

On the Local Public Goods and their Spillovers

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Abstract

What are the economic implications of having the same type of local public goods in each neighboring region? This question is addressed in the present study. Specifically, this study aims to clarify how spillovers in the provision of local public goods affect social welfare in each region. The analysis clarifies that when spillovers occur, the provision of local public goods to neighboring regions may result in highly desirable outcomes for each region.

Key words: Local public goods, Nash equilibrium, Spillovers, Social welfare

JEL Classification: H41, I3, R5

1. Introduction

We demonstrate that even when two regions are adjacent, it is highly desirable to provide local public goods to each region. This study focuses on the provision of local public goods with spillover effects. Williams (1966), Brainard and Dolbaer (1967), and Boskin (1973) initiated this line of research during the late 1960s and the early 1970s, eventually culminating in the work of Oates (1972). Bloch and Zenginobuz (2007) revitalized this field by applying game theory. This study employs a game-theoretic approach.

Despite different contexts, the model used in this study is closely related to that of Sato (2019). While Sato (2019) examines the relationship between spillovers and social welfare, the model in this study characterizes this relationship more specifically. As clarified by Sato (2019), positive synergies exist in spillovers. In this study, we show that in the Nash equilibrium, as the parameter of the local public good spillover increases, social welfare increases in both regions within the regional economic area and that the increase in social welfare is greater than the parameter.

The model in this study considers an economy consisting of two homogeneous neighboring regions. In this economy, each regional government competitively supplies the same type of local public goods, and the benefits of these public goods affect not only their own regions, but also neighboring regions. This effect is referred to as the spillover effect. This study considers a situation in which spillovers occur mutually between two regions.

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The remainder of this paper is organized as follows. The model is described in the next section. In Section 3, we derive the Nash equilibrium and demonstrate the relationship between spillovers and social welfare. Finally, in Section 4, we discuss the conditions under which the conclusions of this study are valid.

2. Model

Consider an economy consisting of two neighboring regions. Each local government supplies a public good. Once supplied, the benefits of local public goods spill over to neighboring regions to a greater or lesser extent. In other words, residents of this economy benefit not only from local public goods in their own regions but also from local public goods in another region. Hereafter, the level of the local public good supplied by the government of region i ($i = 1, 2$) is denoted by $g_i > 0$.

Governments in each region do not know the supply levels of local public goods in other regions. This is assumed to be common knowledge. Therefore, this study considers simultaneous-move games.

The social welfare function for the region i is defined as follows:

$$U_i(g_i, g_j) = 2(\sqrt{g_i} + \theta\sqrt{g_i g_j}) - g_i, i, j = 1, 2, j \neq i \quad (1)$$

where U_i denotes the social welfare of region i , Equation (1) represents the social welfare function of Batabyal (2018) with $\alpha=1$, $\gamma=1$, and $\beta=\theta$. θ is a parameter indicating spillovers. We assume that the value of θ is less than 1 and belongs to the half-open interval $[0, 1)$, accounting for the case where there is no spillover. Additionally, we assume that the marginal cost of providing local public goods is 1.

Based on Equation (1), social welfare in region i depends on g_i and g_j . Partially differentiating the level of public goods in each region, g_i , we obtain the following equation:

$$\frac{\partial U_i(g_i, g_j)}{\partial g_i} = \frac{1}{\sqrt{g_i}} + \frac{\theta g_j}{\sqrt{g_i g_j}} - 1 \quad (2)$$

Second-order partial differentiation of Equation (2) with respect to g_i yields

$$\frac{\partial^2 U_i(g_i, g_j)}{\partial g_i^2} = -\frac{1}{2} \left(\frac{1}{g_i \sqrt{g_i}} + \frac{\theta g_j}{g_i \sqrt{g_i g_j}} \right) < 0 \quad (3)$$

Thus, given $g_j > 0$, the value of g_i that maximizes U_i satisfies the following condition:

$$1 + \theta\sqrt{g_j} = \sqrt{g_i} \quad (4)$$

Based on Equation (4), when g_j is given, the best response for region i is as follows:

$$BR_i(g_j) = (1 + \theta\sqrt{g_j})^2 \quad (5)$$

Similarly, when g_i is given, the best response for region j is as follows:

$$BR_j(g_i) = (1 + \theta\sqrt{g_i})^2 \quad (6)$$

Based on the results of the analysis above, the Nash equilibrium is derived in the next section.

3. Nash Equilibrium

The values of g_i and g_j at the Nash equilibrium can be obtained by solving Equations (5) and (6) simultaneously: Consequently, at the Nash equilibrium, $g_i = g_j$, so we set $g_i = g_j = g_{NE}$. This g_{NE} is expressed using the following equation:

$$g_{NE} = \left(\frac{1}{1 - \theta} \right)^2 \quad (7)$$

From Equation (7), we can clearly derive the following lemma.

Lemma 1. At the Nash equilibrium, the provision of public goods is positive in both regions.

By substituting the Nash equilibrium level of local public goods into Equation (1), the value of social welfare at the Nash equilibrium can be obtained. This yields the following equation:

$$U_i(g_{NE}) = \left(\frac{1}{1 - \theta} \right)^2 \quad (8)$$

This means that at the Nash equilibrium, U_i depends on the value of θ . Equation (8) is illustrated in Figure 1. This figure illustrates the following proposition.

Proposition 1. At the Nash equilibrium, social welfare in any region increasingly depends on spillover, and the increase in social welfare is greater in intervals with a high degree of spillover than in intervals with a relatively smaller degree of spillover.

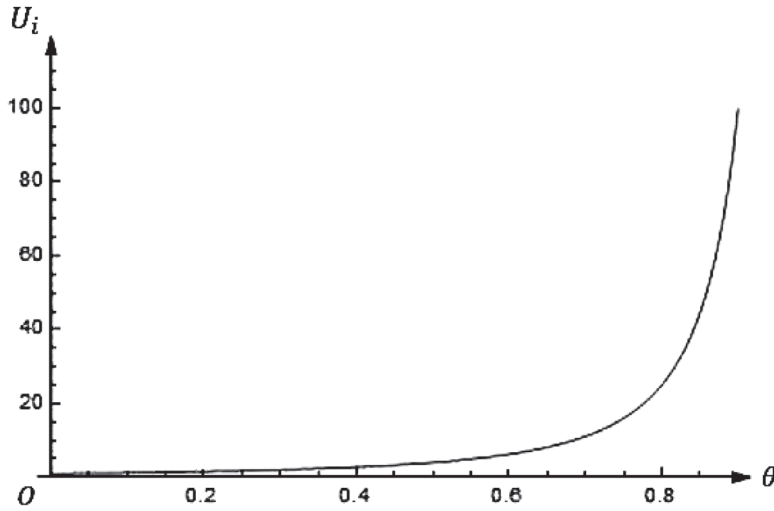


Figure 1. Relationship between spillover and social welfare

4. Concluding Remarks

This study demonstrates that when the degree of spillover is high in an economy consisting of two neighboring regions, the provision of local public goods by the governments of both regions leads to highly desirable social conditions.

A concrete example of this result is local “public safety” measures, such as police and fire departments. When spillovers are relatively low, there is little improvement in security in the neighboring regions. However, when spillovers are sufficiently high, security increases sharply. This implies that residents of both regions highly value the presence of fire and police services in their neighboring jurisdictions.

Note: The analysis in this paper extends part of Fujino (2021).

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