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The Regional Allocation of Public Investment with Transfer Policy and Migration Behavior

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Abstract:

This paper analyzes the allocation of public investment across regions when the government can use a transfer policy. When taxation and transfer can be used to solve regional inequalities, should the government change the allocation of public investment? Previous studies have found that the government should use taxation and transfer to reduce regional inequality. These studies assume that individuals cannot migrate across regions, but when they are free to do so, the government should consider migration behavior to increase welfare. The optimal allocation of public investment depends on the degree of increasing returns and the public investment productivity in any region that enjoys such increasing returns. When the degree of increasing returns is higher and the productivity of public investment is smaller, the government should decrease that region's public investment, instead of which individuals of that region should receive a transfer. The government should use that transfer to concentrate individuals in the region so as to utilize the technology of increasing returns. In this situation, the transfer policy is not utilized to redistribute income. This policy should be used to control economic glomeration.

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1 Introduction

Regional differences exist in many countries for a variety of reasons. For example, Fujita, Krugman and Venables (1999) have shown that economic agglomeration yields regional disparities. When these disparities are present, should the government attempt to reduce regional inequality?

To solve the problem of regional inequality, what policy should the government use? One effective instrument is public investment. Furukawa (2006) has analyzed an optimal public investment allocation for urban and rural areas where the urban areas have scale economies. Furukawa concludes that when the productivity of public investment in the rural area is larger and the degree of scale economies in the urban area is smaller, it is optimum that the former should be allocated more public investment than the latter. Yamano and Ohkawara (2000), in evaluating the regional allocation of public investment in Japan, have showed that public investment is allocated across regions in order to moderate income inequality. However, public investment is not the only instrument that can reduce regional inequality. Transfer can also be used to solve that problem. For example, Fuest and Huber (2006) have analyzed regional policy using a subsidy. They show that the government should grant a subsidy to firms in the poor regions to increase welfare. Moreover, Martin (1999) has examined public policy from the viewpoint of its effect on regional income distribution, growth and economic geography. In Martin's model, public policy contains both public investment and transfer. Martin concludes that each public policy that reduces regional inequality generates lower growth on the basis of industrial location.

This paper analyzes the allocation of public investment across regions when the government is free to use transfer policy. When taxation and transfer can be used to solve regional inequality, should the government change the allocation of public investment? Some studies have examined regional policy in terms of public investment and transfer. Caminal (2004) have showed that the government should allocate public investment efficiently in most cases when it can redistribute income through taxation. Referring to Caminal's model, de la Fuente (2004) has empirically analyzed the optimal public investment policy across Spanish regions. Although such studies have concluded that the government should use taxation and transfer to reduce regional inequality, they assume that individuals cannot migrate across regions. When in fact individuals are free to migrate across regions, the government should consider the effects of migration behavior to increase welfare. This paper examines the allocation of public investment by using a model in which regional differences exist because of economic agglomeration and individuals are allowed to migrate across regions without cost.

The remainder of the paper is as follows. Section 2 introduces the model. Section 3 analyzes the optimal policy of government. Section 4 summarizes the results.

2 The model

The current model considers an economy that is composed of regions 1 and 2, with each region differing with respect to the production of private goods. Because of that production, one region has scale economies, while the other does not. I assume that region 1 has scale economies. In region 1, a service sector exists comprised of one consumption service good and N intermediate service goods that are used to produce the consumption service good. Each intermediate service good is produced by labor and the public infrastructure. In region 2, the manufacture good is produced using labor and the public infrastructure.

The labor force is comprised of individuals, each of whom supplies one unit of labor. In region i $(i = 1, 2)$, the population of individuals is L_i , while the total population in the economy is $\bar{L} = L_1 + L_2$. In the model, since individuals can migrate among regions without cost, L_i is determined endogenously.

The public infrastructure in each region is provided by the central government, and is not traded across regions. The central government maximizes welfare by allocating the public infrastructure between regions. In this paper, public investment denotes the product of that public infrastructure. Moreover, if possible, the government utilizes a transfer policy through taxation.

2.1 Model specification

The utility function of individuals in region i U^i is

$$U^i = (z_i x_i)^{\frac{1}{2}} \tag{1}$$

where z_i is the amount of the consumption service good, and x_i is the amount of the manufacture good. The budget constraint of individuals in region i is

$$P_z z_i + P_x x_i = (1 - t_i) w_i$$

where P_z, P_x are the prices of service and manufacture goods. w_i is region i's labor wage, and t_i is the income tax rate.

From the utility maximization behavior of individuals, the demand functions of each good are

$$x_i = \frac{(1-t_i)w_i}{2P_x} \tag{2}$$

$$z_i = \frac{(1-t_i)w_i}{2P_z} \tag{3}$$

The manufacture good is tradable across regions without cost, and I assume that it is produced only in region 2 from the public infrastructure and labor. The production function is as follows:

$$X_i = G_2^{\beta} L_{dm} \tag{4}$$

where G_2 is the public infrastructure supplied in region 2, and L_{dm} is the manufacture's labor input. The manufacture good is provided under perfect competition. The producer of this good maximizes the profit as if the public infrastructure is given. The first-order condition for profit maximization is as follows:

$$P_x G_2^{\beta} = w_2 \tag{5}$$

The service good is produced from intermediate service goods and is tradable across regions, whereas intermediate service goods are not. I assume that intermediate service goods are produced only in region 1. The production function of the service good Z is defined by

$$Z = \left[\int_0^N (z^n)^{\rho} dn\right]^{\frac{1}{\rho}}, \quad 0 < \rho < 1 \tag{6}$$

where z^n is the intermediate service good n , and N is the number of intermediate service goods endogenously determined. ρ is the parameter of substitution. This production function realizes increasing returns through the variety of intermediate service goods N, the effect of which is more powerful when ρ is smaller. Since the service good is produced under perfect competition, the first-order condition for profit maximization is thus

$$p_r = P_z \left[\int_0^N (z^n)^{\rho} dn\right]^{\frac{1}{\rho}-1} (z^r)^{\rho-1} \quad (r \in [0, N_i]) \tag{7}$$

where p_r is the price of the intermediate service good r. From this first order condition, I obtain the demand of the intermediate service good r z^{rd} as

$$z^{rd} = \frac{p_r^{\frac{1}{\rho-1}}}{\left[\int_0^N p_n^{\frac{\rho}{\rho-1}} dn\right]^{\frac{1}{\rho}}} X_i = \frac{p_r^{\frac{1}{\rho-1}}}{B_i^{\frac{1}{\rho-1}}} X_i \tag{8}$$

where

$$B_i = \left[\int_0^N p_n^{\frac{\rho}{\rho-1}} dn\right]^{\frac{\rho-1}{\rho}}$$

is a price index.

Each intermediate service good is produced by one firm using labor and the public infrastructure. The labor requirement for the intermediate service good n is as follows:

$$L_n = \frac{f + bz^{ns}}{G_1^\gamma} \quad (k \in [0, N])$$

where f/G_1^γ is the fixed labor requirement, b/G_1^γ is the marginal labor requirement, and G_1 is the public infrastructure in region 1. z^{ns} is the intermediate service good output. Each firm is under monopolistic competition, knows the demand function (8) , and has monopoly power. Given the price index B_i , the public infrastructure, and the total amount of the service good production Z, each firm maximizes its profit. The first-order condition for profit maximization is

$$p_n = \frac{w_i b}{\rho G_1^\gamma} \tag{9}$$

In the equilibrium, a zero profit condition that holds because of free entry is written as

$$p_n z^{ns} = w_i \frac{f + bz^{ns}}{G_1^\gamma} \tag{10}$$

From these conditions, the intermediate service good output and the required labor input are

$$z^{ns} = \frac{\rho f}{b(1-\rho)} \tag{11}$$

$$L_n = \frac{f}{(1-\rho)G_1^\gamma} \tag{12}$$

Because production technologies are symmetrical in the case of intermediate service goods, (11) and (12) are the same for all firms. Using this condition, I simplify the first order condition for the service good (7) , which is then rewritten as

$$P_z = \frac{p_n}{N^{\frac{1}{\rho}-1}} \tag{13}$$

2.2 Government behavior

The public infrastructure is not tradable across regions. The government provides the public infrastructure in each region meaning public investment. The public infrastructure in region i is produced by labor in that region. The production function is as follows.

$$G_1 = \frac{L_{G1}}{N}, \quad G_2 = L_{G2} \tag{14}$$

where L_{Gi} $(i = 1, 2)$ is the labor input. For the context of region 1's production function, this paper refers to Matsumoto (2000). In region 1, the production function of the public infrastructure includes the congestion cost. The number of intermediate service good firms N represents this congestion effect. The amount of the public infrastructure decreases as N rises. For simplicity, I assume that this congestion effect does not arise in region 2. If this congestion effect arises in region 2, main results remain qualitatively unchanged.

To finance the production of the infrastructure, the government imposes an income tax on each region's workers. When the government is unable to adopt the transfer or redistribution policy, the tax is uniform across regions. This uniform income tax rate is t. The government's budget constraint is

$$w_1 L_{G1} + w_2 L_{G2} = t(w_1 L_1 + w_2 L_2) \tag{15}$$

Next, I consider the case in which the government adopts a transfer or redistribution policy. In this case, I assume that the government applies different income tax rates in each region. The income tax rate in region i is written as t_i . The government's budget constraint is then

$$w_1 L_{G1} + w_2 L_{G2} = t_1 w_1 L_1 + t_2 w_2 L_2 \tag{16}$$

2.3 Equilibrium

Market clearing conditions for both service and manufacture goods are

$$L_1 x_1 + L_2 x_2 = X = G_2^{\beta} L_{dm} \tag{17}$$

$$L_1 z_1 + L_2 z_2 = Z = \left[\int_0^N (z^n)^{\rho} dn \right]^{\frac{1}{\rho}} \tag{18}$$

$$z^{nd} = z^{ns} \ (n \in [0, N]) \tag{19}$$

Considering the symmetry of the service sector, labor market equilibrium conditions are

$$L_1 = NL_n + L_{G1} \tag{20}$$

$$L_2 = L_{dm} + L_{G2} \tag{21}$$

Because individuals are free to migrate across regions, they prefer regions where the utility is higher. In the equilibrium, $(1-t_1)w_1 = (1-t_2)w_2$ holds because of the utility function and the above migration behavior. In the following, I first analyze the case in which the government is unable to adopt the transfer policy. I then analyze the case in which the government can adopt that policy.

First, consider the case where the government is unable to adopt the transfer policy. In the equilibrium, $w_1 = w_2$ then holds because of migration behavior and the uniform tax rate. From the market clearing conditions for service goods, (2) , (3) , (9) , (11) , (13) and $w_1 = w_2$, I obtain the number of intermediate service goods as

$$N = \frac{(1-\rho)G_1^{\gamma}}{f}\frac{(1-t)}{2}\bar{L} \tag{22}$$

From the market clearing conditions, (14) and $\bar{L} = L_1 + L_2$,the equilibrium populations of each region are

$$L_1 = \frac{\bar{L} + NG_1 - G_2}{2} \tag{23}$$

$$L_2 = \frac{\bar{L} - NG_1 + G_2}{2} \tag{24}$$

I derive the indirect utility function of this equilibrium. Substituting (2) , (3) , (9) , (13) , (22) and $w_1 = w_2$ into the utility function (1) , I obtain

$$V^i = (1-t)^{\frac{1}{2}\left(\frac{1}{\rho}+1\right)} G_1^{\frac{\gamma}{2\rho}} G_2^{\frac{\beta}{2}} \left[\left(\frac{1}{2}\right)^{\frac{1}{\rho}+1} \frac{\rho}{b} \left(\bar{L}\frac{1-\rho}{f}\right)^{\frac{1}{\rho}-1}\right]^{\frac{1}{2}} \tag{25}$$

When the government is unable to adopt the transfer policy, the objective function of the government is (25) .

Next, consider the case in which the government can adopt the transfer policy. In that case, $(1-t_1)w_1 = (1-t_2)w_2$ holds because of the migration behavior and different tax rates. Corresponding to the no transfer policy case, I derive the equilibrium numbers of intermediate service goods and populations of each region. The equilibrium number of intermediate service goods is then given by

$$N = \frac{(1-\rho)G_1^{\gamma}}{f}\frac{(1-t_1)}{2}\bar{L} \tag{26}$$

where I substitute the condition $(1-t_1)w_1=(1-t_2)w_2$ for $w_1=w_2$, and the equilibrium populations of each region are

$$L_1 = \frac{1-t_2}{(1-t_1)+(1-t_2)}\left[\frac{1-t_1}{1-t_2}\bar{L}+NG_1-\frac{1-t_1}{1-t_2}G_2\right] \tag{27}$$

$$L_2 = \frac{1-t_2}{(1-t_1)+(1-t_2)}\left[\bar{L}-NG_1+\frac{1-t_1}{1-t_2}G_2\right] \tag{28}$$

Substituting (2) , (3) , (9) , (13) , (26) and $(1-t_1)w_1=(1-t_2)w_2$ into the utility function (1) , the indirect utility function is derived as

$$V^i = (1-t_1)^{\frac{1}{2\rho}}(1-t_2)^{\frac{1}{2}}G_1^{\frac{\gamma}{2\rho}}G_2^{\frac{\beta}{2}}\left[\left(\frac{1}{2}\right)^{\frac{1}{\rho}+1}\frac{\rho}{b}\left(\bar{L}\frac{1-\rho}{f}\right)^{\frac{1}{\rho}-1}\right]^{\frac{1}{2}} \tag{29}$$

The government's objective function is (29) when it can adopt the transfer policy. The next section analyzes the behavior of the government in detail. For analyzing the effect of the transfer policy, I compare the case when the transfer policy is adopted to the case when it is not.

3 Effect of the transfer policy

This section shows the optimal policy. First, I analyze the optimal policy of the public infrastructure allocation in which the government is constrained from choosing the transfer policy through taxation. Next, I examine the case where the government is free to utilize that policy through taxation. To evaluate the effect of the transfer policy on the public infrastructure policy, I compare those two cases.

3.1 Uniform tax case

The objective of the government unable to use the transfer policy through taxation is to maximize the utility function (25) subject to the budget constraint (15) . Substituting $w_1=w_2$ and (22) into the budget constraint (15) , I obtain

$$t\bar{L}=\frac{(1-\rho)G_1^{\gamma+1}(1-t)}{2f}\bar{L}+G_2 \tag{30}$$

The government chooses the public infrastructure G_1, G_2 and the tax rate t in order to maximize the objective function (25) . Solving this maximization problem, I obtain both the optimal public infrastructure and the tax rate

$$G_1 = \left[\frac{2\gamma}{1+\rho(\gamma+1)}\frac{f}{1-\rho}\right]^{\frac{1}{\gamma+1}} \tag{31}$$

$$G_2 = \frac{\beta\rho(\gamma+1)}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma}\bar{L} \tag{32}$$

$$t = \frac{\beta\rho(\gamma+1)+\gamma}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma} \tag{33}$$

(32) shows that when the public infrastructure productivity of the manufacture sector β is greater, the amount of the public infrastructure in a corresponding region should be raised. However, the relationship between the infrastructure productivity of the service sector γ and the amount of the public infrastructure G_1 is not monotonic, nor similar to the case of γ is the relationship between ρ and G_1 .

Substituting these values into equilibrium populations (23) , (24) , the populations in each region are

$$L_1 = \frac{1}{2}\frac{1+\rho(\gamma+1)+2\gamma}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma}\bar{L} \tag{34}$$

$$L_2 = \frac{1}{2}\frac{1+\rho(\gamma+1)+2\beta\rho(\gamma+1)}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma}\bar{L} \tag{35}$$

Comparing these populations, if $\gamma > \beta\rho(\gamma+1)$, the population in region 1 is higher than that in region 2, and vice versa.

3.2 Transfer policy through taxation

I consider the case in which the government can use the transfer policy through taxation. The government maximizes the utility function (29) subject to the budget constraint (16) . In this case, $(1-t_1)w_1 = (1-t_2)w_2$ is formed because of individual migration behavior. Considering (26) , the budget constraint is rewritten as

$$(t_1+t_2)\bar{L} = \frac{(1-\rho)(1-t_1)G_1^{\gamma+1}}{f}\bar{L} + 2G_2 \tag{36}$$

Solving the utility maximization problem, the optimal public infrastructure and the tax rate are derived as

$$G_1 = \left[\gamma\frac{f}{1-\rho}\right]^{\frac{1}{\gamma+1}} \tag{37}$$

$$G_2 = \frac{\beta\rho(\gamma+1)}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma}\bar{L} \tag{38}$$

$$t_1 = \frac{\rho(\gamma+1)-1+\beta\rho(\gamma+1)+\gamma}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma} \tag{39}$$

$$t_2 = \frac{-\rho(\gamma+1)+1+\beta\rho(\gamma+1)+\gamma}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma} \tag{40}$$

From these values, populations in each region are derived as

$$L_1 = \frac{1+\gamma}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma}\bar{L} \tag{41}$$

$$L_2 = \frac{\rho(\gamma+1)+\beta\rho(\gamma+1)}{1+\rho(\gamma+1)+\beta\rho(\gamma+1)+\gamma}\bar{L} \tag{42}$$

In the following, I analyze the effect of the transfer policy through taxation. To analyze that effect, I compare the values of the government policy with those when the government is unable to use the transfer policy.

First, I analyze the public infrastructure . For region 1, by comparing (31) and (37) , it is shown that (31) is equal to (37) if $1 = \rho(\gamma+1)$. When $1 > \rho(\gamma+1)$, (37) is smaller than (31) . In that case, the government that is free to use the transfer policy should diminish the public infrastructure in region 1, conversely, when $1 < \rho(\gamma+1)$, the government should increase the public infrastructure in region 1. In region 2, (32) and (38) show that the government should choose the same amount of the public infrastructure regardless of its transfer policy.

Next, I consider the tax rate. From (33) , (39) and (40) , when $1 = \rho(\gamma+1)$, the tax rate is equal across regions and is also equal when the government is unable to use the transfer policy. If $1 > \rho(\gamma+1)$, the tax rate in region 1 is lower than that in region 2. This implies that individuals in region 1 receive the income transfer financed by the additional tax in region 2. Conversely, if $1 < \rho(\gamma+1)$, the tax rate in region 1 is higher than that in region 2.

These government policies affect the populations of each region. When $1 = \rho(\gamma+1)$, (34) , (35) , (41) and (42) reveal that the populations of each region are unchanged regardless of the government policy. When $1 > \rho(\gamma+1)$, individuals concentrate more in region 1 in contrast to the case in which the government is constrained from using the transfer policy. When $1 < \rho(\gamma+1)$, individuals concentrate more in region 2.

From these results, I obtain the following proposition.

Proposition

Suppose that the government can adopt different income tax rates in each region.

(i) If $1 < \rho(\gamma+1)$, the government should increase the amount of the public infrastructure and raise the income tax rate in region 1, whereas it should maintain the current amount and cut the tax rate in region 2, in contrast to the case where it is unable to adopt different tax rates.

(ii) If $1 > \rho(\gamma + 1)$, the government should decrease the amount of the public infrastructure and cut the tax rate in region 1, whereas it should leave the amount unchanged and raise the tax rate in region 2, in contrast to the situation where adopting different income tax rates is not possible.

The proposition shows that the optimal policy depends on ρ and γ .

γ is the public infrastructure productivity of the intermediate service sector. If this parameter rises, it is expected that the optimal policy would consist of increasing the infrastructure and raising the tax rate in region 1. In this case, the increasing returns of the service sector would cease, since region 1 has a smaller population relative to the number of intermediate service goods. On the other hand, it is possible that region 1 would receive more infrastructure by using its tax revenue. That infrastructure would yield more benefits because of the higher γ . Moreover, it is possible to reduce the income tax rate in region 2 by using the tax revenue in region 1. As a result, in the optimal policy in which γ is larger, it is likely that region 1 would receive more public infrastructure by using the additional tax burden, while region 2 could receive the transfer by using that tax revenue in region 1.

ρ is related to the degree of increasing returns in the service sector, so that if ρ falls, the level of increasing returns is higher. In this case, it is expected that the optimal policy would consist of decreasing the infrastructure and cutting the tax rate in region 1. When this policy is adopted, decreasing the infrastructure results in a loss because the productivity of the intermediate service sector declines. Cutting the tax rate in region 1 and raising it in region 2, however, would yield more benefit, since more individuals are concentrated in region 1, allowing the increasing returns of the service sector to rise. The degree of this benefit outweighs the loss because of the smaller ρ . Therefore, in the optimal policy when ρ is smaller , it is likely that region 1 would receive the transfer instead of the public infrastructure financed by the additional tax in region 2. In that policy, the government should use the transfer policy to control the distribution of the population rather than to reduce regional inequality because individuals could migrate between regions. Ottaviano and Thisse (2002) have reported that regional policy is required to control undesired regional agglomeration when it threatens to arise. In this paper's model, the government should use the transfer policy to control regional agglomeration.

4 Conclusion

The allocation of public investment in the region affects not only regional productivity but also regional inequality. However, taxation or transfer can serve as the political instruments to resolve such inequality. This paper has examined the optimal allocation of public investment across two regions when the government is able to use the transfer policy through taxation. In that model, one region has the technology of increasing returns to scale, while the other region does not. Moreover, individuals can migrate across regions without cost.

The optimal allocation of public investment depends on the degree of increasing returns and the public investment productivity in the regions that enjoy the increasing returns. When the degree of increasing returns is higher and the productivity of public investment is lower, the government should decrease the public investment in that region, and should instead ensure that individuals of that region would receive the transfer. The government should use that transfer to concentrate individuals in the region so as to utilize the technology of increasing returns. In that situation, the transfer policy is not utilized to redistribute income. This policy should be used to control economic agglomeration.

When the degree of increasing returns is lower and the productivity of public investment is higher, the government should increase the public investment and raise the tax rate in the region that enjoys the increasing returns. In this case, the increasing returns of the service sector decline because of a lower population in that region. However, the additional infrastructure in that region yields more benefits that can be used to cut the income tax rate in region 2. In this situation, the government should use more public investment to improve the welfare.

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