ECONOMIC RESEARCH CENTER
DISCUSSION PAPER

E-Series

No.E21-2

Tax Competition, Economic Growth, and Social Welfare

by

Toshiki Tamai

February 2021

ECONOMIC RESEARCH CENTER
GRADUATE SCHOOL OF ECONOMICS
NAGOYA UNIVERSITY

Tax Competition, Economic Growth, and Social Welfare

Toshiki Tamai*

February 10, 2021

Abstract

Tax competition is one of the central issues of the interregional and public finance analyses. We address this issue by focusing on the dynamic aspects of tax competition and developing an endogenous growth model. This model incorporates knowledge spillover, perfectly mobile capital, and local public goods financed by capital tax. We show that equilibrium tax rate negatively associates with the degree of tax competition. Hence, escalating tax competition stimulates capital accumulation in a dynamic model and enhances economic growth by lowering tax rates. The tax rates and economic growth may have a hump-shaped relationship through a change in the number of regions if the congestion effect on common knowledge access is sufficiently large. Regarding efficiency in a decentralized economy, fierce tax competition worsens social welfare even if it raises equilibrium growth rate. Thus, undersupply of public goods due to intense competition must be addressed, in which tax coordination is desirable. However, mild tax competition is superior to tax coordination. Therefore, resolving insufficient investment due to knowledge spillover should be prioritized.

Keywords: Tax competition; Economic growth; Social welfare; Knowledge spillover
JEL classification: H23; H71; H72; O41

*Address: Graduate School of Economics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan. Tel: +81-52-789-4933. E-mail: tamai@soec.nagoya-u.ac.jp. I am grateful to Akira Kamiguchi and Hikaru Ogawa for their comments. This work was supported by JSPS KAKENHI Grant Numbers 16K03726, 18H00865, 20H01492, the Nitto Foundation, and the Zengin Foundation for Studies on Economics and Finance.

1 Introduction

Tax competition has been long examined in the literature as one of the core issues of international and regional economics and local public finance. The consequences of tax competition are controversial and have attracted public attention. In the outstanding study, Oates (1972) argues that tax competition is characterized by race to the bottom, which leads to inefficiently low supply of public goods. Most literature has asserted that fiscal externalities through a mobile tax base causes under-provision of public goods (e.g., Wilson 1986; Zodrow and Mieszkowski 1986), whereas several studies have revealed that inefficiency due to other distortions may be removed.[1]

Recent studies have focused on the dynamic aspects of tax competition and its impact on economic growth.[2] Optimal taxation theory holds that capital taxation impedes capital accumulation and therefore economic growth (e.g., Chamley 1986; Judd 1985). Numerous empirical studies found evidence supporting such view.[3] Hatfield (2015) theoretically shows that capital tax cuts by interregional competition enhances economic growth by raising the rate of return on capital. Köthenbüerger and Lockwood (2010) demonstrate that tax competition may have positive growth effects through "extreme" tax competition in a deterministic growth model without stochastic shocks. Furthermore, they show that stochastic shocks ease tax competition and raise tax rates above a centralized level.

The relationship between tax competition and economic growth has an alternative question. Enhancing economic growth through tax cuts may increase social welfare through permanent increases in future incomes. However, tax decrease reallocates consumption resources at the time when the incident occurs. A decrease in current consumption negatively impacts social welfare. Hence, the growth effects of tax competition should be examined from the viewpoint of not only "economic growth" but also "optimal growth" to improve social welfare. The goal of this study is to investigate whether tax competition promotes social welfare, in addition to examining its growth effects.

We address the issue by developing a multi-region endogenous growth model with regional knowledge spillover and local public goods financed by capital tax. Knowledge spillover is based on Marshall-Arrow-Romer (MAR) externalities and engine for sustainable growth (Arrow 1962; Romer 1986).[4] Positive externalities in the model prevent all or nothing of capital movement and "extreme" tax competition suggested by Köthenbüerger and Lockwood (2010). Therefore, our framework is parallel to standard models of static tax competition, such as Zodrow and Mieszkowski (1986), except for endogenous determination of capital stock and economic growth through capital accumulation.

Miyazawa et al. (2019) recently present a two-region endogenous growth model similar to our framework to examine the fiscal sustainability under tax competition. Our theoretical approach is consistent with their contribution in the sense that we treat spillover effects as economic growth driver. However, our study has different aims. We demonstrate that equilibrium tax rate negatively depends on degree of tax competition; therefore tax competition enhances economic growth. Furthermore, given that our model assumes multiple regions, we address the relationship between tax competition, economic growth, and the number of regions, which Hoyt (1991) examined using a static model.

We begin by reexamining the relationship between tax competition and economic growth. Then, we focus on dynamic equilibrium, namely, *tax competition equilibrium*, in our analyses to illustrate that governments compete with each other in tax rates such that they behave along with the Nash

[1] See Zodrow (2010) and Baskaran and Lopes da Fonseca (2013) for a survey on recent tax competition literature.

[2] Lejour and Verbon (1997) pioneered the studies on tax competition and economic growth. They develop a two-country endogenous growth model with imperfect capital mobility and two classes of workers and capitalists. Following Lejour and Verbon (1997), Rauscher (2005) presents an endogenous growth model with productive public input and imperfect capital mobility and where the government acts as Leviathan.

[3] Kneller et al. (1999) and Lee and Gordon (2005) find a negative relationship between corporate tax rate and economic growth using multi-country panel data. Djancov et al. (2010) verify that corporate tax rates negatively impact aggregate investment, FDI, entrepreneurial activity, and economic growth. Ferede and Dahlby (2012) show that a 1 percentage point cut in corporate tax rate corresponds to a 0.1-0.2 percentage point increase in annual growth rate using the panel data of Canadian provinces.

[4] Bronzini and Piselli (2009) estimate the long-term relationship between total factor productivity, R&D, human capital and public infrastructure using the panel data of Italian regions. Their empirical evidence shows that R&D and neighboring regions' public infrastructure positively affect regional productivity.

conjectures. Equilibrium growth rate is negatively associated with equilibrium capital tax rate. Furthermore, a degree of fiscal externalities, that is, tax competition intensity, decreases the equilibrium growth rate. These results verify a positive relationship between tax competition and economic growth.

The number of regions affects equilibrium outcome through scale and congestion effects on knowledge spillover, which is discussed in Miyazawa et al. (2019). Our quantitative analysis shows that decreased number of regions alleviates tax competition, except for certain cases, such as strong scale effect (weak congestion effect) and high elasticity of capital-labor substitution. We also numerically found that economic growth and the number of regions may have a non-monotonic (especially hump-shaped) relationship, even though tax rate decreases with the number of regions. In certain cases, increasing competitors reduces not only the tax rate but also economy-wide productivity through congestion effect. Our results imply that tax competition and economic growth have a non-monotonic relationship based on the number of regions.

Chu and Yang (2012) examine the relative merits of decentralized and centralized fiscal systems on economic growth and social welfare in an endogenous growth model with imperfect capital mobility. They show that certain tax competition is desirable because it has an optimal degree. Our result also shows that tax competition is desirable in particular cases. This result is due to the combination of fiscal externality and knowledge spillover, though Chu and Yang (2012)'s result is attributed to capital mobility and government behavior.

We consider the welfare impact of tax competition by comparing tax competition equilibrium with another equilibrium concept namely, *tax coordination equilibrium*.[5] Tax coordination perfectly removes the effects of fiscal externalities. Consumption resource is efficiently allocated between private and public goods. However, tax coordination equilibrium has lower growth rate than tax competition equilibrium. Thus, the welfare order of the two equilibria changes depending on the degree of fiscal externalities and knowledge spillover. Hence, the welfare in the tax coordination equilibrium is above (below) that under "extreme" (mild) tax competition.

Tax competition and tax coordination equilibria yield welfare inferior to centralized equilibrium. Tax competition eases inefficiency caused by knowledge spillover, whereas competition arises from fiscal externality. Tax coordination removes fiscal externalities, though adversely impacts the solution of inefficiency caused by knowledge spillover. Therefore, centralization is the best way to raise growth and welfare if the central government has policy instruments such as investment subsidy and interregional transfers. This result on the relationship between economic growth and decentralization is contrary to Hatfield (2015).

The remainder of this paper is organized as follows. Section 2 describes our theoretical framework and provides the preliminary consideration for effects of changes in capital tax rates. Section 3 presents two concepts of equilibrium, namely, tax competition equilibrium and tax coordination equilibria, and characterizes these equilibria. Section 4 conducts a comparative analysis of the two equilibria and examines their optimality. Section 5 examines the relationship between equilibrium outcomes and the number of regions. Finally, Section 6 concludes this paper by showing future research directions.

2 The model

Consider a dynamic competitive economy consists of n regions with continua of identical residents and firms. The residents' population and mass of firms in each region are respectively normalized to unity. The time in the model is discrete and indexed by t. Time-dependent economic variables are notated, such as $x(t)$, and we describe them as x. The notation x' is used for the variable in the next time period $t+1$, that is, $x(t+1) \equiv x'$ at period t.[6] Final good production has two inputs, namely, capital and labor, of which only capital moves across regions in an economy.

[5] The present study characterizes the two types of equilibria of tax competition and coordination to address the issue. The task is motivated by Batina (2009), Wildasin (2003), and Tamai (2008), who study such issues using dynamic models with a neoclassical production function. This paper complements the previous studies by incorporating knowledge spillover to ensure sustainable growth and investigating the relationship between tax competition and economic growth.

[6] At the period $t+1$, x' is $x(t+2)$.

2.1 Basic setup

Firms produce homogenous goods through capital and labor inputs, where MAR type spillover exists. Each firm controls only its capital and labor inputs for profit maximization. Such firm-specific behaviors, particularly capital use, positively affect a firm's productivity including that of other firms at the economy-wide level. Thus, the production function in the region i is formulated as

$$Y_i = F(K_i, \xi L_i),$$

where ξ is the labor productivity. Following Romer (1986), knowledge spillover affects the labor productivity. Furthermore, accessing knowledge may entail congestion costs. Thus, the labor productivity function is formulated as[7]

$$\xi = \frac{K}{n^v},$$

where v is the degree of congestion and

$$\sum_{i=1}^{n} K_i \equiv K.$$

We assume that the production function F is continuously twice differentiable, strictly concave with respect to each input, and constant-returns-to-scale. By the assumption of the linearly homogenous production function, we obtain

$$y_i = \xi f\left(x_i\right),$$

where

$$y_i \equiv \frac{Y_i}{L_i}, x_i \equiv \frac{k_i}{\xi}, k_i \equiv \frac{K_i}{L_i}, f\left(x_i\right) \equiv F\left(x_i, 1\right).$$

Let r and w_i be the economy-wide interest rate and the wage rate of the region i, respectively. Physical capital used in region i is taxed by the regional government at the rate of τ_i. Each region's representative firm subject to production technology maximizes its profit, taking r, w_i, k, and τ as given. In a competitive economy, profit maximization of the representative firm in region i leads to

$$r = f'\left(x_i\right) - \tau_i, \tag{1a}$$

$$w_i = \xi\left[f\left(x_i\right) - x_i f'\left(x_i\right)\right]. \tag{1b}$$

The regional government imposes capital tax to finance government expenditures for public good provision. Hence, the government's budget equation is

$$\tau_i k_i = \tau_i \kappa_i k = g_i, \tag{2}$$

where g_i denotes public goods supplied to region i's residents and

$$\kappa_i \equiv \frac{k_i}{k}.$$

Furthermore, we assume that the government is democratically elected by the residents as the tax rate decision-maker. Thus, the tax rate will be determined as the level that is preferred by median residents. The government's decisions follow a representative resident because all residents are identical.

The preference of the representative resident is specified as

$$\sum_{t=0}^{\infty} \beta^t \left[\log c_i + \theta \log g_i\right], \tag{3}$$

[7] Lejour and Verbon (1997) assume that productivity depends on domestic capital spillover. Irman and Wigger (2006) and Miyazawa et al. (2019) also adopt the assumption that labor productivity depends on the economy-wide capital stock, without scale effects and incorporating scale and congestion effects, respectively, in a two-country endogenous growth model. We will discuss this point in Section 5.

where β is the discount factor ($\beta = 1/(1+\rho)$, $\beta > 0$, $\rho > 0$), c_i is the private good consumption, and θ is the taste for public good consumption ($\theta > 0$). The resident earns labor and capital income from supplying his/her labor and capital he/she holds. Total income is allocated between consumption and investment. Then, the resident's budget equation is

$$a_i' = (1+r)\, a_i + w_i - c_i. \tag{4}$$

Capital and labor market clearing conditions are

$$\sum_{i=1}^{n} K_i = \sum_{i=1}^{n} a_i L_i \text{ and } L_i = 1.$$

Capital market clearing condition holds that aggregate capital demand is equal to aggregate capital supply (i.e., aggregate asset holding). In labor markets, regional labor demand equals regional labor supply.

2.2 Preliminary results

We now characterize the equilibrium system for given tax policies τ_i. Note that the relationship between x_i and κ_i is given by $\kappa_i = z x_i$ ($z \equiv n^{1-v}$). Equation (1a) yields

$$\kappa_i = \kappa_i\,(r + \tau_i)\,, \tag{5}$$

where

$$\kappa_i'\,(r+\tau_i) = z \cdot x_i'\,(r+\tau_i) = \frac{z}{f''(x_i)} < 0.$$

The ratio of regional capital input to average capital stock decreases with the rental cost of private capital.

By the definition of κ_i, we obtain

$$\sum_{i=1}^{n} \kappa_i = n. \tag{6}$$

The system composed of Equations (1a)–(6) is given as

$$\begin{aligned} r &= r\,(\tau_i, \tau_{-i})\,, && (7a)\\ w_i &= w_i\,(\tau_i, \tau_{-i}, \xi)\,, && (7b)\\ g_i &= g_i\,(\tau_i, \tau_{-i}, k)\,. && (7c) \end{aligned}$$

Total differentiation of Equations (7a)–(7c) yield (see Appendix A for the details)

$$\begin{aligned} \frac{\partial r}{\partial \tau_i} &= -\frac{\kappa_i'\,(r+\tau_i)}{\sum \kappa_i'\,(r+\tau_i)} < 0, && (8a)\\ \frac{\partial w_i}{\partial \tau_i} &= -\left(1 + \frac{\partial r}{\partial \tau_i}\right) \kappa_i k < 0, && (8b)\\ \frac{\partial g_i}{\partial \tau_i} &= \left(1 - \epsilon_i^i\right) \kappa_i k, && (8c) \end{aligned}$$

where

$$\begin{aligned} \epsilon_i^i &\equiv -\frac{\tau_i}{\kappa_i}\frac{\partial \kappa_i}{\partial \tau_i} > 0, && (9a)\\ \frac{\partial \kappa_i}{\partial \tau_i} &= z\frac{\partial x_i}{\partial \tau_i} = \frac{z}{f''(x_i)}\left(1 + \frac{\partial r}{\partial \tau_i}\right) < 0. && (9b) \end{aligned}$$

In Equations (7a)–(7c), τ_{-i} denotes a vector of taxes, except for the tax rate in region i. These equations are similar to those derived by Wildasin (1989). Regional capital in our model is measured relative to its average level.

Base on Zodrow and Mieszkowski (1986), we impose the following assumption:

Assumption 1. $0 < \epsilon_i^i < 1$.

The economy is situated on the left side of the Laffer curve. Under Assumption 1, we have

$$\frac{\partial g_i}{\partial \tau_i} = \left(1 - \epsilon_i^i\right) \kappa_i k > 0.$$

To clarify the relationship between tax competition, economic growth, and welfare, we initially consider an economy without scale effect.

Assumption 2. $v = 1$.

Under Assumption 2, scale and congestion effects are offset each other. Thus, we have $z = 1$, $x_i = \kappa_i$, and $\xi = k$. Scale and congestion effects quantitatively impact economic variables, though they do not qualitatively affect the relationship between tax competition, economic growth, and welfare. Analyzing the relationship between equilibrium outcomes and the number of regions will be insightful. Hoyt (1991) demonstrates that tax rate increases as the number of regions decreases using a static model of tax competition. From the dynamic analysis perspective, the impact of a change in the number of regions on economic growth is important for the examination of the relationship between tax competition and economic growth. We will set aside Assumption 2 in Section 5 and examine the effects of the number of regions.

3 Equilibrium analysis

Following the conventional theory of tax competition, we focus on two comparable equilibrium concepts. The first concept holds that each government chooses the tax rate in their region taking the tax rates in other regions, whereas the second one asserts that all governments change their tax rates simultaneously at the same margin from the initially identical level. The analysis developed in this section characterizes growth and welfare effects of tax competition.

3.1 Tax competition equilibrium

The government's objective function coincides with the present value of the residents' utility, (3). Each government needs the information about other regions' capital tax rates to determine its region's tax rate. We focus on governments that choose their tax rates through the Nash behavior as a natural extension of static tax competition models. The Nash equilibrium is defined as tax competition equilibrium as follows:

Definition 1. *Tax competition equilibrium is a set of sequences* $\{\tau_i(t), \kappa_i(t), k(t)\}$ *satisfying Equations (1a)–(6) and the clearing condition for factor markets and maximizing* $\sum_{t=0}^{\infty} \beta^t \left[\log c_i + \theta \log g_i\right]$ *subject to Equation (4) taking* τ_{-i} *as given.*

We can derive the tax competition equilibrium by solving the optimization problem,

$$V\left(a_i, k\right) = \max_{\tau_i, \alpha_i'} \left\{\log\left(\left(1 + r\left(\tau_i, \tau_{-i}\right)\right) a_i + w_i\left(\tau_i, \tau_{-i}, k\right) - a_i'\right) + \theta \log g_i\left(\tau_i, \tau_{-i}, k\right) + \beta V\left(a_i', k'\right)\right\}. \tag{P1}$$

The first-order conditions are

$$\frac{\partial V\left(a_i, k\right)}{\partial \tau_i} = \left[\frac{\partial r\left(\tau_i, \tau_{-i}\right)}{\partial \tau_i} a_i + \frac{\partial w_i\left(\tau_i, \tau_{-i}, k\right)}{\partial \tau_i}\right] \frac{1}{c_i} + \frac{\theta}{g_i} \frac{\partial g_i\left(\tau_i, \tau_{-i}, k\right)}{\partial \tau_i} = 0, \tag{10a}$$

$$\frac{\partial V\left(a_i, k\right)}{\partial a_i'} = -\frac{1}{c_i} + \beta \frac{\partial V\left(a_i', k'\right)}{\partial a_i'} = 0. \tag{10b}$$

Equation (10a) shows that the marginal cost of a rise in the tax rate must equal its marginal benefit. It yields the equilibrium condition for supplying public good. Equation (10b) shows that the marginal cost of an increase in investment must equal the marginal increase of the discounted value of utility. Furthermore, the transversality condition is required to ensure that the utility function is bounded. By the optimality condition, we have

$$\begin{aligned}\frac{\partial V\left(a_i, k\right)}{\partial a_i} &= \frac{1}{c_i}\frac{\partial c_i}{\partial a_i} + \beta\frac{\partial V\left(a_i', k'\right)}{\partial a_i'}\frac{\partial a_i'}{\partial a_i} \\ &= \left[1 + r\left(\tau_i, \tau_{-i}\right) - \frac{\partial a_i'}{\partial a_i}\right]\frac{1}{c_i} + \beta\frac{\partial V\left(a_i', k'\right)}{\partial a_i'}\frac{\partial a_i'}{\partial a_i} = \frac{1 + r\left(\tau_i, \tau_{-i}\right)}{c_i}.\end{aligned} \tag{11}$$

Thus, Equations (10a)–(11) yield

$$\theta\frac{c_i}{g_i} = -\frac{\frac{\partial r(\tau_i,\tau_{-i})}{\partial \tau_i}a_i + \frac{\partial w_i(\tau_i,\tau_{-i},k)}{\partial \tau_i}}{\frac{\partial g_i(\tau_i,\tau_{-i},k)}{\partial \tau_i}}, \tag{12a}$$

$$\frac{c_i'}{c_i} = \beta\left[1 + r\left(\tau_i', \tau_{-i}'\right)\right]. \tag{12b}$$

Equation (12a) corresponds to the marginal cost of public funds (MCPF) in the tax competition equilibrium. It consists of distortionary effects through factor price and government revenue changes. Equation (12b) denotes the consumption growth rate, referred as the Eular equation. From the symmetricity in all aspects, we have $\kappa_i = 1$, $a_i = k_i = k$,

$$\frac{\partial r\left(\tau_i, \tau_{-i}\right)}{\partial \tau_i} = -\frac{1}{n}, \frac{\partial w\left(\tau_i, \tau_{-i}, k\right)}{\partial \tau_i} = -\left(\frac{n-1}{n}\right)k < 0, \text{ and } \frac{\partial g_i\left(\tau_i, \tau_{-i}, k\right)}{\partial \tau_i} = \left(1 - \epsilon\right)k.$$

Equations (12a), and (12b) establish the following results (see Appendix B for the proof of Lemma 1):

Lemma 1. *A unique tax competition equilibrium exists, which satisfies*

$$\begin{aligned}\theta\frac{c^*}{g^*} &= \frac{1}{1 - \epsilon^*}, \\ \tau^* &= \frac{\left[\left(1 - \beta\right)\left(1 + \alpha A\right) + \left(1 - \alpha\right)A\right]\left(1 - \epsilon^*\right)\theta}{1 + \left(1 - \beta\right)\left(1 - \epsilon^*\right)\theta}, \\ \gamma^* &= \left(1 + \alpha A - \tau^*\right)\beta,\end{aligned}$$

where

$$\alpha \equiv \frac{f'(1)}{f(1)} \in (0, 1), A \equiv f(1) > 0.$$

Note that α is the equilibrium capital share (the output elasticity of capital) and A is the total factor productivity in the equilibrium. Let be $\eta^{-1} \equiv -f''(1) > 0$. Then, η is the equilibrium marginal effect of a rise in the capital cost on κ from the definitions. The level of ϵ or η measures the degree of fiscal externality. By the definition of ϵ and η with the symmetricity of regions, we have

$$\epsilon = \left(\frac{n-1}{n}\right)\eta\tau. \tag{13}$$

Equation (13) illustrates the one-to-one correspondence between ϵ and τ and between ϵ and η. In the tax competition equilibrium, the equilibrium tax rate, τ^*, in Lemma 1 and Equation (13) yield

$$\Gamma\left(\epsilon; \eta\right) \equiv -\left(1 - \beta\right)\theta\epsilon^2 + \left[1 + \left(1 - \beta\right)\theta + \Theta\right]\epsilon - \Theta = 0,$$

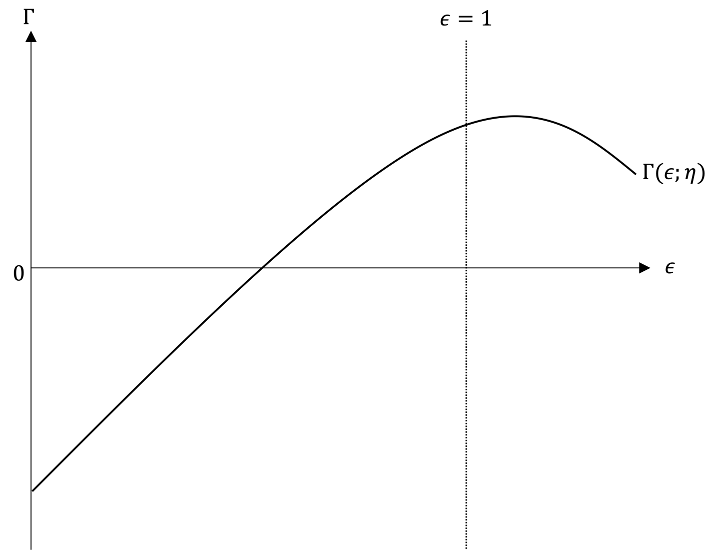


Figure 1. Tax competition equilibrium

where

$$\Theta \equiv \left[(1-\beta)(1+\alpha A) + (1-\alpha) A \right] \left(\frac{n-1}{n} \right) \theta \eta > 0.$$

Figure 1 illustrates the graph of $\Gamma(\epsilon; \eta)$. A unique level of ϵ exists, which is consistent with Assumption 1. A rise in η moves the graph of $\Gamma(\epsilon; \eta)$ downward for $\epsilon < 1$. Indeed, the total differentiation of $\Gamma(\epsilon; \eta)$ and implicit function theorem lead to

$$\frac{\partial \epsilon^*}{\partial \eta} = \frac{(1-\epsilon^*)\left[(1-\beta)(1+\alpha A) + (1-\alpha) A \right]}{1 + (1-\beta)(1-2\epsilon^*)\theta + \left[(1-\beta)(1+\alpha A) + (1-\alpha) A \right] \eta} > 0. \tag{14}$$

Therefore, ϵ^* is positively associated with η. If η is large, the equilibrium marginal effect of a rise in the capital cost on κ is also large. It brings about intense response to a change in the capital tax rate. Hence, the elasticity of κ with respect to τ increases with an increase in η.

In Lemma 1, the equilibrium condition of public good provision shows that the MCPF increases with an increase in ϵ. Fiscal externality relatively reduces public good supply to private goods. The effects of fiscal externality are commonly shown in static models (e.g., Zodrow and Mieszkowski 1986). As shown in the dynamic model of tax competition with imperfect capital mobility, a degree of capital mobility significantly determines equilibrium tax rate on capital (e.g., Lejour and Verbon 1997; Tamai 2008). With perfect capital mobility, equilibrium tax rate depends on the elasticity of substitution. Thus, we have

$$\frac{\partial \tau^*}{\partial \epsilon^*} = -\frac{\left[(1-\beta)(1+\alpha A) + (1-\alpha) A \right] \theta}{\left[1 + (1-\beta)(1-\epsilon^*)\theta \right]^2} < 0, \tag{15a}$$

$$\frac{\partial \tau^*}{\partial \eta} = \frac{\partial \tau^*}{\partial \epsilon^*} \frac{\partial \epsilon^*}{\partial \eta} < 0. \tag{15b}$$

Equation (15a) implies that fiscal externality generates tax competition. The mechanism behind this result is similar to that clarified by static models (e.g., Zodrow and Mieszkowski 1986; Wildasin 1989). Equilibrium tax and economic growth rate illustrate the dynamic aspect of the result. Based on Lemma 1 and Equation (15a), tax competition reduces equilibrium capital tax rate and raises equilibrium growth rate. Hatfield (2015) and Miyazawa et al. (2019) also show a positive relationship between tax competition and economic growth. Their result is similar to that of our model because their models assume a linear production function with respect to capital.[8] In addition, we provide new insights into the relationship between tax competition and economic growth. The equilibrium tax rate due to tax competition depends on the intensity of fiscal externality. Then, capital tax rate is endogenously determined and negatively associated with the degree of tax competition. Therefore, intense tax competition reduces the equilibrium tax rate on capital and enhances economic growth.

These results are summarized as the following proposition:

Proposition 1. *Equilibrium growth rate in tax competition equilibrium increases with fiscal externality intensity.*

Specified production functions are useful for interpreting the impacts of ϵ^* and η. We consider the following CES production function:

$$f(x) = \left[\alpha x^{-\sigma} + (1-\alpha)\right]^{-\frac{1}{\sigma}} A, \tag{16}$$

where σ denotes the substitution parameter ($\sigma \geq -1$). Note that $x = \kappa$ under Assumption 2 and elasticity of substitution between capital and labor is given by $1/(1+\sigma)$. Under Equation (16) with $v = 1$ and symmetricity of regions, we obtain

$$f(1) = A, f'(1) = \alpha A, \text{ and } \eta = \frac{1}{(1+\sigma)(1-\alpha)\alpha A}.$$

High (low) elasticity of capital and labor substitution leads to high (low) elasticity of κ with respect to τ because η is negatively associated with σ. The analysis mentioned above shows that the intensity of fiscal externality is linearly correlated with elasticity of substitution. For higher elasticity of capital and labor substitution, a rise in the capital tax rate reduces capital demand. Hence, the impact on the tax base depends on the elasticity of substitution. Higher substitution elasticity strengthens the fiscal externality and lowers the equilibrium tax rate. The following result is derived from Proposition 1 with equation (16):

Corollary 1. *Equilibrium growth rate is positively associated with the elasticity of capital and labor substitution if the production function is Equation (16).*

The elasticity of substitution between capital and labor is essential for capital and labor share distribution. When the elasticity of substitution is larger than unity, a decrease in the tax rate on capital will reduce labor share. Therefore, Corollary 1 and the fundamental result on factor shares and capital–labor substitution imply that capital tax competition declines labor share but stimulates economic growth. The recent findings suggest that technological progress, which is related to the substitutability between capital and labor, affects capital and labor share distribution (e.g., OECD 2012). Corollary 1 implies that tax competition in recent decades may be one of the reasons for labor share decline.

The following result is helpful to conduct a welfare analysis (see Appendix C for the proof of Lemma 2):

Lemma 2. *The indirect utility function of (P1) is given by*

$$\begin{aligned} V(k,k) &= \frac{\left[\log(1+\alpha A-\tau)+\log\beta\right](1+\theta)\beta}{(1-\beta)^2} \\ &\quad + \frac{\log\left((1-\beta)(1+\alpha A-\tau)+(1-\alpha)A\right)+\theta\log\tau+(1+\theta)\log k}{1-\beta}. \end{aligned}$$

[8] Hatfield (2015) assumes a linear production function presented by Barro (1990). Regional tax policies in the model cause all or none of capital flow because there is no interregional spillover effect. In contrast, Miyazawa et al. (2019) assume that the production function takes the form of the Cobb-Douglas function with spillover effects and without productive government expenditure. We use the generalized production function used in Miyazawa et al. (2019), including the CES production function.

Lemmas 1 and 2 yield the indirect utility function in the tax competition equilibrium for a given k. Welfare levels vary depending on the equilibrium tax rate. Differentiating V with respect to τ provides

$$\frac{dV}{d\tau} = \frac{1}{1-\beta}\left[\frac{\theta}{\tau} - \frac{(1+\theta)\beta}{(1-\beta)(1+\alpha A-\tau)} - \frac{1-\beta}{(1-\beta)(1+\alpha A-\tau)+(1-\alpha)A}\right] \gtreqless 0 \Leftrightarrow \tau \lesseqgtr \widehat{\tau}, \quad (17)$$

where $\widehat{\tau} \in (0, 1+\alpha A)$. The second-order derivative of V with respect to τ becomes

$$\frac{d^2V}{d\tau^2} = -\frac{1}{1-\beta}\left[\frac{\theta}{\tau^2} + \frac{(1+\theta)\beta}{(1-\beta)(1+\alpha A-\tau)^2} + \frac{(1-\beta)^2}{[(1-\beta)(1+\alpha A-\tau)+(1-\alpha)A]^2}\right] < 0.$$

These derivatives show that the welfare curve exhibits an inverted-U shape.

Evaluating Equation (17) at the equilibrium capital tax rate characterizes the relationship between tax competition and welfare. Given that $\tau^* \to 0$ as $\epsilon \to 1$, we have

$$sgn \left.\frac{dV}{d\tau}\right|_{\tau=\tau^*} \to +\infty.$$

Furthermore, $\tau^* > 0$ when $\epsilon = 0$. Thus, we obtain

$$\begin{aligned} sgn \left.\frac{dV}{d\tau}\right|_{\tau=\tau^*} &= \frac{\theta}{\tau^*} - \frac{(1+\theta)\beta}{(1-\beta)(1+\alpha A-\tau^*)} - \frac{(1-\beta)\theta}{\tau^*} \\ &= \left[\frac{1}{(1-\beta)(1+\alpha A-\tau^*)+(1-\alpha)A} - \frac{1+\theta}{(1-\beta)(1+\alpha A-\tau^*)}\right]\beta < 0. \end{aligned}$$

The equilibrium tax rate monotonically decreases with an increase in ϵ. Therefore, a unique level of ϵ exists, where the welfare level in tax competition equilibrium equals that when $\tau = \widehat{\tau}$. Let be $\widehat{\epsilon}$ a critical value. Figure 2 illustrates the economic situation. Then, we have the following result:

Lemma 3. *Welfare level is increasing in ϵ if and only if $\epsilon > \widehat{\epsilon}$, whereas it is decreasing in ϵ if and only if $\epsilon < \widehat{\epsilon}$.*

Welfare level is nonlinearly associated with ϵ, which is the measure of fiscal externality. In the tax competition equilibrium, capital taxation has a distortionary effect on public good supply. Then, capital tax rate is inefficiently set to a low level. The low tax rate stimulates capital accumulation through enhancing private capital investment. Thus, the low tax rate positively impacts welfare given the positive growth effect. Smaller (larger) ϵ strengthens (weakens) the negative welfare effect. The positive (negative) welfare effect dominates over the negative (positive) welfare effect.

3.2 Tax coordination equilibrium

Another equilibrium concept is required for comparison to tax competition equilibrium. Suppose that all governments simultaneously change the tax rate by the same margins initially at the same tax rate. Then, no capital movements occur. Formally, we consider the equilibrium based on the following definition:

Definition 2. *Tax coordination equilibrium is a set of sequences $\{\tau_i(t), \kappa_i(t), k(t)\}$ satisfying Equations (1a)–(6) and the clearing condition for factor markets and maximizing $\sum_{t=0}^{\infty} \beta^t [\log c_i + \theta \log g_i]$ subject to Equation (4) and $\tau_i = \tau_{-i} = \tau$.*

The value function corresponding to the tax coordination equilibrium is

$$V(a_i, k) = \max_{\tau_i, a_i'} \{\log(r(\tau)a_i + w_i(k) - a_i') + \theta \log(\tau k) + \beta V(a_i', k')\}. \quad \text{(P2)}$$

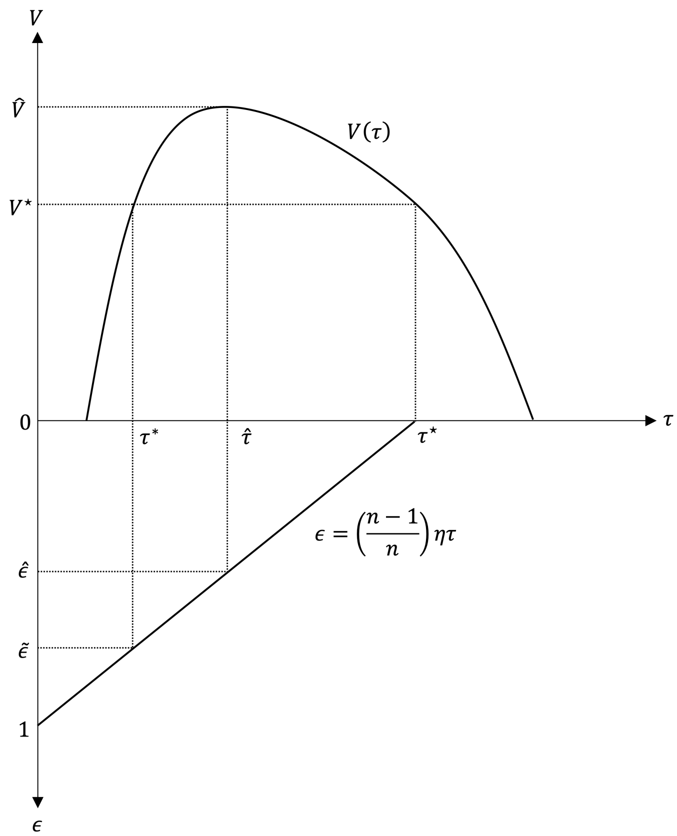


Figure 2. Indirect utility, tax rate, and tax elasticity of capital ratio

The first-order conditions are

$$\begin{aligned} \frac{\partial V(a_i, k)}{\partial \tau} &= \frac{\partial r}{\partial \tau}\frac{a_i}{c_i} + \frac{\theta}{\tau} = 0, & \text{(18a)} \\ \frac{\partial V(a_i, k)}{\partial a_i'} &= -\frac{1}{c_i} + \beta\frac{\partial V(a_i', k')}{\partial a_i'} = 0. & \text{(18b)} \end{aligned}$$

A comparison between the first-order conditions demonstrates that a marginal increase in the capital tax rate has different effects on the value function. In the tax coordination equilibrium, changes in the capital tax rates do not result in capital flow and income loss through capital outflow. The cost of capital tax financing is only the tax burden. Hence, the cost of capital tax in the tax coordination equilibrium is lower than that in the tax competition equilibrium. On the other hand, Equations (10b) and (18b) show that marginal increase in the asset holding in the next period has the same impact on the value function if it has an identical functional form.

The derivative of the value function with respect to a_i and Equations (18a) and (18b) lead to

$$\frac{\partial V(a_i, k)}{\partial a_i} = \frac{1}{c_i}\frac{\partial c_i}{\partial a_i} + \theta\frac{1}{\tau}\frac{\partial \tau}{\partial a_i} + \beta\frac{\partial V(a_i', k')}{\partial a_i'}\frac{\partial a_i'}{\partial a_i} = \frac{1+r}{c_i}. \tag{19}$$

Equation (19) has an identical structure to that of equation (11). However, the difference between Equations (10a) and (18a) provides tax rate differential. This condition affects the level of marginal effect of a_i on the value function even if the functional forms are identical.

Equations (18a), (18b), (19) and (P2) yield the following lemma (see Appendix D for the proof of Lemma 4):

Lemma 4. *There exists a unique tax coordination equilibrium, satisfying*

$$\begin{aligned} \theta \frac{c^\star}{g^\star} &= 1, \\ \tau^\star &= \frac{\left[(1-\beta)(1+\alpha A)+(1-\alpha)A\right]\theta}{1+(1-\beta)\theta}, \\ \gamma^\star &= (1+\alpha A-\tau^\star)\beta. \end{aligned}$$

Tax coordination equilibrium coincides with tax competition equilibrium if and only if $\epsilon = 0$. Furthermore, the form of the value function in the tax coordination equilibrium is identical to that in the tax competition equilibrium.

Fiscal externality does not exist because of no tax rate differential (i.e., $\tau_i = \tau_{-i} = \tau$). The choice of τ does not affect the allocation cost between private and public good, and MCPF is equal to unity. Therefore, private and public goods are efficiently allocated for a given resource. Tax coordination equilibrium is one of the special cases in tax competition equilibria. When $\epsilon = 0$, tax competition does not exist. Hence, this situation equals the tax coordination equilibrium. In the other words, as $\epsilon \to 0$, tax competition equilibrium converges to tax coordination equilibrium.

4 Tax competition vs tax coordination

This section characterizes the properties of and differences between two equilibria. First, we consider their MCPF and equilibrium tax rates. At the equilibrium capital tax rate in the tax coordination equilibrium, the marginal welfare effect of a rise in the tax rate becomes

$$sgn \left. \frac{dV}{d\tau} \right|_{\tau=\tau^\star} = -\frac{\left[(1-\alpha)A+\tau^\star\right]\beta\theta}{(1-\beta)(1+\alpha A-\tau^\star)} < 0. \tag{20}$$

Equation (20) and Lemmas 2–4 show that $\tau^\star \geq \tau^*$ holds because of the concavity and continuity of the indirect utility function. For a given k, higher tax rate leads to lower MCPF. The following proposition is derived from Lemmas 1–5:

Proposition 2. *MCPF in the tax competition equilibrium is larger than that in the tax coordination equilibrium, that is*

$$1 = \theta \frac{c^\star}{g^\star} \leq \theta \frac{c^*}{g^*}.$$

Then, the capital tax rate in the tax competition equilibrium is smaller than that in the tax coordination equilibrium, $\tau^\star \geq \tau^*$.

Without tax coordination, a rise in a region's capital tax rate generates capital outflow that decreases the tax base in one region and increases that of other regions. Hence, this fiscal externality effect increases MCPF. Similar to the static models of tax competition, tax coordination improves the allocation efficiency of private and public goods for a given k. However, this effect does not simply imply that tax coordination improves welfare because of intertemporal decision-making of consumption and investment with positive externality of knowledge spillover effect.

Based on Lemma 2, larger intensity of tax competition leads to lower tax rate on capital. Equilibrium growth rate monotonically decreases with the tax rate because the net return on capital is monotonically decreases with the tax rate. Lemmas 1 and 5 hold that tax competition equilibrium converges to tax coordination equilibrium with less intensity of tax competition. Therefore, Lemmas 1, 2, and 5 provide the following proposition:

Proposition 3. *The balanced growth rate in the tax competition equilibrium is higher than that in the tax coordination equilibrium, that is* $\gamma^* \geq \gamma^\star$.

Capital taxation has a distortionary effect on private investment because the public good in this model is unproductive. It negatively works on capital accumulation. Hence, the equilibrium growth rate decreases with an increase in the capital tax rate. Proposition 2 illustrates that the capital tax rate in the tax coordination equilibrium dominates over that in the tax competition equilibrium. These effects show that the equilibrium growth rate in the tax competition equilibrium is larger than that in the tax coordination equilibrium. Proposition 2 holds that tax coordination improves the allocation efficiency between private and public goods, which positively impacts welfare. In contrast, Proposition 3 shows that tax coordination reduces equilibrium growth rate because it increases equilibrium capital tax rate. A decrease in the equilibrium growth rate negatively affects welfare level, and tax coordination does not always improve welfare.

Lemmas 1–5 lead to the following result:

Proposition 4. *Let be* $\widetilde{\epsilon}$ *as the value of* ϵ*, satisfying* $V^* = V^\star$*. Then, there exists a unique value of* $\widetilde{\epsilon}$ *and* $V^* > V^\star$ *holds for* $0 < \epsilon < \widetilde{\epsilon}$.

Proposition 4 enables us to consider the efficiency of decentralized economies. As mentioned above, a decentralized economy have two sources of the inefficiency, namely, fiscal externality and knowledge spillover effects. An effective interregional cooperation of tax policies is required to remove fiscal externality effect. However, such cooperative tax policies raise the capital tax rate and reduce the equilibrium growth rate. When knowledge spillover exists, the growth rate in the decentralized economy is lower than that without a positive externality. Hence, the cooperative tax policies do not always improve economic efficiency.

To analyze the first best outcome, the social planner's problem should be defined.

Definition 3. *Symmetric centralized equilibrium is a set of sequences* $\{\tau(t), k(t)\}$ *satisfying* $\kappa = 1$ *and maximizing* $\sum_{t=0}^{\infty} \beta^t \left[\log c + \theta \log g\right]$ *subject to Equation (4).*

The value function of the optimization problem mentioned above is

$$W(k) = \max_{\tau, k} \left\{\log\left((1+A)k - \tau k - k'\right) + \theta \log(\tau k) + \beta W(k')\right\}. \tag{P3}$$

Solving the optimization problem (P3) leads to the following results (see Appendix E for the proof of Lemma 6):

Lemma 5. *In centralized equilibrium, optimal condition for public good provision, capital tax rate, and economic growth rate are given by*

$$\begin{aligned} \theta \frac{c^o}{g^o} &= 1, \\ \tau^o &= \frac{(1+A)(1-\beta)\theta}{1+\theta}, \\ \gamma^o &= (1+A)\beta. \end{aligned}$$

Furthermore, the value function is

$$W^o = \frac{\log\left((1+A)(1-\beta) - \tau^o\right) + \theta \log \tau^o}{1-\beta} + \left(\frac{1+\theta}{1-\beta}\right) \log k.$$

The social planner maximizes social welfare without any distortionary effects, though the tax instrument takes the form of capital tax. Socially optimal MCPF is equal to unity because one unit of homogenous goods can be transformed into one unit of private and public goods. Lemmas 4 and 5 show that MCPF in the tax coordination equilibrium is equal to that in the socially optimal equilibrium.

However, this condition does not imply that the tax rate in the tax coordination equilibrium is the socially optimal rate. Indeed, we have

$$\tau^o - \tau^\star = -\left\{ \frac{(1+\theta)(1-\alpha)A + (1+A)(1-\beta)\theta}{(1+\theta)[1+(1-\beta)\theta]} \right\} \beta\theta < 0.$$

The tax difference between the tax competition equilibrium and socially optimal equilibrium can be positive or negative: $\tau^o \gtreqless \tau^*$ derived from Lemmas 1 and 5. The magnitude of relationship varies depending on production and utility function parameters. In particular, the elasticity of capital ratio with respect to the tax rate is important to determine the difference. When $\epsilon \to 1$, τ^* becomes zero. Then, $\tau^o > \tau^*$ holds. In contrast, $\tau^o < \tau^*$ when $\epsilon \to 0$. Hence, there exists $\overline{\epsilon}$, which satisfies $\tau^o = \tau^*$. However, public good supply is not socially optimal, though the tax rate is identical to the optimal level.

In the socially optimal equilibrium, distortion does not exist and the rate of return on capital is higher than those with distortionary taxes and positive externality. Therefore, the growth rate in the socially optimal equilibrium is higher than those in the other two equilibria. Thus, we obtain $\gamma^\star < \gamma^* < \gamma^o$ from Lemmas 1, 4, and 5. Welfare difference depends on tax and growth rates. The welfare in the socially optimal equilibrium is naturally the highest, and a high growth rate is essential to raising the welfare level.

As a result of the analysis mentioned above, we establish the following proposition on the difference between three equilibria regarding tax rates, growth rates, and welfare levels (see Appendix F for the proof of Proposition 4):

Proposition 5. *Suppose that the regions are symmetric in all aspects. Then, (i) $\tau^o < \tau^* < \tau^\star$ for $\epsilon < \overline{\epsilon}$ while $\tau^* < \tau^o < \tau^\star$ for $\epsilon > \overline{\epsilon}$. (ii) $\gamma^\star < \gamma^* < \gamma^o$ holds. (iii) $V^\star < V^* < W^o$ for $\epsilon < \widetilde{\epsilon}$ while $V^* < V^\star < W^o$ for $\epsilon > \widetilde{\epsilon}$. The welfare difference between W^o and V^* is decreasing in α.*

Proposition 5 holds that tax competition and tax coordination equilibria are inferior to centralized equilibrium in the welfare level. The result implies that tax competition is better (worse) than tax coordination as the second best policy if competition is mild (intense). Furthermore, Proposition 5 indicates the importance of the spillover effect to welfare. Parameter $(1-\alpha)$ stands for the degree of spillover effect. When $\alpha = 1$, the spillover effect is vanished. Then, the negative welfare effect of tax competition is minimized. In contrast, smaller α strengthens negative welfare effect.

5 Number of regions and equilibrium outcomes

This section analyzes the relationship between equilibrium outcomes and number of regions. We focus on tax competition equilibrium without Assumption 2 and several endogenous variables, such as the elasticity of κ with respect to tax rate, equilibrium tax rate, and economic growth rate. In the symmetric tax competition equilibrium ($\kappa = 1$), we have $x = z^{-1} = n^{v-1}$. Thus, the equilibrium value of ϵ satisfies

$$\Xi(\epsilon; n) \equiv -(1-\beta)\theta\epsilon^2 + [1 + (1-\beta)\theta + \Omega]\epsilon - \Omega = 0,$$

where $\eta = \eta(n)$,

$$\begin{aligned}
\Omega &\equiv [(1-\beta)(1+s_k B) + (1-s_k)B]\left(\frac{n-1}{n^v}\right)\theta\eta > 0, \\
s_k &\equiv \frac{f'(z)}{zf(z)} = s_k(n), \\
B &\equiv zf(z) = B(n).
\end{aligned}$$

If $v = 1$, then we obtain $s_k = \alpha$ and $B = A$. Hence, $\Xi = \Gamma$ and $\Omega = \Theta$ hold for $v = 1$. Note that s_k and B are the capital share and output-capital ratio, respectively.

Total differentiation of Ξ yields

$$\frac{d\epsilon}{dn} = \left[\frac{1-\epsilon}{1+(1-2\epsilon)(1-\beta)\theta+\Omega}\right]\frac{d\Omega}{dn}. \tag{21}$$

The effect of a change in n on ϵ^* depends on $d\Omega/dn$, which is composed of the effects on $(c+g)/k$ and κ. The sign of $d\Omega/dn$ is undetermined without any assumptions. Depending on σ and v, $d\Omega/dn$ could be positive or negative under Equation (16). Based on the conventional view of tax competition, ϵ is expected to positively associate with n. If $v = 1$, then we have

$$\frac{ds_k}{dn} = \frac{dB}{dn} = \frac{d\eta}{dn} = 0. \tag{22}$$

Hence, Equation (21) becomes[9]

$$\frac{d\epsilon}{dn} = \frac{(1-\epsilon)\Theta}{[1+(1-2\epsilon)(1-\beta)\theta+\Theta](n-1)n} > 0 \text{ for } v = 1.$$

Equation (13) and equilibrium growth rate are rewritten as

$$\begin{aligned} \epsilon^* &= \left(\frac{n-1}{n^v}\right)\eta\tau^*, \\ \gamma^* &= (1+s_k B-\tau^*)\beta. \end{aligned} \tag{23}$$

Using the above equations, we obtain

$$\frac{n}{\tau^*}\frac{d\tau^*}{dn} = -\frac{n}{\eta}\frac{d\eta}{dn} - \frac{n}{n-1} + v - \frac{n}{\epsilon^*}\frac{d\epsilon^*}{dn}, \tag{24}$$

$$\frac{d\gamma^*}{dn} = \left[B\frac{ds_k}{dn} + s_k\frac{dB}{dn} - \frac{d\tau^*}{dn}\right]\beta. \tag{25}$$

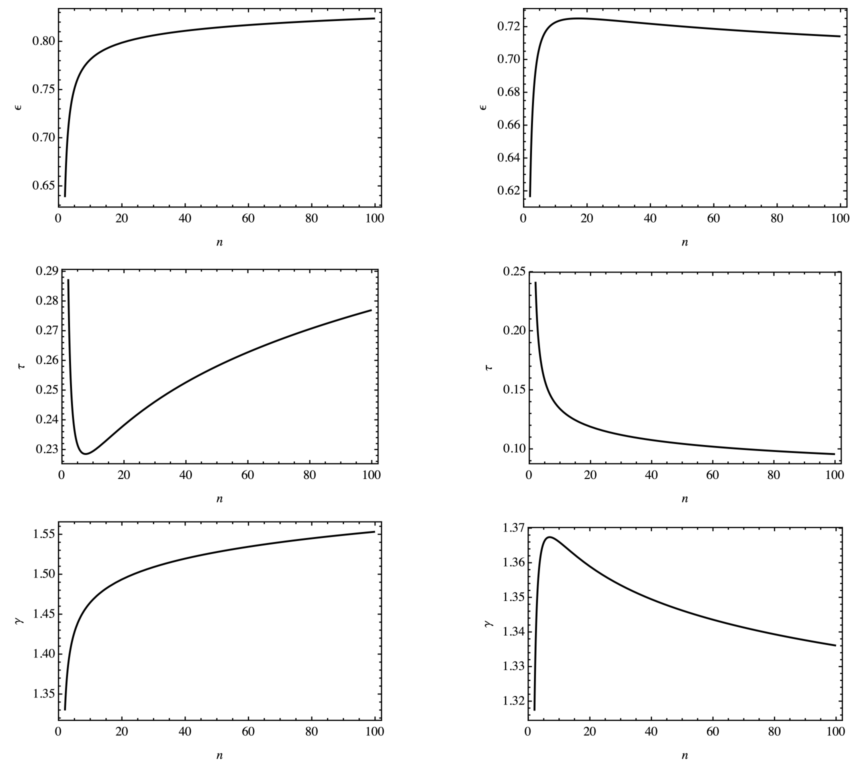
The effect of a change in n on τ^* depends on that on κ^*. Hence, the shape of production function and the degree of congestion are the key determinants of the sign of Equation (24). The effect of a change in n on γ^* coincides with that on post-tax interest rate. The number of regions affects economic growth rate through changes in the capital share, output-capital ratio, and tax rate. These effects of a change in n are ambiguous. Thus, we rely on a numerical analysis to clarify the signs of Equations (21), (24), and (25). However, we can obtain analytical results in certain case. When $v = 1$, Equations (21)–(25) lead to

$$\begin{aligned} \frac{d\tau^*}{dn} &= -\left[\frac{1}{(n-1)n} + \frac{n}{\epsilon^*}\frac{d\epsilon^*}{dn}\right]\frac{\tau^*}{n} < 0, \\ \frac{d\gamma^*}{dn} &= -\beta\frac{d\tau^*}{dn} > 0. \end{aligned}$$

The analyses developed above provide the following results:

Proposition 6. *Suppose that Assumption 2 holds. Regardless of the elasticity of capital and labor substitution, an increase in the number of regions raises the elasticity of capital ratio with respect to capital tax rate, reduces the equilibrium capital tax rate, and increases the equilibrium growth rate in tax competition equilibrium.*

As Proposition 6 is our analytical benchmark, we now examine Equations (21), (24), and (25) through numerical computations. Suppose that Equation (16) is the production function. We set $(\alpha, \rho, A) = (0.3, 0.01, 2)$. Then, β approximates 0.99. We consider three cases in the CES production function ($\sigma = -0.5, 0, 1$) and two cases in the degree of congestion ($v = 0.8, 1.2$).



(a) $v = 0.5$ (b) $v = 2$

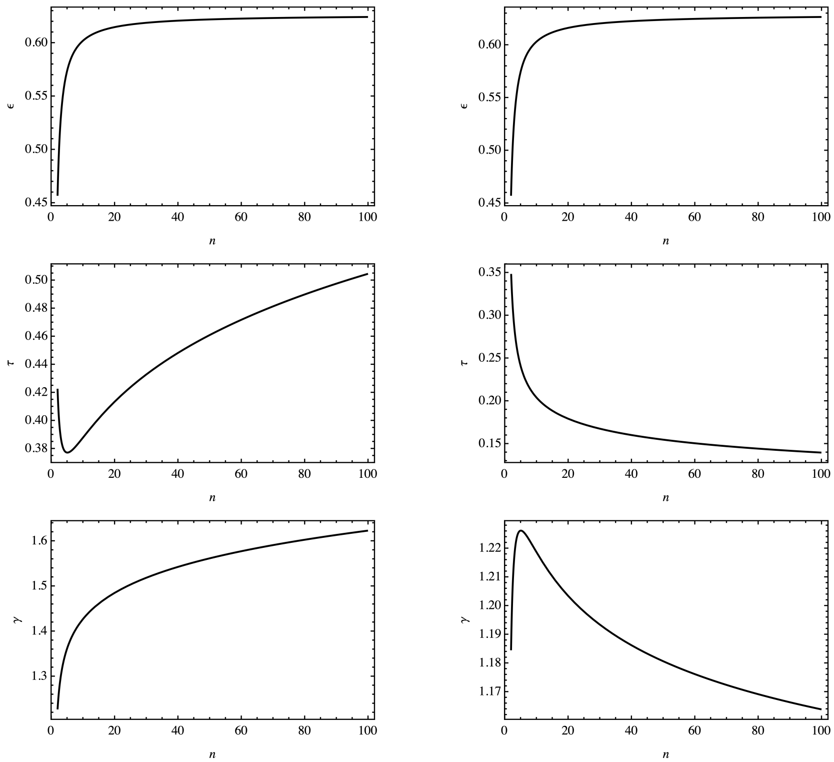
Figure 3. Number of regions and economic variables when $\sigma = -0.5$

In case 1 ($\sigma = -0.5$), the elasticity of capital-labor substitution equals 2. Three panels (a) in Figure 3 illustrate the effects of a change in n on ϵ, τ, and γ if scale effect dominates the congestion effect. For $v = 0.8$, s_k, and η decrease with n, whereas B and r increase with n through the scale effect. Given that the number of regions positively impacts Ω, an increase in n raises ϵ (see Equation (21)). From equation (23), the equilibrium tax rate follows a motion opposite to ϵ for a given n. An increase in n affects τ through a change in κ. η and its coefficient in Equation (23) oppositely respond to an increase in n. The effects on ϵ, η, and its coefficient in Equation (23) generate a non-monotonic relationship between τ and n. Regarding γ-n relationship, bottom panel (a) of Figure 3 shows that the equilibrium growth rate monotonically increases with the number of regions because the scale effect dominates the congestion and tax-distortion effects.

Three panels (b) in Figure 3 show the impacts of a change in n on ϵ, τ, and γ when the congestion effect dominates the scale effect. ϵ monotonically increases with n, whereas τ monotonically decreases with n. If $v = 1.2$, all of the effects on s_k, r, and η are opposite to those of $v = 0.8$. They generate a non-monotonic effect of n on ϵ. τ monotonically decreases with n. Contrary to panel (a), panel (b) shows that there exists a hump-shaped relationship between equilibrium growth rate and number of regions. For a small n, an increase in n has a strong marginal impact on economic growth through a decrease in the tax rate. However, the congestion effect overweighs the positive growth effect of the decreased tax rate for a large n.

In case 2 ($\sigma = 0$), the elasticity of capital-labor substitution is equal to unity. Hence, the production function takes the form of the Cobb-Douglas function. The curves in Figure 4 are similar to those in case 1. The intuitions are identical to those of case 1, except for upper panel of (b). However, its quantitative effects differ from those in case 1. For $v = 0.8$, ϵ is smaller than that in case 1, whereas τ and γ are larger than those in case 1. For $v = 1.2$, ϵ and τ are larger than those in case 1, though γ is

[9] Note that the numerator and denominator are positive based on Assumption 1.



(a) $v = 0.8$ (b) $v = 1.2$

Figure 4. Number of regions and economic variables when $\sigma = 0$

smaller than that in case 1. These differences are due to the presence of the effects on capital share.

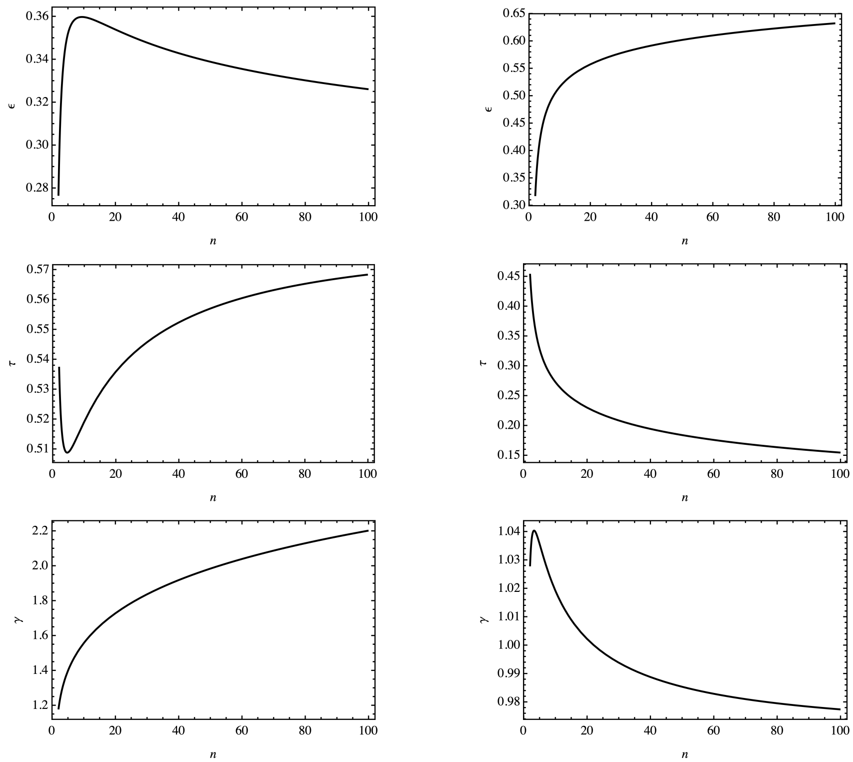
In case 3 ($\sigma = 1$), the elasticity of capital-labor substitution is 0.5. For $v = 0.8$, the effect of a change in n on s_k is opposite to that of case 1, though the impacts on B, η, and r have the same signs of those in case 1. If n is small, then an increase in n positively impacts Ω through an increase in capital income. On the other hand, the positive effect on capital income is overweighed by other negative effects on Ω, such as a decrease in η. Hence, a non-monotonic relationship between Ω and n exists. Economic growth rate monotonically increases with n because the qualitative impact of non-monotonicity is small, though r and τ oppositely respond to a change in n. For $v = 1.2$, ϵ and τ curves become similar to those of case 1. However, the relationship between ϵ and n differs from that of case 1 because the effect of n on s_k is opposite to that of case 1.

The results of the three cases are summarized below:

Remark 1. *(a) When the scale effect dominates the congestion effect, the equilibrium tax rate decreases with the number of regions for a small n though it increases with n for a large n. (b) When the congestion effect dominates the scale effect, the equilibrium tax rate monotonically decreases with the number of regions.*

Remark 2. *(a) When the scale effect dominates the congestion effect, economic growth rate monotonically increases with the number of regions. (b) When the congestion effect dominates the scale effect, there exists a hump-shaped relationship between economic growth rate and number of regions.*

Hoyt (1991) theoretically showed that a decrease in the number of regions increases the tax rate and public service level using a static model of tax competition. Several empirical studies also found that the number of regions negatively impacts local tax rates (e.g., Breuillé and Zanaj 2013). Regarding τ-n relationship, Panels (b) derive the same result as Hoyt (1991). Panels (a) differ from the pioneering



(a) $v = 0.8$ (b) $v = 1.2$

Figure 5. The number of regions and economic variables when $\sigma = 1$

study. However, for a small n, panels (a) also yield a negative relationship between tax rate and number of regions. Hence, these results are consistent with the empirical evidence under certain conditions.

Our main finding from the numerical simulation shows that economic growth and number of regions have a non-monotonic relationship regardless of elasticity of substitution. Previous studies demonstrate that an increase in n decreases capital tax rate (e.g., Hoyt 1991), and that a decreased tax rate enhances economic growth as growth rate is negatively associated with the tax rate (e.g., Miyazawa et al. 2019). This view holds if $v = 1$ (Proposition 6). However, if $v \neq 1$, the number of regions is not monotonically associated with the degree of tax competition ϵ and equilibrium tax rate. In certain cases, scale and congestion effects complicate γ-n relationship. Even if tax rate monotonically decreases with number of regions, the congestion effect overweighs the positive growth effect of decreased tax rate for a large n. Then, increasing competitors cannot positively impact economic growth.

6 Conclusion

This paper examined the relationship between tax competition, economic growth, and social welfare in an endogenous growth model with local public goods and freely mobile capital. Following Arrow (1962) and Romer (1986), knowledge spillover engines for sustainable growth. Jurisdictional governments tax capital that moves among regions for local public good supply. MAR and fiscal externalities occur because of knowledge spillover and mobile tax base. These two externalities have different effects on economic growth and social welfare. Knowledge spillover causes less capital investment and negatively impacts economic growth, whereas fiscal externality brings about capital tax rate competition in a decentralized economy and positively affects economic growth by lowering the tax rates. Fiscal externality inefficiently lowers capital tax rate, resulting in the underprovision of local public goods. Inefficient resource allocation worsens social welfare even if higher growth rate enhances welfare. Hence, the welfare effect of tax competition could be positive or negative.

Tax competition intensity is positively associated with the elasticity of capital-labor substitution. Strong fiscal externality with high elasticity of substitution intensifies capital tax rate competition. On the one hand, intense tax competition increases investment by reducing the tax rate and boosts economic growth. On the other hand, intense tax competition brings about extremely low supply of local public goods. The negative welfare effect of underprovision of public goods dominates the positive welfare effect of economic growth. Intense tax competition is undesirable; thus tax coordination improves social welfare. In contrast, mild tax competition enhances economic growth and increases social welfare because the positive welfare effect of tax competition through accelerated economic growth is larger than its negative welfare effect through undersupply of public goods. These results imply that tax competition is preferable depending on the degree of fiscal externality (i.e., the elasticity of substitution). However, tax competition and coordination are the second best policies because tax competition and coordination equilibria are inferior to social optimum in the welfare level.

The number of regions affects equilibrium outcomes through scale and congestion effects on knowledge spillover as discussed in Miyazawa et al. (2019). Our quantitative analysis shows that a decreased number of regions alleviate tax competition, except for certain cases, such as strong scale effect (equivalently, weak congestion effect) and high elasticity of capital-labor substitution. We also numerically found that economic growth and the number of regions may have a non-monotonic (especially hump-shaped) relationship though tax rates decrease with the number of regions. In certain cases, increasing competitors reduces not only tax rate but also economy-wide productivity of knowledge spillover through the congestion effect. Our results imply that tax competition and economic growth have a non-monotonic relationship in the aspect of the number of regions.

Finally, we provide future direction of this research. Our study reveals that tax coordination is desirable under intense tax competition, suggesting that centralization improves social welfare in such a case. We assumed only an identical tax rate common among all regions in the tax coordination that corresponds to centralization. However, as shown in the previous studies, the central government plays an active role in improving economic inefficiency through instruments such as interregional transfer and subsidy. Incorporating the role and policy instruments of the central government can explain issues of centralization and decentralization in local public finance. Our main results are based on the analyses of symmetric equilibrium, though it shed light on the dynamic aspects of tax competition from economic growth and social welfare perspectives. We need to model asymmetric regions to illustrate the strategic relationship among jurisdictional governments. This study provides an analytical basis for these extensions.

Appendix

A. Derivations of Equations (8a)–(9b)

Total differentiation of Equations (5) and (6) provide

$$\begin{aligned} 0 &= \sum_{i=1}^{n} x_i' \left(r+\tau_i\right) \frac{\partial \left(r+\tau_i\right)}{\partial \tau_i} = \frac{\partial r}{\partial \tau_i} \sum_{-i} x_j' \left(r+\tau_j\right) + x_i' \left(r+\tau_i\right) \left(1+\frac{\partial r}{\partial \tau_i}\right) \\ \Leftrightarrow \quad & \frac{\partial r}{\partial \tau_i} = -\frac{x_i' \left(r+\tau_i\right)}{\sum_{i=1}^{n} x_i' \left(r+\tau_i\right)} = -\frac{\kappa_i' \left(r+\tau_i\right)}{\sum_{i=1}^{n} \kappa_i' \left(r+\tau_i\right)} \in (-1,0). \end{aligned} \tag{A1}$$

Partial differentiation of Equation (5) with respect to τ and Equation (A1) yield

$$\frac{\partial \kappa_i}{\partial \tau_i} = z \frac{\partial x_i}{\partial \tau_i} = x_i' \left(r+\tau_i\right) \left(1+\frac{\partial r}{\partial \tau_i}\right) z < 0. \tag{A2}$$

Using Equations (1b), (2), and (A2), we obtain

$$\frac{\partial w_i}{\partial \tau_i} = -x_i f''\left(x_i\right) \frac{\partial x_i}{\partial \tau_i} \xi = -\left(1+\frac{\partial r}{\partial \tau_i}\right) \kappa_i k < 0, \tag{A3}$$

$$\frac{\partial g_i}{\partial \tau_i} = \left[\kappa_i + \tau_i \frac{\partial \kappa_i}{\partial \tau_i}\right] k = \left(1-\epsilon_i^i\right) \kappa_i k. \tag{A4}$$

B. Proof of Lemma 1

Applying Equations (1a) and (A1)–(A4) with symmetricity of regions to Equations (12a) and (12b) leads to

$$\theta \frac{c}{g} = \theta \frac{c}{\tau k} = \frac{1}{1-\epsilon}, \tag{A5}$$

$$\frac{c'}{c} = \left(1+\alpha A-\tau\right) \beta. \tag{A6}$$

Summing up both sides of Equation (4) and inserting Equations (1a) and (1b) into it, we have

$$\frac{k'}{k} = 1+A-\tau-\frac{c}{k}. \tag{A7}$$

Equations (A6) and (A7) provide

$$\begin{aligned} \frac{c}{k} &= 1+A-\tau-\left(1+\alpha A-\tau\right)\beta = \left(1-\beta\right)\left(1+\alpha A-\tau\right) + \left(1-\alpha\right) A \\ & \Leftrightarrow \quad \frac{c'}{c} = \frac{k'}{k}. \end{aligned} \tag{A8}$$

Using Equations (A5) and (A8), we obtain

$$\tau = \frac{\left[\left(1-\beta\right)\left(1+\alpha A\right) + \left(1-\alpha\right) A\right]\left(1-\epsilon\right)\theta}{1+\left(1-\beta\right)\left(1-\epsilon\right)\theta}. \tag{A9}$$

Equation (A9) becomes the quadratic equation $\Gamma\left(\epsilon;\eta\right) = 0$ using Equation (13). The discriminant of the quadratic polynomial is

$$\left[1+\left(1-\beta\right)\theta+\Theta\right]^2 - 4\left(1-\beta\right)\Theta\theta = 1+2\left(1-\beta\right)\theta+\Theta+\left[\left(1-\beta\right)\theta-\Theta\right]^2 > 0.$$

$\Gamma(\epsilon;\eta) = 0$ have two real positive roots. Furthermore, the calculation shows

$$\Gamma(1;\eta) = -(1-\beta)\theta + 1 + (1-\beta)\theta + \Theta - \Theta = 1 > 0.$$

Therefore, only one root of $\Gamma(\epsilon;\eta) = 0$ (smaller one) is unique solution to $\Gamma(\epsilon;\eta) = 0$, which is consistent with $0 < \epsilon < 1$ (Assumption 1). The unique value of ϵ determines the unique value of τ from Equation (13). These results prove Lemma 1.

C. Proof of Lemma 3

Suppose that the value function takes the form of

$$V(a_i, k) = \phi_0 + \phi_1 \log k + \phi_2 \log(a_i + \psi k), \tag{A10}$$

where ϕ_i and ψ are undetermined coefficients ($i = 0, 1, 2$). Then, the partial derivative of Equation (A10) and the symmetricity of regions provide

$$\frac{\partial V(a_i, k)}{\partial k} = \frac{\phi_1}{k} + \frac{\psi\phi_2}{a_i + \psi k} \Rightarrow \left.\frac{\partial V(a_i, k)}{\partial k}\right|_{a_i = k} = \frac{\phi_1}{k} + \frac{\psi\phi_2}{(1+\psi)k}. \tag{A11}$$

The following equation is derived from (P1):

$$\frac{\partial V(a_i, k)}{\partial k} = \frac{1}{c_i}\frac{\partial c_i}{\partial k} + \theta\frac{1}{g_i}\frac{\partial g_i}{\partial k} + \beta\frac{\partial V(a_i', k')}{\partial k'}\frac{\partial k'}{\partial k}. \tag{A12}$$

Using the symmetricity of regions and Equation (A10), Equation (10b) becomes

$$\frac{1}{c_i} = \beta\frac{\partial V(a_i', k')}{\partial a_i'} = \beta\frac{\phi_2}{a_i' + \psi k'}. \tag{A13}$$

Differentiating Equation (A13) leads to

$$-\frac{1}{c_i}\frac{\partial c_i}{\partial k} = -\frac{\psi}{a_i' + \psi k'}\frac{\partial k'}{\partial k} \Rightarrow \left.\frac{k}{c_i}\frac{\partial c_i}{\partial k}\right|_{a_i = k} = \frac{\psi}{1+\psi}. \tag{A14}$$

From Equations (A11)–(A14), we obtain

$$\phi_1 + \frac{\psi\phi_2}{1+\psi} = \frac{\psi}{1+\psi} + \theta + \left[\phi_1 + \frac{\psi\phi_2}{1+\psi}\right]\beta.$$

A comparison between the coefficients of this equation yields

$$\phi_1 = \frac{\theta}{1-\beta}, \phi_2 = \frac{1}{1-\beta}.$$

Evaluating Equation (A13) at $a_i = k$, we have

$$\beta\left.\frac{\partial V(a_i', k')}{\partial a_i'}\right|_{a_i = k} = \frac{\beta\phi_2}{(1+\psi)k'} = \frac{1}{c}. \tag{A15}$$

Inserting Equation (A8) into Equation (A15) leads to

$$\begin{aligned}\frac{\beta\phi_2 k}{(1+\psi)k'} &= \frac{1}{(1-\beta)(1+\alpha A - \tau) + (1-\alpha)A} \\ &\Rightarrow \frac{\phi_2}{1+\psi} = \frac{1+\alpha A - \tau}{(1-\beta)(1+\alpha A - \tau) + (1-\alpha)A}.\end{aligned}$$

Therefore, we have

$$1+\psi=\frac{(1-\beta)(1+\alpha A-\tau)+(1-\alpha)A}{(1-\beta)(1+\alpha A-\tau)}.$$

Equations (P1) and (A10) give

$$\begin{aligned}\phi_0+(\phi_1+\phi_2)\log k+\phi_2\log(1+\psi) &= \log((1+A)k-\tau k-k')+\theta(\log\tau+\log k)\\ &\quad +\beta[\phi_0+(\phi_1+\phi_2)\log k'+\phi_2\log(1+\psi)]\\ &= \log((1-\beta)(1+\alpha A-\tau)+(1-\alpha)A)+[1+\theta+(\phi_1+\phi_2)\beta]\log k\\ &\quad +\theta\log\tau+\beta\{\phi_0+(\phi_1+\phi_2)[\log(1+\alpha A-\tau)+\log\beta]+\phi_2\log(1+\psi)\}.\end{aligned}$$

Comparing the coefficients, we obtain

$$(\phi_1+\phi_2)\log k=[1+\theta+(\phi_1+\phi_2)\beta]\log k\Leftrightarrow 1+\theta=(1-\beta)(\phi_1+\phi_2),$$

and

$$\begin{aligned}(1-\beta)\phi_0 &= \log((1-\beta)(1+\alpha A-\tau)+(1-\alpha)A)+\theta\log\tau\\ &\quad +\beta(\phi_1+\phi_2)[\log(1+\alpha A-\tau)+\log\beta]-(1-\beta)\phi_2\log(1+\psi)\\ &= \theta\log\tau+\frac{[\log(1+\alpha A-\tau)+\log\beta](1+\theta)\beta}{1-\beta}+\log(1-\beta)+\log(1+\alpha A-\tau).\end{aligned}$$

Hence, ϕ_0 is determined as

$$\phi_0=\frac{1}{1-\beta}\left[\theta\log\tau+\frac{[\log(1+\alpha A-\tau)+\log\beta](1+\theta)\beta}{1-\beta}+\log(1-\beta)+\log(1+\alpha A-\tau)\right].$$

Inserting all coefficients into Equation (A10), we arrive at

$$\begin{aligned}V &= \phi_0+\phi_1\log k+\phi_2[\log(1+\psi)+\log k]\\ &= \frac{1}{1-\beta}\left\{\theta\log\tau+\frac{[\log(1+\alpha A-\tau)+\log\beta](1+\theta)\beta}{1-\beta}+\log((1-\beta)(1+\alpha A-\tau)+(1-\alpha)A)+(1+\theta)\log k\right\}.\end{aligned}$$

D. Proof of Lemma 4

Using the symmetricity of regions and Equation (2), Equation (18a) becomes

$$\theta\frac{c}{g}=1\Leftrightarrow\frac{c}{k}=\frac{\tau}{\theta}. \tag{A16}$$

From Equations (1a), (18b), and (19), Equation (A6) holds in the tax coordination equilibrium. The resource constraint is identical to Equation (A7). Using Equations (A6), (A7), and (A16), we have

$$(1+\alpha A-\tau)\beta=1+A-\frac{1+\theta}{\theta}\tau.$$

Solving this equation with respect to τ leads to

$$\tau^\star=\frac{[(1-\beta)(1+\alpha A)+(1-\alpha)A]\theta}{1+(1-\beta)\theta}.$$

Equations (A5) and (A16) are coincided each other if and only if $\epsilon=0$. Furthermore, the functional form of the value function is common between these two equilibria because the tax rate is constant over time.

E. Proof of Lemma 5

The first-order conditions are

$$\frac{\partial W(k)}{\partial \tau} = -\frac{k}{(1+A)k - \tau k - k'} + \frac{\theta}{\tau} = 0, \tag{A17}$$

$$\frac{\partial W(k)}{\partial k'} = -\frac{1}{(1+A)k - \tau k - k'} + \beta \frac{\partial W(k')}{\partial k'} = 0. \tag{A18}$$

Using Equation (2) and the resource constraint, Equation (A17) becomes

$$\theta \frac{c}{g} = \theta \frac{c}{\tau k} = 1. \tag{A19}$$

We have

$$\begin{aligned} \frac{\partial W(k)}{\partial k} &= \frac{1}{c}\frac{\partial c}{\partial k} + \theta \frac{1}{g}\frac{\partial g}{\partial k} + \beta \frac{\partial W(k')}{\partial k'}\frac{\partial k'}{\partial k} \\ &= \frac{1}{c}\left[1 + A - \left(\frac{\partial g}{\partial k} + \frac{\partial k'}{\partial k}\right) + \frac{\partial g}{\partial k} + \frac{\partial k'}{\partial k}\right] = \frac{1+A}{c}. \end{aligned} \tag{A20}$$

Using Equations (A18), (A20), and the resource constraint, we obtain

$$\frac{c'}{c} = (1+A)\beta. \tag{A21}$$

The resource constraint becomes

$$\frac{k'}{k} = 1 + A - \tau - \frac{c}{k} = 1 + A - \left(\frac{1+\theta}{\theta}\right)\tau \tag{A22}$$

Equations (A21) and (A22) lead to

$$\tau^o = \frac{(1+A)(1-\beta)\theta}{1+\theta} \Longleftrightarrow \frac{c'}{c} = \frac{k'}{k}.$$

We consider that the value function takes the form of

$$W(k) = \chi_0 + \chi_1 \log k. \tag{A23}$$

Equations (P3), (A22), and (A23) with τ^o yield

$$\chi_0 + (1-\beta)\chi_1 \log k = \log((1+A)(1-\beta) - \tau) + (1+\theta)\log k + \theta \log \tau + \beta\left\{\chi_0 + \chi_1\left[\log(1+A) + \log\beta\right]\right\}. \tag{A24}$$

A comparison between the coefficients of Equation (A24) provides

$$\begin{aligned} \chi_1 &= \frac{1+\theta}{1-\beta}, \\ \chi_0 &= \frac{\log((1+A)(1-\beta) - \tau) + \theta \log \tau + \frac{(1+\theta)\beta}{1-\beta}\left[\log(1+A) + \log\beta\right]}{1-\beta}. \end{aligned}$$

Hence, we arrive at

$$\begin{aligned} W^o &= \frac{\log((1+A)(1-\beta) - \tau^o) + \theta \log \tau^o}{1-\beta} + \left(\frac{1+\theta}{1-\beta}\right)\log k \\ &= \frac{(1+\theta)\left[\log(1+A) + \log(1-\beta)\right] + \theta\log\theta - (1+\theta)\log(1+\theta) + (1+\theta)\log k}{1-\beta} \\ &\quad + \frac{(1+\theta)\beta\left[\log(1+A) + \log\beta\right]}{(1-\beta)^2}. \end{aligned}$$

F. Proof of Proposition 5

The partial derivatives of the value functions yield

$$\frac{d\left(W^{o}-V^{*}\right)}{d\alpha}=-\frac{\left[\left(1-\beta\right)\left(1+\alpha A-\tau\right)\theta+\left(1+\theta\right)\left(1-\alpha\right)A\right]\beta A}{\left(1-\beta\right)\left(1-\beta\right)\left(1+\alpha A-\tau\right)\left[\left(1-\beta\right)\left(1+\alpha A-\tau\right)+\left(1-\alpha\right)A\right]}<0.$$

References

[1] Arrow, K.J. (1962), The economic implications of learning by doing, *Review of Economic Studies*, 29 (3), 155–173.

[2] Barro, R.J. (1990), Government spending in a simple model of endogenous growth, *Journal of Political Economy*, 98 (5), part2, S103–S124.

[3] Baskaran, T. and M. Lopes da Fonseca (2013), The economics and empirics of tax competition: a survey, Discussion Papers, Center for European Governance and Economic Development Research, No. 163.

[4] Batina, R. (2009), State capital tax competition and coordinated tax reform in an overlapping generations economy, *Regional Science and Urban Economics*, 39 (4), 472–478.

[5] Bronzini, R. and P. Piselli (2009), Determinants of long-run regional productivity with geographical spillovers: the role of R&D, human capital and public infrastructure, *Regional Science and Urban Economics*, 39 (2), 187–199.

[6] Breuillé M.-L. and S. Zanaj (2013), Mergers in fiscal federalism, *Journal of Public Economics*, 105 (C), 11–22.

[7] Chamley, C. (1986), Optimal taxation of capital income in general equilibrium with infinite lives, *Econometrica*, 54 (3), 607–622.

[8] Chu, A.C. and C.C. Yang (2012), Fiscal centralization versus decentralization: growth and welfare effects of spillovers, leviathan taxation, and capital mobility, *Journal of Urban Economics*, 71 (2), 177–188.

[9] Djankov, S., T. Ganser, C. McLiesh, R. Ramalho, and A. Shleifer (2010), The effect of corporate taxes on investment and entrepreneurship, *American Economic Journal: Macroeconomics*, 2 (3), 31–64.

[10] Ferede, E. and B. Dahlby (2012), The impact of tax cuts on economic growth: evidence from the Canadian provinces, *National Tax Journal*, 65 (3), 563–594.

[11] Hatfield, J.W. (2015), Federalism, taxation, and economic growth, *Journal of Urban Economics*, 87 (C), 114–125.

[12] Hatfield, J.W. and K. Kosec (2013), Federal competition and economic growth, *Journal of Public Economics*, 97 (C), 144–159.

[13] Hoyt, W. (1991), Property taxation, Nash equilibrium, and market power, *Journal of Urban Economics*, 30 (1), 123–131.

[14] Irmen, A. and B.U. Wigger (2006), National minimum wages, capital mobility, and global economic growth, *Economics Letters*, 90 (2), 285–289.

[15] Judd, K.L. (1985), Redistributive taxation in a simple perfect foresight model, *Journal of Public Economics*, 28 (1), 59–83.

[16] Kneller, R., M.F. Bleaney, and N. Gemmell (1999), Fiscal policy and growth: evidence from OECD countries, *Journal of Public Economics*, 74 (2), 171–190.

[17] Köthenbürger, M. and B. Lockwood (2010), Does tax competition really promote growth? *Journal of Economic Dynamics and Control*, 34 (2), 191–206.

[18] Lee, Y. and R.H. Gordon (2005), Tax structure and economic growth, *Journal of Public Economics*, 89 (5–6), 1027–1043.

[19] Lejour, A.M. and H.A. Verbon (1997), Tax competition and redistribution in a two-country endogenous-growth model, *International Tax and Public Finance*, 4 (4), 485–497.

[20] Miyazawa, K., H. Ogawa, and T. Tamai (2019), Capital market integration and fiscal sustainability, *European Economic Review*, 120, 103305.

[21] Oates, W.E. (1972), *Fiscal Federalism*, Harcourt Brace Jovanovich, New York.

[22] OECD (2012), Labour Losing to Capital: What Explains the Declining Labour Share?, Chapter 3, *OECD Employment Outlook 2012*.

[23] Rauscher, M. (2005), Economic growth and tax-competing leviathans, *International Tax and Public Finance*, 12 (4), 457–474.

[24] Romer, P. (1986), Increasing returns and long-run growth, *Journal of Political Economy*, 94 (5), 1002–1037.

[25] Tamai (2008), A note on dynamic analysis of fiscal competition, *Urban Studies*, 45 (3), 651–657.

[26] Thornton, J. (2007), Fiscal decentralization and economic growth reconsidered, *Journal of Urban Economics*, 61 (1), 64–70.

[27] Wildasin, D.E. (2003), Fiscal competition in space and time, *Journal of Public Economics*, 87 (11), 2571–2588.

[28] Wilson, J.D. (1986), A theory of inter-regional tax competition, *Journal of Urban Economics*, 19 (3), 296–315.

[29] Zodrow, G.R. (2010), Capital mobility and capital tax competition, *National Tax Journal*, 63 (4), 865–902.

[30] Zodrow, G.R. and P. Mieszkowski (1986), Pigou, Tiebout, property taxation, and the underprovision of local public goods, *Journal of Urban Economics*, 19 (3), 356–370.