Public Investment Competition, Spillover Effects and Regional Integration

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1. Introduction

Recently, there has been a trend to discussion of decentralization and the common problem of autonomy in taxation and public investment. Accordingly, it is important to discuss whether decentralized decision-making with regard to a tax and public investment is socially efficient. Recently, regional activation has become an extremely important problem in all regions of Japan. It is important to consider local public investment as a local public policy to enhance regional activation. Herein, we especially discuss decentralized decision making with regard to local public investment because we specifically examine public finance in Japan. When we examine competition in public investment among local governments, the spillover effect for the local public good must also be considered because not only residents in one region but also residents in other regions might enjoy benefits from one region's local public good or service.

As described herein, we analyze whether decentralized decision making for public investment is socially efficient when each local government chooses the level of public investment in its region under a situation in which capital is perfectly mobile among regions and a local public good has a spillover effect. Furthermore, municipal mergers have been enhanced in Japan. Therefore, we also analyze regional integration.

Theoretical studies of public investment competition include those of Keen and Marchand (1997), Hindriks et al. (2008), and Dembour and Wauthy (2009).

Keen and Marchand (1997) analyze regional competition with regard to capital tax and public investment. They assumed simultaneous tax and investment choices. They show undertaxation and overinvestment in equilibrium.

Hindriks et al. (2008) consider a model of federation with two heterogeneous regions that seek to attract capital by competing in capital income taxes and public investment that enhance capital productivity. Their feature is that regions make public investments before tax decisions so that public investments have a strategic effect on tax choices and so that regions can attract capital by investing more or taxing less. They find that underinvestment and undertaxation exist in equilibrium.

Dembour and Wauthy (2009) produce analyses showing that local governments choose infrastructure levels in a first stage and compete in taxes in a second stage, which is similar to the result reported by Hindriks et al. (2008). However Dembour and Wauthy (2009) examine the properties of Subgame Perfect Nash equilibria in this stage game depending on the extent to which the benefits of infrastructure spill over from one region to the other. They show that the presence of inter-regional spillovers allows jurisdictions to control the intensity of tax competition and therefore affects the optimal levels of infrastructure selected at equilibrium.

These theoretical studies of public investment competition specifically examine the timing of choice for public investment and capital tax rate and conclude various results. However, these studies do not consider spillover effects for local public goods in their model framework. Actually, it is important to consider spillover effects for local public goods. For example, spillover effects for local public goods occur in mobile factors, such as public traffic.

This paper is based on the framework of Hindriks et al. (2008). In Hindriks et al. (2008), each local government chooses the capital tax rate and public investment under a situation in which the spillover effects with the provision of local public good do not exist. In contrast, in this paper, each local government chooses the level of public investment. The central government controls the capital tax rate under a situation in which the local public good has spillover effects.

Results show that public investment in equilibrium is more socially desirable if either the spillover effect is large, or the capital tax rate is high. Furthermore, regional integration can achieve a socially optimal level of investment for any degree of economies of scale.

2. Model

Consider a country comprising two regions i=1,2. In each region, the local government chooses a level of public investment I_i that enhances domestic capital productivity. The regions' choices, denoted as $I = (I_1, I_2)$, determine the allocation of capital x_1 and x_2 across regions, the precise mechanism of which will be described below. The production in each region is given by the function $F_i(x_i, I_i)$, which is increasing, twice continuously differentiable, and concave in the level of capital x_i for $i = 1,2$. Naturally, the private capital and public investment are complements, so that the cross derivative of $\partial^2 F_i/\partial x_i \partial I_i$ is positive. The cost of public investment is given as the convex function $c_i(I_i)$, which is assumed to be quadratic for analytical tractability: $c_i(I_i) = I_i^2/2$. In each region, the local government levies on the mobile tax base (capital) and supplies a local public good that has spillover effects. Therefore, the budget constraint of the local government is $tx_i = g_i$. Here, t is a capital tax that is equal among regions. g_i is the local public good in region i.

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

$$\frac{\partial F_1(x_1, I_1)}{\partial x_1} = \frac{\partial F_2(x_2, I_2)}{\partial x_2}. \tag{1}$$

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

$$W_i = F_i(x_i, I_i) - \frac{\partial F_i(x_i, I_i)}{\partial x_i} x_i + g_i + \lambda g_j - \frac{I_i^2}{2}, \tag{2}$$

In that equation, $i \neq j$ and λ is the spillover effect $(0 \leq \lambda \leq 1)$. We assume no domestic ownership of capital. Regions tax capital because it is simple to extract rents from the capital owners.

Next, we specify the production functions. The production functions are given as

$$F_i(x_i, I_i) = (\gamma + I_i)x_i - \delta \frac{x_i^2}{2}, \tag{3}$$

where parameter $\delta \geq 1$ is the rate of decline of the marginal product of capital with the amount of capital invested in the region. Consequently, the regional production functions exhibit decreasing returns to capital and constant returns to investment. The welfare in the region i simplifies to the following.

$$W_i = \frac{\delta x_i^2}{2} + g_i + \lambda g_j - \frac{I_i^2}{2}. \tag{4}$$

We first provide a benchmark by deriving the efficient outcome that maximizes the sum of the two regional welfare levels.

Lemma 1

The socially optimal level of capital is $x_1^o = x_2^o = \frac{1}{2}$ and socially optimal level of investment is $I_1^o = I_2^o = t - \gamma + \frac{\delta}{2}$.

3. Competing in Public Investment

In this section, we analyze the local government decision of the level of investment. The timeline is the following. In the first stage, each local government chooses its investment independently. In the next stage, the firm in each region chooses its demand for capital. We solve this game backwards.

First we analyze the equilibrium of capital market. Eq. (1) and the constraint of amount of capital yields the following levels of capital in respective regions.

$$x_i^r = \frac{I_i - I_j + \delta}{2\delta} \tag{5}$$

Given the public investment of another region, each local government i anticipates the allocation of capital and independently chooses its investment I_i to maximize W_i.

We can derive the first-order condition as presented below.

$$\delta x_i^r \frac{dx_i^r}{dI_i} + t\frac{dx_i^r}{dI_i} = I_i - \lambda t \frac{dx_j^r}{dI_i} \tag{6}$$

Here, $\frac{dx_i^r}{dI_i} = \frac{1}{2\delta}$ and $\frac{dx_j^r}{dI_i} = -\frac{1}{2\delta}$. The left-hand side of eq. (6) is the sum of the marginal benefits of consumption of private good and public good from increase of capital by the investment in region i. Consequently, the left-hand side of eq. (6) is the marginal benefit from the investment in region i. The first term of the right-hand side of eq. (6) is the marginal increase of the cost from investment in region i. The second term of the right-hand side of eq. (6) is the marginal decrease of the benefit from the spillover effect from the decrease of another region's capital by investment in region i. Therefore, the right-hand side of eq. (6) is the marginal cost from the investment in region i. Consequently, eq. (6) is the condition under which the marginal benefit from the investment equals the marginal cost from the investment in region i. The local government in region i determines its investment to meet eq. (6) given the investment in the other region.

The investment in region i which meets eq. (6) in each region is the following.

$$I_i^r = \frac{I_j - \delta - 2t + 2\lambda t}{1 - 4\delta} \tag{7}$$

Here, the investment in region i denotes I_i^r. Equation (7) denotes the best reaction function of the local government in region i on the investment, which is decided by the local government in the other region. From eq. (7), we can derive the equilibrium level of investment as presented below.

$$I_1^* = I_2^* = \frac{4\delta^2-2\delta+8t\delta(1-\lambda)-4t(1-\lambda)}{-8\delta+16\delta^2} \tag{8}$$

4. Efficiency of Public Investment

In this section, we analyze the efficiency of public investment from comparison equilibrium of public investment with the socially optimal level of public investment. We subtract the socially optimal level of investment from the equilibrium level of public investment, which yields the following.

$$I^* - I^o = \frac{4\delta^2+8t\delta-\delta+2t\lambda(1-2\delta)-2t-8t\delta^2-4\gamma\delta+8\gamma\delta^2-4\delta^3}{-4\delta+8\delta^2} \tag{9}$$

Here, we assume that $\gamma > \frac{4\delta^3-3\delta+1}{8\delta^2-4\delta}$. From this assumption of γ, when the spillover effect does not exist ($\lambda = 0$), the sign of eq. (9) is positive ($I^* - I^o > 0$). Therefore, we obtain the following result.

Proposition 1

Let $\gamma > \frac{4\delta^3-3\delta+1}{8\delta^2-4\delta}$. Then when the spillover effect does not exist, a unique symmetric equilibrium involving overinvestment prevails in each region.

Next we analyze the effect by which spillover affects the equilibrium. We differentiate λ from eq. (9). Therefore, we can derive the following equation.

$$\frac{d(I^*-I^o)}{d\lambda} = \frac{2t(1-2\delta)}{-4\delta+8\delta^2} < 0 \tag{10}$$

From eq. (10), we can obtain the following result.

Proposition 2

Public investment in equilibrium is more socially desirable if the spillover effect is large.

The interpretation of proposition 2 is the following. When public investment in region i increases, the capital in the other region j decreases. Consequently, the public good provision in the other region j decreases because of the decrease of the capital in its region.

According to these circumstances, the benefit of spillover from the other region j to the region i will decrease. This situation is the marginal cost from the public investment in region i. Here, if the spillover effect is large, then the local government in region i will overestimate the marginal cost from the public investment. Consequently, the greater the spillover effect, the more socially desirable is public investment in equilibrium.

Next we analyze the effect by which the increase of the capital tax rate affects the equilibrium. We differentiate between t and eq. (9). Therefore, we can derive the following equation.

$$\frac{d(I^*-I^o)}{dt} = \frac{8\delta(1-\delta)+2\lambda(1-2\delta)-2}{-4\delta+8\delta^2} < 0 \tag{11}$$

From eq. (11), we can obtain the following result.

Proposition 3

Public investment in equilibrium is more socially desirable if the capital tax rate is high.

The interpretation of proposition 3 is the following. When the public investment in region i increase, the capital in its region will increase. Consequently, the public good provision in the region i increases because of the increase of the tax revenue from increase of capital. This situation illustrates the marginal benefit from public investment in region i.

However, when the public investment in region i increases, the capital in the other region j decreases. Consequently, the public good provision in the other region j decreases because of the decrease of tax revenue from the decrease of capital in its region.

According to this situation, the benefit of spillover from the other region j to region i will decrease. This situation is the marginal cost from the public investment in region i.

The marginal benefit of public investment and the marginal cost of public investment will increase if the capital tax rate is high. Here, because the increase of marginal cost of public investment is greater than the increase of marginal benefit of public investment, the higher the capital tax rate, the greater the degree to which public investment in equilibrium is socially desirable.

5. Regional Integration

This section presents analysis of regional integration. Next, we consider the situation in which each local government mutually integrates as one government. Here, if each local government integrates, then economies of scale might occur. However, integrated government might not be able to realize the residents' actual preference of local public good in each region. Therefore, we assume the following welfare for region i.

$$W_i = F_i(x_i, I_i) - \frac{\partial F_i(x_i,I_i)}{\partial x_i} x_i + \alpha\left(g_i + \lambda g_j\right) - \beta \frac{I_i^2}{2} \tag{12}$$

Here, α denotes the degree of comprehension of the residents' actual preference of local public good in each region $(0 < \alpha < 1)$. β signifies the degree of infrastructural cost reduction effect from economies of scale$(0 < \beta < 1)$. Integrated government decides public investment in each region to maximize the sum of the revised two regional welfare eq. (12).

We can derive the level of investment as presented below.

$$I_1^I = I_2^I = t - \gamma + \frac{\delta}{2} \tag{13}$$

Therefore, we obtained the following result.

Proposition 4

Regional integration can achieve a socially optimal level of investment for any degree of economies of scale and comprehension of the residents' actual preference of the local public good in each region.

Appendix

Proof of Lemma 1: To determine a Pareto optimal allocation, we consider the following problem.

$$\max_{x_i, I_i} \frac{\delta x_1^2}{2} + \frac{\delta x_2^2}{2} + (1+\lambda)g_1 + (1+\lambda)g_2 - \frac{I_1^2}{2} - \frac{I_2^2}{2}$$

$$\text{s.t.}\ \ x_1 + x_2 = 1$$

$$tx_1 = g_1, tx_2 = g_2$$

$$t - \frac{\partial F_1}{\partial x_1} = 0, t - \frac{\partial F_2}{\partial x_2} = 0$$

The Lagrangian function is the following.

$$\mathcal{L} = \frac{\delta x_1^2}{2} + \frac{\delta x_2^2}{2} + (1+\lambda)tx_1 + (1+\lambda)tx_2 - \frac{I_1^2}{2} - \frac{I_2^2}{2} + v(x_1 + x_2 - 1)$$
$$+\mu_1(t - \gamma - I_1 + \delta x_1) + \mu_2(t - \gamma - I_2 + \delta x_2)$$

Here, the variables v, μ_1 and μ_2 are Lagrangian variables. Consequently, the first-order condition is the following.

$$\frac{\partial \mathcal{L}}{\partial x_i} = \delta x_i + (1+\lambda)t + v + \mu_i \delta = 0$$

$$\frac{\partial \mathcal{L}}{\partial I_i} = -I_i - \mu_i = 0$$

$$\frac{\partial \mathcal{L}}{\partial v} = x_1 + x_2 - 1 = 0$$

$$\frac{\partial \mathcal{L}}{\partial \mu_i} = t - \gamma - I_i + \delta x_i = 0, \quad (i = 1,2)$$

The socially optimal allocations which meet the first-order condition above are the following. The socially optimal level of capital is $x_1^o = x_2^o = \frac{1}{2}$. The socially optimal level of investment is $I_1^o = I_2^o = t - \gamma + \frac{\delta}{2}$.

Main References

[1] Dembour, C. and X. Wauthy (2009), "Investment in public infrastructure with spillovers and tax competition between contiguous regions," *Regional Science and Urban Economics*, 39, pp.679-687.

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