Chukyo University Institute of Economics

Discussion Paper Series

July 2020

No. 2002

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Akiyoshi Furukawa

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Akiyoshi Furukawa *

Abstract

This paper investigates optimal and equilibrium population distributions in regions with two districts where all resident individuals migrate freely. In each district, local public goods with positive spillover effects are provided. This paper analyzes whether agglomeration arises when regional population decreases. It also examines the effects of national transfers to local governments on the population distribution.

This paper shows that a reduction in the regional population causes population agglomeration and the diminishment of some districts, although maintaining two districts remains optimal. Earmarked transfers of local public goods maintain the two districts in equilibrium, although the lump-sum transfers do not.

JEL classification: R23, R51, H41, H71

Keywords: regional population; local public good; external effect; national transfers

*School of Economics, Chukyo University 101-2 Yagoto Honmachi, Showa-ku, Nagoya, 466-8666, Japan Tel.: +81-52-835-7111 Fax: +81-52-835-7197 e-mail:ecockawa@mecl.chukyo-u.ac.jp

1 Introduction

In recent years, the number of municipalities decreased due to the consolidation of small municipalities. Consolidation is being promoted in developed countries to take advantage of economies of scale in information and transportation technology. Countries experiencing a declining birthrate and an aging population promote this consolidation to maintain communities as they experience population shrinkage. Avellaneda and Gomes (2014) showed how consolidation is being promoted in developed countries. Moreover, migration behavior is fostering population shrinkage in small municipalities.

However, not all small municipalities are vanishing as a result of consolidation. Because small municipalities are often not compelled to consolidate from outside, some do not do so and remain independent. Nakagawa (2016) indicated that the large scale of municipal mergers in Japan during recent years had little impact on many small municipalities. Weese (2008, 2013) found that the optimal number of municipalities in Japan is less than the current number. That is, some small municipalities persist in the face of a sub-optimal distribution of entities.

In urban and regional economies, the equilibrium sizes of municipalities are determined through a balance of increasing and decreasing returns. For example, Behrens, Kanemoto, and Murata (2015) presented an application of the Henry-George theorem in a second-best world. However, when the differences in production and increasing returns are strong, the population agglomerates in some municipalities while others diminish. A local government may promote that agglomeration through the provision of local public goods. Roos (2004) reported certain effects of local public goods. As the population decreases, the agglomeration economies remain strong in spite of decreasing returns. That is, smaller municipalities cannot survive in equilibrium. This paper investigates the question of the survival of small municipalities in equilibrium.

This paper analyzes optimal and equilibirum distribution of population in a region with two districts where all individuals can migrate freely. In these districts there is a difference in production and diseconomies of scale do not exist. For production efficiency, it is optimal for all population to agglomerate in a single district. In this model, we introduce a local public good with a positive spillover effect. Then, we analyze whether agglomeration arises as the regional population decreases and whether this equilibrium of population distribution is optimal. If it is not optimal, the central government can resolve the problem. If the central government cannot compel small municipalities to consolidate, an alternative policy would be monetary transfers from the central government to local governments. This paper analyzes the effect of transfers from the central government on the population distribution.

This paper is organized as follows. Section 2 presents the model. Section 3 analyzes the equilibrium and optimal population distribution. Section 4 considers the effects of national transfers on the population distribution. Section 5 concludes the paper.

2 The Model

The model of this paper follows Dur and Staal (2008) and Buettner and Hadulla (2013). Consider a region with a population $\bar{L}$ that consists of two districts (district 1 and 2). The residents of district i ($i = 1, 2$) are l_i, and $\bar{L} = l_1 + l_2$. The residents are homogeneous and can be mobile across districts. Each resident's utility is equalized across the districts in equilibrium. Each resident provides one unit of labor.

Private goods are produced with labor as the input and are numeraire goods. In a district i, one labor unit can produce y_i units of the private good. It is assumed that $y_1 > y_2$ which means that district 1 is more productive than the district 2. The private good is consumption good and is used to produce a local public good.

In each district, a nonrival local public good is provided. It is produced with the private good as the input. To produce one local public good, p units of the private good are needed. Local public goods are financed by a local lump-sum tax that must be imposed on each resident, t_i. In Section 4, we present transfers from the central government to local governments. The budget constraint of the local government in district i is the following:

$$pg_i = t_i l_i \tag{1}$$

where g_i is the amount of local public good produced in district i. The residents' budget constraint is $y_i = x_i + t_i$ where x_i is the amount of consumption of the private good in district i.

Local public goods in one district have positive spillover effects on the other one, and they do not have any negative externality of congestion. The utility function for a resident in district i is as follows:

$$U_i = \sqrt{g_i} + k_i\sqrt{g_j} + x_i \tag{2}$$

where g_j is the amount of the local public good in the other district j $(i \neq j, j = 1, 2)$, and $k_i \in [0, 1]$ is the degree of spillover to district i. We assume that $k_2 > k_1$, that is, the spillover effect of the local public good 1 is larger than that of the other good. Note here that the utility function is quasi-linear, and local public goods are not necessities, that is, they are neither consumed nor produced when there are zero residents in the district. In the following, we discuss the case where all residents migrate to one district, and the population of the other district is zero.

3 Equilibrium of Regional Population

We analyze each district's population. First, we characterize the optimal district population. This optimization accounts for the possibility that all residents are agglomerated into one district, while the other district diminishes. Second, we derive the equilibrium district population. Because residents are mobile across districts, each district's population is endogenous. We present the condition in which two regions coexist in equilibrium.

3.1 Social Optimum

The social optimum denotes the case where the representative resident's utility is maximized. Resource constraints in the region are represented as follows:

$$l_1 y_1 + l_2 y_2 = l_1 x_1 + l_2 x_2 + p g_1 + p g_2$$

where $l_2 = \bar{L} - l_1$. As a result of free migration, each resident's utility is equalized across districts. Therefore, the social optimum is determined as follows:

$$\max_{l_1, x_1, x_2, g_1, g_2} \quad \sqrt{g_1} + k_1 \sqrt{g_2} + x_1$$

$$s.t. \quad l_1 y_1 + (\bar{L} - l_1) y_2 = l_1 x_1 + (\bar{L} - l_1) x_2 + p g_1 + p g_2$$

$$\sqrt{g_1} + k_1 \sqrt{g_2} + x_1 = k_2 \sqrt{g_1} + \sqrt{g_2} + x_2$$

The socially optimal amount of local public goods (g_1^*, g_2^*) is derived from this maximization problem:

$$g_1^* = \left[\frac{\bar{L}}{2p} \frac{k_2(1-k_1)^2 + (1-k_2)^2 - k_1 + k_2 + k_1 k_2 - {k_2}^2 - \frac{(1-k_2)(y_1-y_2)2p}{\bar{L}}}{(1-k_1)^2 + (1-k_2)^2} \right]^2$$

$$g_2^* = \left[\frac{\bar{L}}{2p} \frac{(1-k_1)^2 + k_1(1-k_2)^2 + k_1 - k_2 + k_1k_2 - {k_1}^2 - \frac{(1-k_1)(y_1-y_2)2p}{\bar{L}}}{(1-k_1)^2 + (1-k_2)^2} \right]^2$$

Likewise, socially optimal populations for a district (l_1^*, l_2^*) is determined as follows:

$$l_1^* = \frac{\{(1-k_2)^2 - k_1 + k_2\}\bar{L} - 2p(y_1 - y_2)}{(1-k_1)^2 + (1-k_2)^2} \tag{3}$$

$$l_2^* = \frac{\{(1-k_1)^2 + k_1 - k_2\}\bar{L} + 2p(y_1 - y_2)}{(1-k_1)^2 + (1-k_2)^2} \tag{4}$$

We assume that $\{(1-k_2)^2 - k_1 + k_2\}\bar{L} - 2p(y_1 - y_2) > 0$; that is, the population of district 1 is not zero. Larger production differences $y_1 - y_2$ in a district indicate a larger difference of consumption of private goods $x_1 - x_2$. Then, in district 2, the local public good should be provided more extensively to compensate for the loss of utility. To provide the good, the population of the less productive district (district 2) should be larger.

From (4), if $\{(1-k_1)^2 + k_1 - k_2\}\bar{L} + 2p(y_1 - y_2) < 0$, the optimal population of district 2 is negative. Then, will be optimal for all residents to agglomerate to district 1 and for district 2 to diminish. When the difference of the spillover effect k_i is smaller, $(1-k_1)^2 + k_1 - k_2 > 0$, and that case does not arise. This means that the two district should coexist. Conversely, when the difference is larger, that case may come about. If

$$\bar{L} < \frac{2p(y_1 - y_2)}{k_2 - k_1 - (1 - k_1)^2} = \bar{L}_0 \tag{5}$$

then the population of district 2 is not zero. Otherwise, total population $\bar{L}$ is larger than $\bar{L}_0$, and the case in which all residents agglomerate to district 1 is realized. Regardless of any spillover effects, as the regional population decreases, the two districts should continue to coexist.

3.2 Equilibrium

To analyze equilibrium district populations, we first consider the behavior of the local government. Each local government provides local public goods to maximize residents' utility in its district. Here, it is assumed that each local government takes the amount of population as given. Then, the equilibrium levels for local public goods and lump-sum taxes are obtained by maximizing (2) with respect to g_i and t_i, subject to budget constraints (1). The equilibrium levels for local public goods and lump-sum taxes are given as follows:

$$\begin{aligned} g_i &= \left(\frac{l_i}{2p}\right)^2 \\ t_i &= \frac{l_i}{4p} \end{aligned}$$

The indirect utility function is then derived as follows:

$$V_i = \frac{l_i}{4p} + k_i \frac{l_j}{2p} + y_i$$

Due to free migration, l_1 increases (decreases) if $V_1 > V_2$ ($V_1 < V_2$). When $V_1 = V_2$, migration does not occur. Therefore, the equilibrium populations of each district are calculated in the following way:

$$l_1 = \frac{\left(k_1 - \frac{1}{2}\right) \bar{L} + 2p(y_1 - y_2)}{k_1 + k_2 - 1} \tag{6}$$

$$l_2 = \frac{\left(k_2 - \frac{1}{2}\right) \bar{L} - 2p(y_1 - y_2)}{k_1 + k_2 - 1} \tag{7}$$

This migration equilibrium is stable if

$$\frac{d(U_1 - U_2)}{dl_1} = \frac{1 - k_1 - k_2}{2p} < 0$$

For larger spillover effects of local public goods, this condition still holds. Due to the assumption that the spillover effects of the local public good provided in district 1 are larger than in the other district, this condition holds whenever $k_1 > 1/2$. In the following analysis, we assume that $k_1 > 1/2$ holds.

From (7), if

$$\bar{L} < \frac{2p(y_1 - y_2)}{k_2 - \frac{1}{2}} = \bar{L}_E \tag{8}$$

the equilibrium population of district 2 is negative. For a sufficiently large total population, the two districts coexist in equilibrium. Conversely, for smaller total populations, all residents seek to migrate to the more productive district. Because the amount of local public good is smaller, the centrifugal effect is smaller than the centripetal effect.

When the total population is larger, the two districts can coexist, although it is optimal for all residents to agglomerate to district 1 if the difference in spillover effect is larger. A reduction in total population makes the sustainability of the two districts desirable because the effects of local public goods are more important than the effects of private production. A comparison of (5) with (8) shows that $\bar{L}_0 > \bar{L}_E$ holds. This means that district diversity is optimal and is realized in equilibrium when the total population satisfies $\bar{L}_E < \bar{L} < \bar{L}_0$. However, if total population decreases and $\bar{L} < \bar{L}_E$, all residents agglomerate to one district, although this agglomeration is not optimal.

For smaller difference in spillover effects, it is always optimal for two districts to coexist. As the total population grows, this dispersion population distribution arises in equilibrium. The decrease in total population leads to an agglomeration in equilibrium, although it is not optimal. In summary, the following proposition holds.

> **Proposition 1** If total population satisfies $\bar{L} \in [\bar{L}_E, \bar{L}_0]$, two districts always exist, and their mutual existence is optimal. A reduction in total population leads to an agglomeration such that all residents migrate to one district, although this agglomeration is not optimal.

Depopulation causes population agglomeration, and some districts diminish, although the maintainance of several districts is optimal. Therefore, depopulation leads to inefficiency in the regional economy.

4 Effects of Transfers to Local Governments

The previous section shows that depopulation causes the population to agglomerate in one district, although this agglomeration is not optimal. This section investigates whether the national government is correct to protect equilibrium population distribution by making transfers to local governments. Following Dur and Staal (2008), this paper analyzes two types of transfers: a lump-sum transfers that can be spent freely and earmarked transfers that provide some local public good in unit allotments. These transfers are financed by means of a national tax. The model assumes that the regional economy has only a negligible effect on national tax revenue and ignores the analysis of such effects.

4.1 Lump-sum Transfers

The central government provides a lump-sum transfer s per unit resident to the local governments. The budget constraint for district i's local government is expressed as follows:

$$pg_i = t_i l_i + s l_i \tag{9}$$

Each local government maximizes (2) with respect to g_i and t_i, subject to budget constraints (9). The local public good and lump-sum tax in equilibrium are calculated as follows:

$$\begin{aligned} g_i &= \left(\frac{l_i}{2p}\right)^2 \\ t_i &= \frac{l_i}{4p} - s \end{aligned}$$

Lump-sum transfers do not affect the amounts of local public good, and they decrease the lump-sum tax. The equilibrium populations of each district is not affected by the lump-sum transfers through migration behavior because they only affect each resident's income.

Lump-sum transfers do not improve the population distribution. This is because the utility function is quasi-linear, and income effects are not considered here. Then, the lump-sum transfers only affect incomes and do not improve the amounts of local public goods.

4.2 Earmarked Transfers

The central government could also provide earmarked transfers σ per unit of local public good. In this case, the budget constraints of district i's local government is as follows:

$$pg_i = t_i l_i + \sigma g_i \tag{10}$$

Each local government maximizes (2) subject to its budget constraint (10). Then, the amount of local public goods and lump-sum taxes in equilibrium are as follows:

$$\begin{aligned} g_i &= \left\{ \frac{l_i}{2(p-\sigma)} \right\}^2 \\ t_i &= \frac{l_i}{4(p-\sigma)} \end{aligned}$$

Earmarked transfers increase the amount of local public goods and the lump-sum tax.

After migration behavior, the equilibrium populations for the districts are as follows:

$$l_1 = \frac{\left(k_1 - \frac{1}{2}\right)\bar{L} + 2(p-\sigma)(y_1 - y_2)}{k_1 + k_2 - 1}$$
$$l_2 = \frac{\left(k_2 - \frac{1}{2}\right)\bar{L} - 2(p-\sigma)(y_1 - y_2)}{k_1 + k_2 - 1}$$

The earmarked transfers decrease the population of district 1 and increase the population of district 2. This restricts population agglomeration. If total population decreases, district 2 may not exist in equilibrium. However, the earmarked transfer enables the central government to maintain an equilibrium in which both districts exist. In summary, the following proposition holds:

> **Proposition 2** Where the total population decreases ($\bar{L} < \bar{L}_E$) and district 2 does not exist in equilibrium, through earmarked transfers that provides per unit of local public good, it is possible that district 2 can be maintained in equilibrium.

Lump-sum transfers do not affect population distribution. Therefore, as the total population decreases, lump-sum transfers do not two districts to be maintained in equilibrium, although it is optimal for two districts to exist. However, in this case, earmarked transfers promote the existence of small districts. Therefore, earmarked transfers increase efficiency in the regional economy.

5 Conclusion

This paper analyzes optimal and equilibrium population distributions in a region where two districts exist. In each district, local public goods with positive spillover effects are provided. Because each resident can migrate freely, these local public goods may bring about an agglomeration in which all residents are located in one district, and the other district diminishes. This paper analyzes whether such an agglomeration would arise as the regional population decreases. Moreover, it examines the effects of national transfers to local governments to improve population distributions.

This paper shows that the reduction of regional populations cause population agglomeration, and in this cases, some districts diminish, although maintaining two districts would be optimal. Moreover, smaller spillover effects promote this situation. The national government can resolve these problems with transfers to local governments. Earmarked transfers that provide local public goods in unit allotments can maintain two districts in equilibrium, although the lump-sum transfers do not.

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