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Leadership in Tax Ccompetition with Fiscal Equalization Transfers

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Abstract

We propose a timing game of asymmetric tax competition with fiscal equalization scheme. The study finds that governments tend to play a sequential-move game as the scale of equalization transfer increases, which explains the emergence of tax leaders in tax competition. The presence of a tax leader is likely to exacerbate capital misallocation among countries, suggesting that equalization transfers aimed at narrowing the interregional fiscal gap might cause a problem of efficient capital allocation.

Keywords: tax competition, endogenous timing, leadership, equalization transfers.

JEL Classification Numbers: H30, H87.

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1 Introduction

Which country leads tax competition? Since the seminal work presented by Kempf and Rota-Graziosi (2010), the appearance of leadership in tax competition has attracted the attention of both empirical and theoretical researchers. For instance, the empirical work of Altshuler and Goodspeed (2002, 2015) estimates the reaction function of the follower, including a lagged value of the leader's tax rate in the previous year, and demonstrates that European countries set their corporate tax rates following the United States but no policy leader exists in tax competition within European Union (EU) countries. The result on leadership in European countries is challenged by two studies with opposite arguments: Redoano (2007) shows that small countries in Europe follow the big countries, Germany and France, while Chatelais and Peyrat (2008) point out that small countries, such as Belgium, play the role of leader in tax competition among EU countries. In addition, theoretical researchers have intensively attempted to seek the factors that lead to the (non-) emergence of equilibrium leadership in tax competition. Most of them suggest the interregional asymmetries in endowments and technology are the determinants of the equilibrium pattern of leadership in tax competition.[1]

When we study tax competition among asymmetric countries, the interregional equalization transfer cannot be disregarded in either the practical or theoretical perspectives. This is attributed to the fact that it is a common feature of federations that regions are linked by a fiscal transfer scheme so as to narrow the interregional gap based on concern for horizontal equity. Although equalization transfers are performed mainly because of interregional equality objectives, they are also important from the efficiency perspective since the introduction of equalization transfers has significant impacts on tax incentives and thereby might improve the efficiency of tax competition among conflicting regions.[2]

The purpose of this study is to analyze the equilibrium pattern of leadership in the presence of an equalization transfer scheme. Specifically, this study aims to answer whether a Stackelberg leader in tax competition is likely to emerge when regions are linked by the equalization transfer scheme. Since the structure of the game, that is, the sequential-move or simultaneous-move game, changes the efficiency of the tax competition equilibrium, our research enables us to establish how the equalization transfer scheme, which aims to reduce the regional fiscal gap, affects the efficiency of the decentralized tax setting through the (non-)appearance of a Stackelberg tax leader.

[1] To name a few, Ogawa (2013), Kempf and Rota-Graziosi (2015), and Hindriks and Nishimura (2015a) identify the pattern of equilibrium leadership focusing on the capital ownership between countries. Hindriks and Nishimura (2015b) show the form of regional asymmetry in production technology matters to determine which country leads in tax competition. Eichner (2014) examines the role of public goods provision and Ida (2014) studies tax leadership with double taxation by comparing the deduction method and the credit method. Kawachi et al. (2015) study equilibrium leadership in public investment competition and Ogawa and Susa (2016) incorporate heterogeneity in capital endowment within the country. Furthermore, recently, the analysis has been extended to the repeated game framework by Itaya and Yamaguchi (2015). See Keen and Konrad (2013) for a review of the leadership game in the tax competition model.

[2] The efficiency role of equalization transfers has been examined intensively, but the studies present conflicting views on their effects. Equalization transfers might mitigate the problem caused by tax competition in some cases, but not in others. See, for instance, a series of studies by Köthenbürger (2002, 2005, 2007), which have presented various analyses that capture the effects of fiscal transfer on regional tax incentives, and those theoretical hypotheses have been tested in subsequent empirical studies (e.g., Buettner, 2006; Smart, 2007; Egger et al., 2010). In addition, Gaigne and Riou (2007), Hindriks et al. (2008), Kotsogiannis (2010), Wang et al. (2014), and Ogawa and Wang (2015) study equalization transfers in static and dynamic tax-competition models.

The rest of this paper is organized as follows. In the next Section 2, we present a model of asymmetric tax competition, in which the asymmetry is captured by the technology differentials between two countries. Focusing on the revenue base equalization scheme, the equilibrium properties are presented to derive the main results in Section 3. Section 4 concludes the paper.

2 Model

The basic observable delay game in the tax competition model follows the works of Kempf and Rota-Graziosi (2010) and Ogawa (2013), among others. There are two countries, and in each country i ($i = S, L$), there are homogeneous residents normalized by 1. The production of private goods in country i requires capital and labor with constant-returns-to-scale technology. We assume that the production per capita in country i is represented by the function $f^i(k_i) = (A_i - k_i)k_i$, where k_i is the amount of capital per capita located in country i and A_i is the country-specific parameter that represents the productive efficiency. Without any loss of generality, we assume $\Lambda \equiv A_L - A_S > 0$.[3]

The total amount of capital in this economy used for production is $2\bar{k}$. A resident in country i has an initial endowment of capital, $\theta\bar{k}$, where θ ($0 \leq \theta \leq 1$) characterizes the form of capital ownership. When $\theta = 0$, the capital is fully owned by absentee owners; however, $\theta = 1$ corresponds to a non-absentee ownership environment. $\theta = 0$ and $\theta = 1$ are a special case, however, and thus, we study the equilibrium leadership, including the general case of $\theta \in (0, 1)$.

The resident's preference in country i is given by $u(c_i) = c_i$, where c_i is the consumption of a private numeraire good. A resident in country i receives labor income $f^i(k_i) - f^i_k(k_i)k_i$, return from capital investment $r\theta\bar{k}$, and lump-sum transfer from the government g_i, where r is the price of capital. Hence, the budget constraint of the resident requires

$$c_i = f^i(k_i) - f^i_k(k_i)k_i + r\theta\bar{k} + g_i. \tag{1}$$

The government in each country can use only unit tax on mobile capital. The budget constraint of country i becomes

$$g_i = t_i k_i + B_i, \quad \text{where} \quad B_i \equiv \alpha(t_j k_j - t_i k_i). \tag{2}$$

In (2), t_i is the unit tax rate and B_i is the fiscal transfer allocated to country i, where α represents the scale of fiscal transfer scheme, which is given exogenously. It is obvious that the fiscal transfer scheme is budget balancing (i.e., $B_i + B_j = 0$).

When $\alpha \in [1/2, 1]$, the revenue-rich (-poor) country obtains a small (large) share of the difference in tax base. To avoid this irrelevant situation, we make the following assumption.

Assumption 1. $\alpha \in [0, 1/2)$.

[3] A_i is not intended to capture regional differences in a limited sense, but it does capture the productivity differences in a broad sense, including the differences in country risks, business customs, geographical environment, labor quality, and so on. While technological differences might disappear relatively quickly through information spillovers, other factors that distinguish countries are difficult to represent on the same level, at least in the short run. Since the way to express the regional differentials in technology do not affect the main result of this study, we express the regional asymmetry in terms of A_i for a simple and efficient expression.

Since capital is perfectly mobile among countries, the market-clearing conditions are given by $r = f_k^i(k_i) - t_i$ and $2\bar{k} = k_L + k_S$. Under these conditions, the capital located in country i and the capital price are obtained as follows.

$$k_L = \bar{k} + \frac{\Lambda - t_L + t_S}{4}, \tag{3}$$

$$k_S = \bar{k} - \frac{\Lambda - t_L + t_S}{4}, \tag{4}$$

$$r = \frac{\Omega}{2} - \frac{4\bar{k} + t_L + t_S}{2}, \quad \text{where } \Omega \equiv A_L + A_S. \tag{5}$$

3 Equilibrium

3.1 Timing Game

In the timing game of tax competition, which is based on the observable delay game formulated by Hamilton and Slutsky (1990), there are two possible time periods (*early* or *late*) for the choice of tax rate, and each government may choose its tax rate in only one of the two periods. In stage one, the governments simultaneously announce in which period they will choose their tax rates, and they are committed to their choices. In stage two, after the announcements, the governments select their tax rates knowing when the other government will choose their tax rate. A simultaneous-move game occurs if all the governments decide to choose their tax rates in the same period (i.e., *early, early* or *late, late*). By contrast, a sequential-move game occurs if the governments decide to choose their tax rates in different periods (i.e., *early, late* or *late, early*).

We denote G^N as a simultaneous-move game in which governments simultaneously choose their tax rates; G^L as a sequential-move game in which country L chooses its tax rate in the early period and country S, in the late period; and G^S as a sequential-move game in which country L chooses its tax rate in the late period and country S, in the early period.

In the following analysis, to ensure active tax competition ($k_i > 0$ for all i in any games), we make the following assumption.[4]

Assumption 2. $\Lambda < 8(1-\alpha)\bar{k}$.

3.2 Simultaneous-move game (G^N)

We begin with Game G^N, in which two governments choose their tax rates simultaneously. Substituting (1) and (2) into $u_i = c_i$, the objective function of government i is given by $u_i = (A_i - k_i)k_i + r(\theta\bar{k} - k_i) + \alpha(t_j k_j - t_i k_i)$. Thus, the problem of government i ($i = S, L$) at the beginning of the second stage is defined as follows.

$$\begin{aligned} \max_{t_i} \quad & u_i = (A_i - k_i)k_i + r(\bar{k} - k_i) + \alpha(t_j k_j - t_i k_i), \\ \text{s.t.} \quad & (3) - (5). \end{aligned}$$

The first-order condition yields

[4]See the second equation in (10) below. If this Assumption 2 is violated, all capital is concentrated in country L and country S becomes non-active.

$$t_L = \frac{t_S + (1-2\alpha)\Lambda + 4\bar{k}(1-\theta-2\alpha)}{3-4\alpha}, \quad (6)$$

$$t_S = \frac{t_L - (1-2\alpha)\Lambda + 4\bar{k}(1-\theta-2\alpha)}{3-4\alpha}, \quad (7)$$

which give us the equilibrium tax rates as

$$t_L^N(\alpha,\theta) = \frac{8\bar{k}(1-\alpha)(1-\theta-2\alpha) + \Lambda(1-2\alpha)^2}{4(1-2\alpha)(1-\alpha)} \text{ and } t_S^N(\alpha,\theta) = \frac{8\bar{k}(1-\alpha)(1-\theta-2\alpha) - \Lambda(1-2\alpha)^2}{4(1-2\alpha)(1-\alpha)}. \quad (8)$$

The superscript N in each variable denotes Game N and the subscripts L and S represent each country. The same notation applies to the subsequent analysis. From (8), we obtain

$$t_L^N(\alpha,\theta) - t_S^N(\alpha,\theta) = \frac{\Lambda(1-2\alpha)}{2(1-\alpha)} > 0, \quad (9)$$

suggesting that country S sets a lower tax rate than country L. This is because country S has lower technology, $\Lambda \equiv A_L - A_S > 0$, and thus, it has to choose a lower tax rate so as to invite mobile capital into the country.

Substituting (8) into (3)–(5), we obtain the following equilibrium values:

$$k_L^N(\alpha,\theta) = \bar{k} + \frac{\Lambda}{8(1-\alpha)}, \quad k_S^N(\alpha,\theta) = \bar{k} - \frac{\Lambda}{8(1-\alpha)}, \quad \text{and} \quad r^N(\alpha,\theta) = \frac{\Omega}{2} - \frac{2\bar{k}(2-\theta-4\alpha)}{1-2\alpha}. \quad (10)$$

Using (10), we obtain the utility (payoffs) in countries L and S in the simultaneous-move game, $u_L^N(\alpha,\theta)$ and $u_L^N(\alpha,\theta)$ as

$$u_L^N(\alpha,\theta) = M(\alpha,\theta) + \frac{\bar{k}\Lambda\left(3-\theta-6\alpha+4\alpha^2\right)}{4(1-\alpha)}, \quad (11)$$

$$u_S^N(\alpha,\theta) = M(\alpha,\theta) - \frac{\bar{k}\Lambda\left(3-\theta-6\alpha+4\alpha^2\right)}{4(1-\alpha)}, \quad (12)$$

where

$$M(\alpha,\theta) \equiv \frac{\Omega\theta\bar{k}}{2} + \frac{\Lambda^2(3-4\alpha)}{64(1-\alpha)^2} + \frac{\bar{k}^2\left(3-6\theta+2\theta^2-6\alpha+8\theta\alpha\right)}{(1-2\alpha)}.$$

3.3 Sequential-move games (G^L and G^S)

There are two Stackelberg games, G^L and G^S, and the equilibrium values for two games can be obtained in a standard manner, which are summarized in Appendices A and B. In game G^L, in which country L chooses its tax rate in the early period and country S does so in the late period, the tax rates and utility levels are obtained as $t_L^L(\alpha,\theta), t_S^L(\alpha,\theta), u_L^L(\alpha,\theta)$, and $u_S^L(\alpha,\theta)$ in (13)–(16). In game G^S, in which country S chooses its tax rate in the early period and country L does so in the late period, the tax rates and utility levels are obtained as $t_L^S(\alpha,\theta), t_S^S(\alpha,\theta), u_L^S(\alpha,\theta)$, and $u_S^S(\alpha,\theta)$ in (17)–(20).

3.4 Equilibrium in the first stage

Using the utility levels derived, we obtain the following result.

Proposition 1. Under the revenue base equalization scheme, three types of equilibrium in the timing game are derived:

(i) When $\frac{\Lambda}{\bar{k}} < \frac{8(1-\theta)(1-\alpha)}{1-2\alpha}$, there are two sequential-move equilibria: one country chooses its tax rate in the early period and the other does so in the late period.[5]

(ii) When $\frac{8(1-\theta)(1-\alpha)}{1-2\alpha} < \frac{\Lambda}{\bar{k}} < \frac{8(1-\theta)(1-\alpha)(11-8\alpha)}{(1-2\alpha)(9-8\alpha)}$, there is a single sequential-move equilibrium, in which country L chooses its tax rate in the early period and country S does so in the late period.

(iii) When $\frac{8(1-\theta)(1-\alpha)(11-8\alpha)}{(1-2\alpha)(9-8\alpha)} < \frac{\Lambda}{\bar{k}}$, there is a single simultaneous-move equilibrium, in which both countries choose their tax rates in the same (early) period.

Proof. See Appendix C.

Figure 1 presents our results graphically. Area (G^L, G^S) corresponds to (i), and areas (G^L) and (G^N) correspond to (ii) and (iii) of the above proposition, respectively. Under Assumptions 1 and 2, the valid area is restricted by $\Lambda/\bar{k} < 8(1-\alpha)$ and $\alpha < 1/2$, respectively.

In the absence of an equalization transfer scheme ($\alpha = 0$), Kempf and Rota-Graziosi (2010) show that the two Stackelberg equilibria prevail by assuming $\theta = 0$, and Ogawa (2013) finds a single simultaneous-move equilibrium when $\theta = 1$. Setting $\alpha = 0$, Figure 1 replicates their results. If $\theta = 0$, two curves representing $u_S^N = u_S^L$ and $u_L^N = u_L^L$ are drowned through the y-intercept, $\Lambda/\bar{k} = 8$, and only games G^L and G^S constitute the equilibrium. By contrast, if $\theta = 1$, the two curves cross the origin and match with the x-axis, meaning that game G^N constitutes the equilibrium in the timing game. In this sense, the equalization transfer scheme does not change the pattern of leadership in two extreme cases, $\theta = 0$ and $\theta = 1$, obtained in the previous studies.

However, the equalization transfer scheme does effect the emergence of leadership in tax competition in general, $0 < \theta < 1$: observing the figure from left to right, we find that the Stackelberg outcome is likely to prevail as the scale of the equalization transfer scheme increases. Overall, it is observed that the simultaneous-move outcome is derived when the asymmetry between the two countries, represented by Λ, is large and the scale of the equalization transfer (α) is small. However, the Stackelberg outcome is derived with low asymmetry between the countries and large scale of the equalization transfer scheme. We summarize the result as follows.

Collorary. Tax leadership is likely to prevail when equalization transfers are made between countries.

Two essential factors allow us to interpret the classification of equilibria in Figure 1: (i) the incentive to control the price of capital in the market and (ii) the incentive to reduce the tax rate under a revenue-base equalization scheme. The former incentive is pinned down by Ogawa (2013). Country $L(S)$, which imports (exports) capital, has an incentive to lower (raise) the capital price by raising (lowering) the tax rate in the country. Since the capital price in the market is lowered (raised) if the tax rate in a country is raised (lowered), the two countries have conflicting motivation to manipulate the price of capital, and they aim to be the tax leader to gain first-mover advantage. This leads both governments to set in the early

[5] If we use the risk-dominant criterion to refine the equilibria, the sequential-move equilibrium, G^L, in which country L leads, would survive. See Kempf and Rota-Graziosi (2010).

stage, resulting in the simultaneous-move outcome. The latter incentive prevails in our model due to the equalization transfer scheme. In the presence of revenue-based equalization transfers, the governments have incentive to choose lower tax rates than the tax rates without equalization transfers. This is because a part of the decrease in tax revenue accompanied by the tax cut is offset by the fiscal transfers allocated to the country under the revenue equalization transfer scheme. The equalization transfer scheme gives both capital-importing and -exporting countries the same incentive to set lower tax rates. This weakens the incentive to become the tax leader, as explained in (i), leading the governments to accept the role of the Stackelberg follower, and thus, they play the sequential-move game.

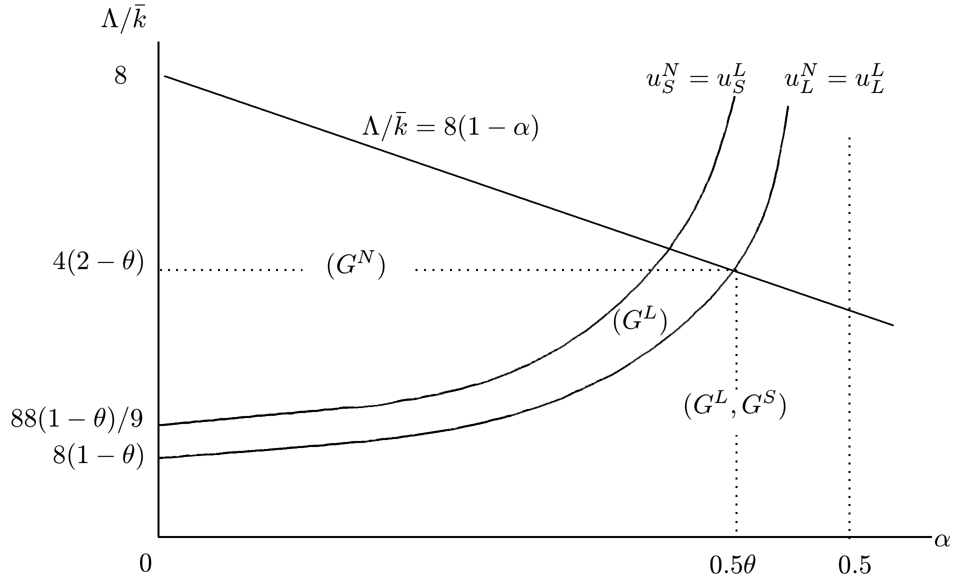

Figure 1. Equilibrium $(0 < \theta < 1)$

3.5 Does equalization transfer distort efficient allocation of capital?

In our model, the total welfare of two countries is given by $u_L + u_S = f^L(k_L) + f^S(k_L) - 2r\bar{k}(1-\theta)$, and the absentee capital owners, who reside outside of the two countries, receive the income of $2r\bar{k}(1-\theta)$. If we define social welfare as the sum of welfare in two countries and the capital income of absentee capital owners, it is obvious that the first-best allocation of capital between countries L and S satisfies $f_k^L(k_l) = f_k^L(k_S)$, meaning that the tax gap should be zero between the two countries, $t_L - t_S = 0$, in the equilibrium.

Here, we consider whether the emergence of the leader in tax competition distorts or improves efficient capital allocation by comparing the tax gap in each equilibrium.

The tax gap in the simultaneous-move equilibrium is already given by (9), which can be compared with the tax gap in games G^L and G^S. From (13) and (14), a gap in tax rates in game G^L is given by

$$t_L^L(\alpha,\theta) - t_S^L(\alpha,\theta) = \frac{\Lambda\,(2\alpha-1)\,(4\alpha-3) - 4\bar{k}\,(\theta-1)}{(2\alpha-1)\,(4\alpha-5)},$$

and from (17) and (18), a tax rate gap in game G^S is obtained as

$$t_L^S(\alpha,\theta) - t_S^S(\alpha,\theta) = \frac{\Lambda\,(2\alpha-1)\,(4\alpha-3) + 4\bar{k}\,(\theta-1)}{(2\alpha-1)\,(4\alpha-5)}.$$

Comparing the tax gap in game G^N with the gap in G^L, we find that the tax gap in game G^L is larger than the tax gap in game G^N:

$$\{t_L^L(\alpha,\theta) - t_S^L(\alpha,\theta)\} - \{t_L^N(\alpha,\theta) - t_S^N(\alpha,\theta)\} = \frac{8\bar{k}(1-\alpha)(1-\theta) + (1-2\alpha)\Lambda}{2(5-4\alpha)(1-\alpha)(1-2\alpha)} > 0.$$

This suggests that the sequential-move game led by country L worsens the inefficiency caused by the misallocation of capital.

By comparing the tax rate in game G^N with the tax rate in game G^S, we obtain

$$\begin{aligned}\{t_L^S(\alpha,\theta) - t_S^S(\alpha,\theta)\} - \{t_L^N(\alpha,\theta) - t_S^N(\alpha,\theta)\} &= \frac{(1-2\alpha)\Lambda - 8\bar{k}(1-\alpha)(1-\theta)}{2(5-4\alpha)(1-\alpha)(1-2\alpha)} \\ \rightarrow \{t_L^S(\alpha,\theta) - t_S^S(\alpha,\theta)\} &\gtrless \{t_L^N(\alpha,\theta) - t_S^N(\alpha,\theta)\} \Leftrightarrow \frac{\Lambda}{\bar{k}} \gtrless \frac{8(1-\alpha)(1-\theta)}{(1-2\alpha)}.\end{aligned}$$

Notice that this condition is identical to the condition in Proposition 1. Since the tax gap in game G^N is smaller than the tax gap in game G^S when $\frac{\Lambda}{\bar{k}} > \frac{8(1-\alpha)(1-\theta)}{(1-2\alpha)}$, the equilibrium allocation of capital of game G^N is more efficient than in game G^S, implying that the non-emergence of the tax leader in area G^N of Figure 1 is desirable. However, in area G^L of Figure 1, in which country L leads the tax competition, the emergence of the tax leader worsens the misallocation of capital compared with the simultaneous-move tax competition. When $\frac{\Lambda}{\bar{k}} < \frac{8(1-\alpha)(1-\theta)}{(1-2\alpha)}$, either country L or S leads the tax competition, but leadership by country L worsens capital misallocation, since $\{t_L^L(\alpha,\theta) - t_S^L(\alpha,\theta)\} > \{t_L^N(\alpha,\theta) - t_S^N(\alpha,\theta)\}$, but leadership by country S corrects the misallocation of capital that would have appeared in game G^N.

4 Concluding Remarks

In this study, we examined a timing game with a fiscal equalization scheme and showed that the determinants of the emergence of a Stackelberg leader in tax competition are the scale of fiscal transfer and asymmetry between two countries. Depending on these factors, we can derive three outcomes: i) two Stackelberg outcomes, in which one country chooses the tax rate first and the other follows, ii) one Stackelberg outcome, in which the country with higher technology chooses the tax rate first and the country with lower technology follows, and iii) one simultaneous-move outcome, in which both countries choose to become first movers.

Specifically, we find the following effect of the equalization transfer scheme on the emergence of the Stackelberg leader in tax competition: tax leadership is likely to prevail as the scale of equalization transfers increases. The presence of a tax leader is likely to exacerbate capital misallocation among the countries, and thus, our result suggests that equalization transfers help to reduce interregional differentials, but, unfortunately, this results in the emergence of a strategic leader, and thereby worsens capital misallocation in some cases.

In conclusion, we mention several topics that are not thoroughly studied in this research. First, we essentially assumed that the scale of the fiscal equalization scheme is exogenous. Further and deeper analysis on the determination of the scale of fiscal equalization is required. Second, we mainly focus on tax revenue equalization. An alternative is the tax base equalization scheme, which is partly adopted in some countries (e.g., Canada, Denmark, Switzerland, and Australia). However, if we account for the tax base equalization in our specification, the equalization transfer will have no effects on the emergence of tax leaders. In this case, the interregional equity concern may narrow the regional fiscal gap, but does not affect the efficiency of capital allocation in the economy.

Appendices

Appendix A

We derive the sequential equilibrium in game G^L, in which country L leads and country S follows. The maximization problem of the larger country is given by

$$\begin{aligned} \max_{t_L} \quad & u_L = (A_L - k_L)k_L + r(\theta\bar{k} - k_L) + \alpha(t_S k_S - t_L k_L), \\ \text{s.t.} \quad & (3),\ (4),\ (5),\ \text{and}\ (7). \end{aligned}$$

The first-order conditions give the equilibrium tax rates as

$$t_L^L(\alpha,\theta) = \frac{2(1-2\alpha)\left(2-5\alpha+4\alpha^2\right)\Lambda - 8\bar{k}\left(4\theta+14\alpha-18\alpha^2+8\alpha^3-9\theta\alpha+4\theta\alpha^2-4\right)}{2(5-4\alpha)(1-2\alpha)^2}, \tag{13}$$

$$t_S^L(\alpha,\theta) = \frac{\Lambda(1-\alpha)(1-2\alpha)(4\alpha-1) - 4\bar{k}\left(3\theta+12\alpha-18\alpha^2+8\alpha^3-7\theta\alpha+4\theta\alpha^2-3\right)}{(5-4\alpha)(1-2\alpha)^2}. \tag{14}$$

Using (13) and (14) with (3)–(5), we obtain the equilibrium values:

$$\begin{aligned} k_L^L(\alpha,\theta) &= \bar{k} + \frac{(1-2\alpha)\Lambda - 2(1-\theta)\bar{k}}{2(1-2\alpha)(5-4\alpha)}, \\ k_S^L(\alpha,\theta) &= \bar{k} - \frac{(1-2\alpha)\Lambda - 2(1-\theta)\bar{k}}{2(1-2\alpha)(5-4\alpha)}, \\ r^L(\alpha,\theta) &= \frac{\Omega}{2} - \frac{(1-2\alpha)\Lambda - 4\bar{k}\left(7\theta+50\alpha-72\alpha^2+32\alpha^3-16\theta\alpha+8\theta\alpha^2-12\right)}{2(5-4\alpha)(1-2\alpha)^2}. \end{aligned}$$

Substituting these values into the objective functions, we obtain the following utility:

$$u_L^L(\alpha,\theta) = N(\alpha,\theta) + \frac{\Lambda\bar{k}(36\alpha^2-16\alpha^3-4(7-\theta)\alpha+(8-3\theta))}{2(1-2\alpha)(5-4\alpha)}, \tag{15}$$

$$u_S^L(\alpha,\theta) = Z(\alpha,\theta) + \frac{\bar{k}\Lambda(224\alpha^3-64\alpha^4-4\alpha^2(73-4\theta)+4\alpha(43-8\theta)+11\theta-36)}{2(1-2\alpha)(5-4\alpha)^2}, \tag{16}$$

where

$$\begin{aligned} N(\alpha,\theta) \equiv\ & \frac{\Omega\bar{k}\theta}{2} + \frac{\Lambda^2}{4(5-4\alpha)} + \frac{\bar{k}^2\left(16-32\theta+11\theta^2\right)}{(5-4\alpha)(1-2\alpha)^2} \\ & - \frac{4k^2\alpha(4\alpha^2(3-4\theta) - \alpha\left(27-40\theta+4\theta^2\right) - 31\theta+7\theta^2+18)}{(1-2\alpha)^2(5-4\alpha)}, \\ Z(\alpha,\theta) \equiv\ & \frac{\Omega\bar{k}\theta}{2} + \frac{\Lambda^2(3-4\alpha)}{4(5-4\alpha)^2} - \frac{\bar{k}^2(216\theta-83\theta^2-108)}{(1-2\alpha)^2(5-4\alpha)^2} \\ & - \frac{4\alpha\bar{k}^2(16\alpha^3(4\theta-3)+8\alpha^2\left(21-30\theta+2\theta^2\right)-\alpha\left(215-340\theta+56\theta^2\right)+122-219\theta+62\theta^2)}{(1-2\alpha)^2(5-4\alpha)^2}. \end{aligned}$$

Appendix B

We derive the sequential equilibrium in game G^S, in which country S leads and country L follows. The maximization problem of country S is given by

$$\begin{aligned} \max_{t_S} \quad & u_S = (A_S - k_S)k_S + r(\theta\bar{k} - k_S) + \alpha(t_L k_L - t_S k_S), \\ \text{s.t.} \quad & (3),\ (4),\ (5),\ \text{and}\ (6). \end{aligned}$$

The first-order condition yields the equilibrium tax rate as

$$t_L^S(\alpha,\theta) = \frac{\Lambda(1-\alpha)(1-2\alpha)(4\alpha-1) + 4\bar{k}\left(3\theta + 12\alpha - 18\alpha^2 + 8\alpha^3 - 7\theta\alpha + 4\theta\alpha^2 - 3\right)}{(4\alpha-5)(1-2\alpha)^2}, \tag{17}$$

$$t_S^S(\alpha,\theta) = \frac{2(1-2\alpha)\left(2 - 5\alpha + 4\alpha^2\right)\Lambda + 8\bar{k}\left(4\theta + 14\alpha - 18\alpha^2 + 8\alpha^3 - 9\theta\alpha + 4\theta\alpha^2 - 4\right)}{2(4\alpha-5)(1-2\alpha)^2}. \tag{18}$$

Using (17) and (18) with (3)–(5), we obtain the following equilibrium values:

$$\begin{aligned} k_L^S(\alpha,\theta) &= \bar{k} + \frac{(1-2\alpha)\Lambda + 2\bar{k}(1-\theta)}{2(1-2\alpha)(5-4\alpha)}, \\ k_S^S(\alpha,\theta) &= \bar{k} - \frac{(1-2\alpha)\Lambda + 2\bar{k}(1-\theta)}{2(1-2\alpha)(5-4\alpha)}, \\ r^S(\alpha,\theta) &= \frac{\Omega}{2} + \frac{(1-2\alpha)\Lambda + 4\bar{k}\left(7\theta + 50\alpha - 72\alpha^2 + 32\alpha^3 - 16\theta\alpha + 8\theta\alpha^2 - 12\right)}{2(5-4\alpha)(1-2\alpha)^2}. \end{aligned}$$

Substituting these values into the objective functions, we obtain the Following utility:

$$u_L^S(\alpha,\theta) = Z(\alpha,\theta) - \frac{\Lambda\bar{k}(224\alpha^3 - 64\alpha^4 - 4\alpha^2(73-4\theta) + 4\alpha(43-8\theta) + 11\theta - 36)}{2(1-2\alpha)(5-4\alpha)^2}, \tag{19}$$

$$u_S^S(\alpha,\theta) = N(\alpha,\theta) - \frac{\Lambda\bar{k}(36\alpha^2 - 16\alpha^3 - 4(7-\theta)\alpha + (8-3\theta))}{2(1-2\alpha)(5-4\alpha)}. \tag{20}$$

Appendix C

The comparison of their utility gives the following inequalities.

$$\begin{aligned} u_L^N(\alpha,\theta) - u_L^S(\alpha,\theta) &= H_L\{(1-2\alpha)\Lambda - 8\bar{k}(1-\alpha)(1-\theta)\} \gtrless 0, \\ u_L^L(\alpha,\theta) - u_L^N(\alpha,\theta) &= \frac{\{(1-2\alpha)\Lambda + 8\bar{k}(1-\alpha)(1-\theta)\}^2}{64(5-4\alpha)(1-2\alpha)^2(1-\alpha)^2} > 0, \\ u_S^N(\alpha,\theta) - u_S^L(\alpha,\theta) &= H_S\{\Lambda(1-2\alpha)(9-8\alpha) - 8\bar{k}(1-\alpha)(11-8\alpha)(1-\theta)\} \gtrless 0, \\ u_S^S(\alpha,\theta) - u_S^N(\alpha,\theta) &= \frac{\{(1-2\alpha)\Lambda - 8\bar{k}(1-\alpha)(1-\theta)\}^2}{64(5-4\alpha)(1-2\alpha)^2(1-\alpha)^2} > 0, \end{aligned}$$

where

$$\begin{aligned} H_L &\equiv \frac{(3-4\alpha)\{8\bar{k}(1-\alpha)(11-8\alpha)(1-\theta) + \Lambda(1-2\alpha)(9-8\alpha)\}}{64(5-4\alpha)^2(1-\alpha)^2(1-2\alpha)^2} > 0, \\ H_S &\equiv \frac{(3-4\alpha)\{(1-2\alpha)\Lambda + 8\bar{k}(1-\alpha)(1-\theta)\}}{64(5-4\alpha)^2(1-\alpha)^2(1-2\alpha)^2} > 0. \end{aligned}$$

Here, $u_L^N \gtrless u_L^S$ if $\frac{\Lambda}{\bar{k}} \gtrless \frac{8(1-\theta)(1-\alpha)}{1-2\alpha}$, and $u_S^N \gtrless u_S^L$ if $\frac{\Lambda}{\bar{k}} \gtrless \frac{8(1-\theta)(1-\alpha)(11-8\alpha)}{(1-2\alpha)(9-8\alpha)}$. (Q.E.D)

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