}{dK_1} + \frac{dr_2}{dK_2}\right)}{\Delta} \tag{16}$$

and a movement of capital endowment from region 2 to region 1 induces

$$\frac{\partial K_1}{\partial \overline{K_1}} = \frac{\frac{dr_1}{dK_1} + \frac{dr_2}{dK_2}}{\Delta} > 0. \tag{17}$$

Hence, the impact of combined relocation of workers and capital endowment on the allocation of capital can be calculated: $dK_1/dN_1 = \partial K_1/\partial N_1 + (\partial K_1/\partial \overline{K})\ (\overline{K}/\overline{N})$. Since the symmetric equilibrium is efficient, the deviation of equilibrium capital flows from the efficient change in the allocation of capital is of particular interest. Using (4), these deviations are

$$\left.\frac{\partial K_1}{\partial N_1}\right|_{Opt} - \left.\frac{\partial K_1}{\partial N_1}\right|_{NE} = \frac{(1-\epsilon)F_{KK}(\overline{K}/2, \overline{N}/2)\overline{K} - 2(1-\alpha)\epsilon F_K(\overline{K}/2, \overline{N}/2)}{[2-\epsilon-\alpha(1-\epsilon)]F_{KK}(\overline{K}/2, \overline{N}/2)\overline{N}} > 0 \tag{18}$$

and

$$\left.\frac{\partial K_1}{\partial N_1}\right|_{Opt} - \left.\frac{dK_1}{dN_1}\right|_{NE} = -\frac{2(1-\alpha)\epsilon F_K(\overline{K}/2, \overline{N}/2)}{[2-\epsilon-\alpha(1-\epsilon)]F_{KK}(\overline{K}/2, \overline{N}/2)\overline{N}} \geq 0. \tag{19}$$

From (18) follows that a larger and poorer region – independent of whether or not agglomeration externalities arise – employs too little capital relative to the optimum, even in the presence of a fiscal equalization scheme. The sign of the derivative of (18) with respect to α is ambiguous. Hence, a fiscal equalization scheme may very well aggravate spatial inefficiency. This would happen with certainty if there were no agglomeration externalities. In the presence of agglomeration externalities, additional capital flows in the larger region. Eventually, the capital intensity in the larger region may be higher than in the smaller region. Under these circumstances, the fiscal equalization scheme provides an incentive to lower the tax rate thereby attracting more capital and increasing efficiency. Numerical simulations show that this is indeed possible if agglomeration externalities are rather strong. The following proposition summarizes the result:

Proposition 2 *Starting at a symmetric tax competition Nash equilibrium of identical regions, relocation of labor without movement of capital endowment induces too little parallel*

capital flows. If agglomeration externalities are sufficiently strong, the fiscal equalization scheme may increase spatial efficiency. Otherwise, fiscal equalization worsens the outcome of tax competition.

(19) confirms proposition 1, since relocation of workers without a change in the per-capita endowment of capital would maintain spatial efficiency if there were no agglomeration externalities. Under the circumstances, the fiscal equalization scheme has no effect. In contrast, if externalities occur, the larger region employs too little capital, albeit more than the smaller region. Since then the derivative of (19) with respect to α is unambiguously negative, the fiscal equalization scheme improves the allocation of capital. At the equilibrium, the capital intensity of the larger region exceeds that of the smaller region implying that the larger region could reduce transfers to the smaller region by reducing its tax rate. At the end, fiscal equalization leads to a welfare enhancing capital inflow. Full equalization, i.e., $\alpha = 1$, would actually completely restore efficiency. The result is summarized by the following proposition:

Proposition 3 *Starting at a symmetric tax competition Nash equilibrium of identical regions, relocation of labor with parallel movement of capital endowment induces too little parallel capital flows only if agglomeration externalities arise. The fiscal equalization scheme serves as a corrective device.*

3 Concluding remarks

This paper has analyzed tax competition when lump-sum taxes are available in a model which allows for agglomeration externalities. It has shown that asymmetry and not increasing aggregate returns to scale is the main source of inefficiency. Furthermore, it has shown that agglomeration externalities may very well amplify the positive impact of a (partial) fiscal equalization scheme. In the presence of agglomeration externalities in regions with identical per-capita capital endowment, but with different population size, a scheme that equalizes standardized tax revenue across regions increases the efficiency of the allocation of capital. If, in addition, per-capita endowments of capital differ, a fiscal equalization scheme

has also turned out to be efficiency enhancing provided that agglomeration externalities are sufficiently strong.

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