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Transport costs, capital mobility and the provision of local public goods

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Abstract

Using a new economic geography model with local governments, this study analyzes the relation between transport costs, capital mobility and the provision of local public goods that improve regional productivity. First, if capital is immobile, the effect of local public goods on regional competitiveness engenders over-provision of local public goods, whereas the interregional spillover engenders under-provision of local public goods. As transport costs fall, the latter effect becomes stronger than the former; consequently, the provision status of local public goods changes from under-provision to over-provision. Secondly, if capital is mobile, capital flows to regions with a larger market (higher productivity) when transport costs are high (low). Such capital mobility changes the local public policy from under-provision to over-provision as transport costs fall.

JEL classification: H70; H41; R12; R50
Keywords: Local governments; Interregional spillover; New economic geography

1. Introduction

In recent years, the Japanese public sector has been criticized for over-provision of local public goods. Why has the problem of over-investment appeared now? In the contemporary global economy with interregional and international economic integration, the situation surrounding regional economies has changed greatly: transportation costs have decreased, and production factors and goods have become very mobile. Does such an environmental change explain the problem of local public policies?

The relation between factor mobility and a regional policy of providing local public goods has remained a salient issue of public economics and regional economics. Studies of this issue are classifiable into the following two streams. The first current of the literature addresses tax competition. As surveyed comprehensively in Wilson (1999), the taxation of mobile factors engenders under-provision of public goods because higher taxation drives factors out of other countries (regions). In addition, Keen and Marchand (1997) indicate that public goods for production can be over-provided. Secondly, since Tiebout (1956) focused attention on the efficiency of provision of public goods with interregional mobile factors, numerous studies have examined factor mobility. For instance, Wellisch (1994)

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demonstrates that competition between decentralized regional governments makes the provision of public goods efficient (inefficient) if households are (not) perfectly mobile. Recently, Brueckner (2004) discusses the trade-off between Tiebout's efficiency and tax competition's inefficiency. That study unites the two streams.

Although various studies have used multi-regional models that include mobile factors and goods, they have only inadequately treated the "spatial" matter. Those studies have not explicitly considered transport costs, which define space and distance. The effects of transport costs on local public policy are divisible into the following two types. First, in the context of local public policy, transport costs influence the economic independence of regions and thereby determine the interregional spillover of local public goods, which affects local governments' policies. Secondly, transport costs affect the location of economic activities, as discussed especially in the so-called new economic geography. That is, when transport costs are sufficiently high, economic activities become distributed among regions to reduce the transport cost burden; when transport costs are sufficiently low, they concentrate in some regions to derive benefits from agglomeration economies (see e.g., Fujita et al., 1999; Brakman et al., 2001). Such factor movement imparts structural changes to regional economies (e.g., the formation of cities and rural areas); it also affects local public policies. It is our intention to consider the effects of the decline of transport costs (i.e. the globalization) on the behavior of decentralized regional governments as well as the factor movement, using the framework of the new economic geography.

This paper also relates to the following studies, which discuss the effect of local public policies on the interregional and international location of economic activities. In the context of the new economic geography, Martin and Rogers (1995) examine the effect of local public goods (transport infrastructure) on the international location of firms. They did so within the framework of the improved coreperiphery model originating from Krugman (1991). Then, using a similar model, Andersen and Forslid (2003) study interregional tax competition and equilibrium provision of local public goods. These studies were reviewed systematically in Baldwin et al. (2003), along with related papers. On the other hand, some studies of local public goods and agglomeration have been undertaken outside of the field of the new economic geography. For instance, Maurer and Waltz (2000) discuss the location choice of two mobile oligopolistic firms and the provision of local public infrastructure. Justman et al. (2002) investigate the relation between local infrastructure quality and firms' location patterns. Moreover, in the field of international trade, Bougheas et al. (1999) consider the relation between the provision of transport infrastructure and trade patterns.

In addition, it is noteworthy that local public goods are classifiable into various types: amenities, economic and industrial facilities, transport infrastructure, national defense, and so on. The effects of public goods are different. Therefore, we should notice the type that we emphasize. For instance, Keen and Marchand (1997) describe that local public goods for production are typically over-provided, whereas those for consumers are under-provided. Furthermore, within the category of production, industrial facilities improve industrial productivity, and transport infrastructure improves transport costs. Martin and Rogers (1995) show that the provision of transport infrastructure that improves international transport costs has a negative effect on the country in which the infrastructure is located.

The analysis presented in this paper specifically relates to one type that has been discussed at length in the empirical fields on local public sectors: industrial facilities that improve manufacturing productivity in home regions. Aschauer (1989) investigates the effect of public goods (public infrastructure) upon private manufacturing. Numerous empirical studies have addressed the effect of public infrastructure on the respective productivity levels of manufacturing and non-manufacturing sectors. Laying the groundwork, Holtz-Eakin and Lovely (1996) review past studies and examine the effect of local public infrastructure in a general equilibrium model. In their model, public infrastructure offers "direct, cost-saving effects on the manufacturing sector of the economy." They offered that empirical results are somewhat ambiguous, but are consistent with theoretical results. Using a similar framework, Anwar (2001) elucidates the manner in which public infrastructure affects trade patterns. Combining their ideas and the new economic geography, we can advance theoretical studies of the provision of manufacturing infrastructure.

The remainder of this paper is organized as follows. A basic two-region model with a local public sector is presented in Section 2. In Section 3, we analyze the respective behaviors of regional governments, which pursue Nash strategies in providing local public goods, and discuss the effects of factor (capital) mobility on local public policy. Finally, Section 4 concludes this paper.

2. A two-region model with local public sectors

This model is a variant of those of Krugman (1991) and Baldwin et al. (2003). The economy comprises two regions, $r=1, 2$, which are endowed with capital, K_r, and labor, L_r.

The utility of each consumer residing in region r is given as

$$U_r = \left(C_r^M\right)^{\mu}\left(C_r^T\right)^{1-\mu}/\mu^{\mu}(1-\mu)^{1-\mu}, \tag{1}$$

where C_r^M is the consumption index of differentiated manufactured goods, C_r^T is the consumption of a homogeneous traditional good, and μ is the expenditure share of the manufactured goods. The consumption index is represented as

$$C_r^M = \left(\int_0^{n_r} m_{rr}(i)^{\rho}\mathrm{d}i + \int_0^{n_s} m_{sr}(i)^{\rho}\mathrm{d}i\right)^{1/\rho}, \tag{2}$$

where n_r is the number of varieties (or number of firms) in region r, $m_{sr}(i)$ is the consumption in region r of each variety i produced in region s, and ρ is the parameter of substitution between any two varieties. The elasticity of substitution is expressed as $\sigma \equiv 1/(1-\rho)$.

A typical consumer maximizes (1) subject to the budget constraint:

$$E_r = p_r^T C_r^T + \int_0^{n_r} p_{rr}(i)m_{rr}(i)\mathrm{d}i + \int_0^{n_s} p_{sr}(i)m_{sr}(i)\mathrm{d}i, \tag{3}$$

where E_r is (disposable) income, and p_r^T and $p_{sr}(i)$ respectively represent the prices in region r of the traditional good and each manufactured good produced in region s.

Here we assume that manufactured goods incur transport costs in interregional shipment, in the so-called "iceberg" form. That is, to send one unit of manufactured goods from the home region to the other region, $t(>1)$ units must be shipped. Letting p_r be the dispatched price, the delivered price is given as

$$p_{rs}(i) = p_r(i)t, \tag{4}$$

and $p_{rr}(i)=p_r(i)$. Traditional goods, in contrast, incur no transport costs: $p_r^T=p^T$.

Therefore, utility maximization yields the demand functions for the traditional good and for each variety of the manufactured good:

$$C_r^T = (1-\mu)E_r/p^T, \tag{5}$$

$$q_r(i) = \mu\left[E_r P_r^{\sigma-1}p_r(i)^{-\sigma} + E_s t P_s^{\sigma-1}(p_r(i)t)^{-\sigma}\right], \tag{6}$$

where

$$P_r = \left[\int_0^{n_r} p_r(i)^{1-\sigma}\mathrm{d}i + \int_0^{n_s} (p_s(i)t)^{1-\sigma}\mathrm{d}i\right]^{1/(1-\sigma)}. \tag{7}$$

The total indirect utility in each region is expressed as

$$V_r = E_r(P_r)^{-\mu}\left(p^T\right)^{-(1-\mu)}. \tag{8}$$

Two private production sectors exist. First, in the traditional sector, the traditional good is produced under perfect competition and with constant-returns technology using labor. Specifically, we assume that one unit of labor produces one unit of the traditional good $T_r=L_r$, where T_r is the amount of the traditional good produced in region r and L_r is the amount of labor in the traditional sector. This good is assumed to be freely traded. Therefore, we choose this good as numeraire: $P^T=w=1$, where w represents the wage earned by laborers.

Secondly, the manufacturing sector operates under Dixit–Stiglitz monopolistic competition; it produces differentiated goods with increasing-returns technology using both capital and labor. Following Baldwin et al. (2003), we assume that producing each differentiated good requires a fixed amount of capital, F_r, and a marginal input of labor, c. Each firm's cost function is expressed as

$$F_r\pi_r + cq_r(i), \tag{9}$$

where π_r is the reward to capital.[1] A profit maximizing firm sets the price as

$$p_r = \frac{\sigma c}{\sigma - 1}, \tag{10}$$

and the zero-profit condition yields the reward to capital,

$$\pi_r = \frac{c q_r}{(\sigma - 1) F_r}. \tag{11}$$

Next, we turn to a description of the local public sector. Each region has a local government, which provides local public goods: L_r^G. Following Holtz-Eakin and Lovely (1996) and Anwar (2001), we specifically address local public goods' improvement of the manufacturing sector productivity in the region concerned. In this paper, we assume that local public goods reduce the fixed requirement of capital in each region[2]:

$$F_r = (f + G_r)^{-1}. \tag{12}$$

Parameter f implies the effectiveness of local public goods in improving productivity. That is, if f is small, the provision of local public goods reduces the fixed requirement effectively. Thereby, productivity is markedly improved. In contrast, providing local public goods does not improve the productivity greatly if f is large.

The cost of the local public sector in each region is financed by an income tax paid by residents.[3] Therefore, we express the budget constraint of each regional government as

$$\tau_r Y_r = L_r^G, \tag{13}$$

where τ_r is the tax rate, Y_r is the regional total income, and L_r^G is the employment of labor in the local public sector. Assuming that one unit of labor produces one unit of local public goods, we express $L_r^G = G_r$. In addition, the total disposable income of each region is expressed as

$$E_r = (1 - \tau_r) Y_r. \tag{14}$$

Each regional government determines the amount of local public goods to maximize the regional welfare. Letting V_r be the indirect utility of labor, the objective of each regional government is expressed as

$$\max_{G_r} L_r V_r. \tag{15}$$

Here we assume that capital is owned equally by all laborers. Therefore, the total regional income is defined as

$$Y_r = \left(\frac{\pi_1 K_1 + \pi_2 K_2}{L1 + L2} + 1 \right) L_r. \tag{16}$$

The factor market clearing conditions are expressed as

$$K_r = n_r F_r, \tag{17}$$

$$L_r = L_r^T + n_r c q_r + L_r^G. \tag{18}$$

Now we rewrite the capital distribution as follows, for analytical simplicity:

$$K_1 = \theta K; \quad K_2 = (1 - \theta) K, \tag{19}$$

1 The wage of labor is unity as long as the traditional goods production is positive in each region: $L_r^T > 0$. We specifically analyze the case holding the so-called non-full-specialization condition. For details, see Baldwin et al. (2003).

2 In Holtz-Eakin and Lovely (1996) and Anwar (2001), local public goods affect both the fixed and marginal requirements. Such an alteration would not change the main results described in this paper if we were to alter the assumption of the effect of local public goods and consider that local public goods reduce both the fixed capital input and marginal labor input in this model.

3 As discussed in the studies of tax competition, the taxation method has an important effect on public policies (see e.g. Hindriks, 1999). Further explanation of this issue will be presented in the next section.

where θ is the share of capital locating in region 1. Regarding the location of capital, we consider the following two cases: (i) interregionally immobile capital and (ii) mobile capital. In the latter case, capital movement is expressed as

$$\dot{\theta} = \delta(\pi_1 - \pi_2)\theta(1 - \theta). \tag{20}$$

That is, capital moves to a region that offers a higher reward. On the other hand, labor is assumed to be immobile among regions.

Finally, for analytical simplicity, we introduce an index of the openness of the economy, $\phi = t^{-(\sigma-1)} = (0, 1)$, which is decreasing in t. In addition, we choose units such that $c = (\sigma - 1)/\sigma$, $K = 1$, and $L_1 = L_2 = 1$.

3. Provision of local public goods

The two regional governments play a Nash game in the provision of local public goods. We analyze two cases of capital mobility.

3.1. The case with immobile capital

First, we consider the case of immobile capital. The system is complicated. We first analyze the case in which capital is distributed equally between the two regions (for details related to the following analyzes, see Appendix A). With a symmetric capital distribution, local governments' response functions, $\partial V_1/\partial G_1|_{\theta=1/2} = 0$, and $\partial V_2/\partial G_2|_{\theta=1/2} = 0$, yield the following amount of local public goods in equilibrium:

$$G_1^* = G_2^* = \max\left\{\frac{2\mu\sigma - (1+\phi)(\sigma-1)(2\sigma-\mu)f}{2\mu\sigma + (1+\phi)(\sigma-1)(2\sigma-\mu)}, 0\right\}, \tag{21}$$

which is positive when

$$f < \frac{2\mu\sigma}{(1+\phi)(\sigma-1)(2\sigma-\mu)}. \tag{22}$$

That is, when local public goods sufficiently enhance manufacturing productivity, the governments provide local public goods. Additionally, note that the provision in equilibrium is increasing in μ:

$$\frac{\partial G_r^*}{\partial \mu} = \frac{4\sigma^2(1+\phi)(\sigma-1)(1+f)}{[2\mu\sigma + (1+\phi)(\sigma-1)(2\sigma-\mu)]^2} > 0. \tag{23}$$

That is, the increase in the share of manufactured goods increases the effect of local public goods on consumption.

In Fig. 1, the solid line shows (21) as a function of ϕ. This figure shows that the provision of local public goods is decreasing in the openness.

To further clarify the equilibrium efficiency, let us consider the optimal values of G_1 and G_2 maximizing the social welfare, $V_1 + V_2$. Consequently, we obtain the social optimum:

$$G_1^{**} = G_2^{**} = \max\left\{\frac{\mu - f(\sigma-1)}{\sigma - 1 + \mu}, 0\right\}, \tag{24}$$

which is positive if

$$f < \mu/(\sigma - 1), \tag{25}$$

and which is increasing in μ:

$$\frac{\partial G_r^{**}}{\partial \mu} = \frac{(\sigma-1)(1+f)}{(\sigma-1+\mu)^2} > 0. \tag{26}$$

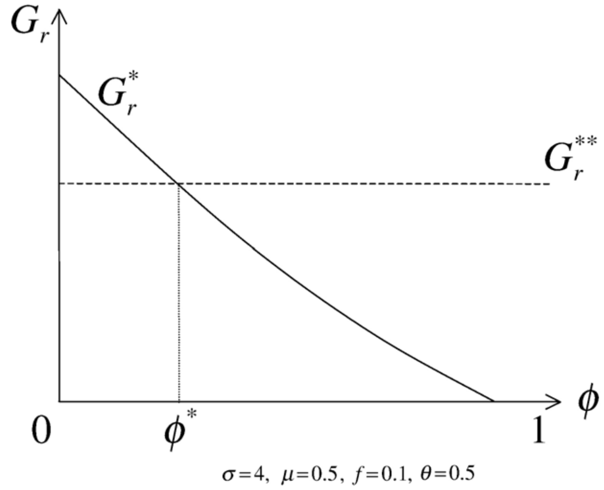

Fig. 1. Provision of local public goods in the case with immobile capital.

The broken line in Fig. 1 shows the social optimum. Comparing the equilibrium provision and the optimal provision, we can see that $G_r^* > G_r^{**}$ when

$$0<\phi<\phi^* = \frac{\mu}{2\sigma - \mu}. \tag{27}$$

Otherwise, the relation is reversed. Hence, we have

Proposition 1. *Assuming that capital is distributed equally between the two regions, when the two regions are sufficiently closed (opened), specifically when $\phi<(>)\phi^*$, regional governments over-provide (under-provide) local public goods.*

That is, with the increased interregional openness, local public policy moves from over-provision to under-provision of local public goods.

The reason is as follows. Effects on regional welfare of providing local public goods are classifiable into two. First, local public goods improve the productivity of manufacturing firms in the home region. Thereby, the firms can take markets from the other region's firms in competition. Consequently, the reward to capital increases. Each regional government therefore has an incentive to provide more local public goods than the other government does, so that the competition between the two governments leads them to over-provide local public goods. Secondly, productivity improvement increases the number of varieties; then it decreases the price index. An important point is that the decline of the price index has an interregional spillover effect. Manufactured goods are consumed not only in the home region, but also in the other region. For that reason, the increase in the number of varieties decreases the other region's price index as well as that of the home region. That is, the effects of local public goods spill over into the other region through the trade of manufactured goods. The spillover increases concomitant with increased interregional openness. However, regional governments do not consider those spillover effects. For that reason, if they pursue Nash strategies, governments will under-provide local public goods. Consequently, as the two regions become sufficiently open, the second effect becomes greater than the first, and local public goods are under-provided.

Now considering an exogenous marginal change in θ from the symmetric distribution, we have

$$\left.\frac{dG_1^*}{d\theta}\right|_{\theta=1/2} = -\left.\frac{dG_2^*}{d\theta}\right|_{\theta=1/2} > 0. \tag{28}$$

That is, a slight increase (decrease) in the share of capital induces the regional government to increase (decrease) the provision of local public goods because the effect of local public goods is greater in a region with a larger manufacturing sector. Therefore, the inflow of capital increases the level of provision of local public goods.

3.2. The case with mobile capital

Consider next that capital is mobile between the two regions. In this case, capital moves to a region with a higher reward, taking the provision of local public goods as given, and local governments, taking into account the effect on capital movement, decide the provision policy. For details of the following analyzes, see Appendix B.

3.2.1. Capital distribution

Before considering government behavior, we derive the capital distribution by equalizing the rewards to capital in two regions. First, when the two local governments provide equal amounts of local public goods, a symmetric capital distribution is obtained. Therefore, we have $\theta^*=1/2$ for the case of $G_1=G_2$.

Then, when a local government changes the amount of local public goods, how does the capital distribution change? The following equation shows the effect of a marginal increase in the provision of local public goods in a region on the capital distribution:

$$\left.\frac{\mathrm{d}\theta^*}{\mathrm{d}G_1}\right|_{G_2=G_1}=-\left.\frac{\mathrm{d}\theta^*}{\mathrm{d}G_2}\right|_{G_2=G_1}=\frac{\phi^2(\sigma-\mu)(f+G_1)+4\sigma(1-G_1)\phi-(\sigma-\mu)(f+G_1)}{4(1-\phi)^2(f+G_1)(1-G_1)\sigma}, \tag{29}$$

which is positive when

$$\phi>\frac{-2\sigma(1-G_1)+\sqrt{4\sigma^2(1-G_1)^2+(\sigma-\mu)^2(f+G_1)^2}}{(\sigma-\mu)(f+G_1)}. \tag{30}$$

That is, the increase (decrease) in local public goods attracts capital when the two regions are sufficiently opened (closed). The reason can be explained as follows: When transport costs are sufficiently high (i.e., when the regions are closed), regional markets are highly segmented. Consequently, capital moves to the region with a larger market, which has lower taxation. On the other hand, when transport costs are sufficiently low (i.e., when the regions are open), regional markets are highly integrated, and capital moves to the region that has higher productivity.

3.2.2. Provision of local public goods

Taking into account the effect of local public policy on the capital distribution, each government chooses an amount of local public goods that maximizes regional welfare. For systemic symmetry, the amounts of local public goods in the two regions might be identical in equilibrium; thereby, the response functions of the local governments are

$$\left.\frac{\mathrm{d}V_1}{\mathrm{d}G_1}\right|_{G_2=G_1}=\frac{\partial V_1}{\partial G_1}+\frac{\partial V_1}{\partial\theta}\frac{\mathrm{d}\theta}{\mathrm{d}G_1}=0, \tag{31}$$

$$\left.\frac{\mathrm{d}V_2}{\mathrm{d}G_2}\right|_{G_2=G_1}=\frac{\partial V_2}{\partial G_2}+\frac{\partial V_2}{\partial\theta}\frac{\mathrm{d}\theta}{\mathrm{d}G_2}=0. \tag{32}$$

The first terms in the two equations are in the same form as the response functions in the case with immobile capital; the second terms imply the effects of capital movement, where $\partial V_1/\partial\theta=-\partial V_2/\partial\theta>0$ and $\mathrm{d}\theta/\mathrm{d}G_1=-\mathrm{d}\theta/\mathrm{d}G_2$ is given by (29). The explicit form of the function is shown in Appendix B. The two response functions yield the following amounts of local public goods in equilibrium:

$$G_1^*=G_2^*=\max\left\{\frac{2\mu\sigma-f[2\sigma(\sigma-1)+\mu(1-\mu)](1-\phi)}{2\mu\sigma+[2\sigma(\sigma-1)+\mu(1-\mu)](1-\phi)},0\right\}. \tag{33}$$

With the comparison of the socially optimal provision given as

$$G_1^{**}=G_2^{**}=\max\left\{\frac{\mu-f(\sigma-1)}{\sigma-1+\mu},0\right\}, \tag{34}$$

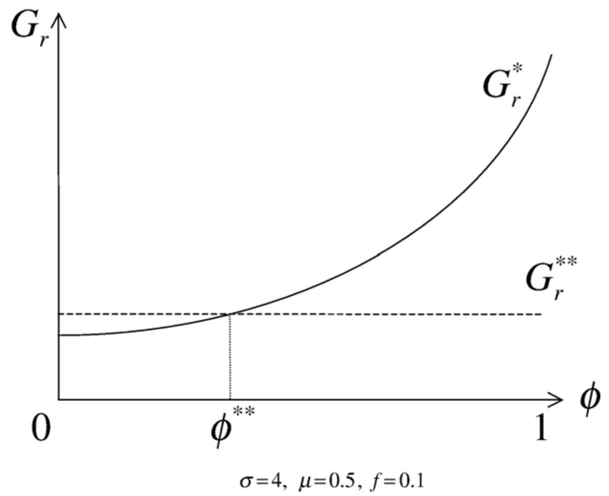

Fig. 2. Provision of local public goods in the case with mobile capital.

we can see that $G_r^* > G_r^{**}$ when

$$\phi > \phi^{**} = \frac{\mu(1-\mu)}{2\sigma(\sigma-1)+\mu(1-\mu)}. \tag{35}$$

Fig. 2 shows the equilibrium provision (the solid line) and the social optimum (the broken line). Consequently, we have

Proposition 2. *Assume that capital is mobile between regions and that local governments take into account the effect of local public policies on capital movement. When the two regions are sufficiently closed (opened), specifically when $\phi<(>)\phi^{**}$, regional governments under-provide (over-provide) local public goods.*

This result is contrary to Proposition 1: Each local government knows that when the regions are sufficiently opened, the increase in the provision of local public goods calls a larger amount of capital into the home region; that capital inflow improves the regional welfare. Therefore, local governments compete for capital inflow and local public goods are over-provided. When the regions are closed to a sufficient degree, however, capital moves to a region with a larger market. Therefore, each local government hesitates to impose taxes for the maintenance of a larger disposable income. As a consequence of political competition, local public goods are under-provided.

Finally it is noteworthy that, as discussed in Hindriks (1999), the method of financing the local public sector has a crucial effect on the results. In this model, we assumed that an income tax is imposed on residents. Instead, if the governments impose taxes on labor and mobile capital (or firms), capital, in avoidance of the tax, will flow into a region with a lower tax. Such a capital movement would reduce the incentive of local governments to provide local public goods.

4. Concluding remarks

Within the context of the new economic geography, we constructed a two-region model in which regional governments play a Nash game in the provision of local public goods. In addition, we discussed how the pattern of the provision changes according to a decline of transport costs and according to a difference in capital mobility.

The results can be summarized as follows: (i) in the case with immobile capital, a decrease in transport costs changes the provision of local public goods from over-provision to under-provision; (ii) in the case with mobile capital, a decrease in transport costs changes the provision of local public from under-provision to over-provision.

Case (i) occurs because the provision of local public goods raises the rewards to capital, and it increases regional income. Therefore, the political competition between local governments raises the amount of local public goods. However, a decline in transport costs increases the spillover effect of local public goods through interregional trade; local governments cut spending for local public goods.

Case (ii) occurs because, regarding the capital distribution, capital flows to a region with a larger disposable income (i.e. with a larger market size) when transport costs are high, and to a region with a higher productivity when transport costs are low. Local governments consider that capital inflow improves the regional welfare. For that reason, they are reluctant to impose a tax for local public goods when transport costs are high, and provide excessive local public goods when transport costs become low. The argument for over-provision is similar to that discussed by Keen and Marchand (1997), who study the provision of local public goods for consumers and for production in a broadly familiar model of tax competition.

Finally, are these results consistent with current trends in local public policies in Japan? One explanation for those tendencies follows case (ii), with high factor mobility and a decrease in transportation costs resulting from the progress of transport technology, along with political decentralization. It is noteworthy that the pattern of local public policies changes along with the level of transport costs and interregional factor mobility.

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Appendix A

In this appendix, we derive the equilibrium provision of local public goods for the case of fixed capital distribution. Manipulating the equations in Section 2, the system is expressed as

$$\max_{G_1} V_1 = E1/P_1^{\mu}, \tag{36}$$

$$\max_{G_2} V_2 = E2/P_2^{\mu}, \tag{37}$$

where

$$E_1 = \frac{\pi_1\theta + \pi_2(1-\theta)}{2} + 1 - G_1, \tag{38}$$

$$E_2 = \frac{\pi_1\theta + \pi_2(1-\theta)}{2} + 1 - G_2, \tag{39}$$

$$P_1 = [(f+G_1)\theta + (f+G_2)(1-\theta)\phi]^{1/(1-\theta)}, \tag{40}$$

$$P_2 = [(f+G_1)\theta\phi + (f+G_2)(1-\theta)]^{1/(1-\theta)}. \tag{41}$$

The rewards to capital are derived using the following equations[4]:

$$\pi_1 = \frac{\mu(f+G_1)}{\sigma}\left(E_1P_1^{\sigma-1} + E_2P_2^{\sigma-1}\phi\right), \tag{42}$$

$$\pi_2 = \frac{\mu(f+G_2)}{\sigma}\left(E_1P_1^{\sigma-1}\phi + E_2P_2^{\sigma-1}\right). \tag{43}$$

The response functions are given as $\partial V_1/\partial G_1=0$ and $\partial V_2/\partial G_2=0$ when the two regional governments solving (36) and (37) play a Nash game. The equilibrium provision of local public goods is obtained by solving the two equations. However, because this system is too complicated to analyze the behavior of the regional governments generally, we specifically address the symmetric case, $\theta=1/2$ and grasp the feature of local public policy.

[4] For details of its derivation, see Fujita et al. (1999) or Baldwin et al. (2003).

For $\theta=1/2$, the two regional governments provide the same amount of local public goods in equilibrium because of systemic symmetry. Therefore, the response function of each local government is given as

$$\left.\frac{\partial V_r}{\partial G_r}\right|_{\theta=1/2,G_2=G_1=G_r}=\frac{[(1+\phi)(f+G_r)/2]^{\mu/(\sigma-1)}}{2(\sigma-\mu)(\sigma-1)(1+\phi)(f+G_r)} \times\{2\mu\sigma-(1+\phi)(\sigma-1)(2\sigma-\mu)f-[2\sigma\mu+(1+\phi)(\sigma-1)(2\sigma-\mu)]G_r\}, \quad (44)$$

and the equilibrium provision of local public goods is given as (21).

Next, we analyze the effect of an exogenous marginal change in θ on equilibrium provision, G_r^*. Totally differentiating the best response functions, $\partial V_1/\partial G_1=0$ and $\partial V_2/\partial G_2=0$, substituting $\theta=1/2$ and (21) into them, and finally solving them for $dG_1/d\theta$ and $dG_2/d\theta$, we have

$$\left.\frac{dG_1}{d\theta}\right|_{\theta=1/2,G_2=G_1=G_r^*}=-\left.\frac{dG_2}{d\theta}\right|_{\theta=1/2,G_2=G_1=G_r^*}=\frac{8(1+f)(\sigma-1)(2\sigma-\mu)\sigma\mu\phi}{(\sigma-1)(2\sigma-\mu)(1-\phi)+2\mu(\sigma-\mu)} \times\frac{1}{(1+\phi)(\sigma-1)(2\sigma-\mu)+2\mu\sigma}>0. \quad (45)$$

That is, a marginal increase in θ raises the equilibrium provision of local public goods in region 1.

Appendix B

This appendix describes political competition in the case of interregionally mobile capital. First, taking G_1 and G_2 as given, solving $\pi_1=\pi_2$ for θ yields the capital distribution:

$$\theta^*=\frac{f+G_2}{2\sigma(2-G_1-G_2)[f+G_1-(f+G_2)\phi][(f+G_1)\phi-(f+G_2)]} \times\{(G_1-G_2)\left[(f+G_1)\{2[\sigma\phi(2-\phi)]-\mu(1-\phi^2)\}-2\sigma\phi(2+f-G_2)\right] -2\sigma(1-\phi)^2(1-G_1)(f+G_1)\}. \quad (46)$$

We examine the case of $G_1=G_2$ and yield $\theta^*=1/2$ and (29) to elucidate the feature of the function.

Then, the response functions are derived from the total differentiation of V_r:

$$\left.\frac{dV_1}{dG_1}\right|_{G_2=G_1}=\frac{\partial V_1}{\partial G_1}+\frac{\partial V_1}{\partial\theta}\frac{d\theta}{dG_1}=0, \quad (47)$$

$$\left.\frac{dV_2}{dG_2}\right|_{G_2=G_1}=\frac{\partial V_2}{\partial G_2}+\frac{\partial V_2}{\partial\theta}\frac{d\theta}{dG_2}=0, \quad (48)$$

where the first terms are given as (44); also, $d\theta/dG_1$ and $d\theta/dG_2$ are given as (29), and

$$\frac{\partial V_1}{\partial\theta}=-\frac{\partial V_2}{\partial\theta}=\frac{2(1-\phi)\sigma\mu(1-G_1)}{(1+\phi)(\sigma-1)(\sigma-\mu)[(1+\phi)(f+G_1)/2]^{-\mu/(\sigma-1)}}>0. \quad (49)$$

Rewriting the response functions, (47) and (48), as

$$\left.\frac{dV_1}{dG_1}\right|_{G_2=G_1}=\left.\frac{dV_2}{dG_2}\right|_{G_2=G_1}=[2(f+G_1)(1-\phi)(\sigma-1)(\sigma-\mu)]^{-1}[(1+\phi)(f+G_1)/2]^{\mu/(\sigma-1)} \times(2\sigma\mu-f[2\sigma(\sigma-1)+\mu(1-\mu)](1-\sigma) -\{2\mu\sigma+[2\sigma(\sigma-1)+\mu(1-\mu)](1-\phi)\}G_1)=0, \quad (50)$$

we have the provision of local public goods as described in (33).

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