A NOTE ON LOCAL PUBLIC GOOD INDUCED SPILLOVERS BETWEEN A LEADING AND A LAGGING REGION

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Abstract

We analyze spatial spillovers in an aggregate economy consisting of a leading and a lagging region where the spillovers stem from the provision of a local public good. Specifically, if the leading region provides the public good then the lagging region obtains some spillover benefits and vice versa. We first solve for the Nash equilibrium levels of the local public goods in the two regions when public investment decisions are simultaneous; next, we determine the equilibrium welfare levels in each region. Second, on the assumption that the public investment decisions are centralized, we compute the levels of the local public goods that maximize aggregate welfare. Finally, we describe an interregional transfer scheme that leads each region to choose non-cooperatively in a Nash equilibrium the same public investment levels as those that arise when aggregate welfare is maximized.

Keywords: Lagging Region, Leading Region, Local Public Good, Spatial Spillover

JEL classification: R11, O18

Batabyal acknowledges financial support from the Gosnell endowment at RIT. The usual disclaimer applies.

1. Introduction

Regional scientists now clearly comprehend the point that irrespective of whether one studies a developed or a developing nation, all manner of inequalities exist in the different regions that make up the nation under consideration. This comprehension has given rise to great interest in examining the characteristics of leading and lagging regions. As pointed out by Batabyal and Nijkamp (2014a), in this two-part classification, lagging regions are generally not dynamic, they are often rural or peripheral or remote, they are technologically backward, and they display slow rates of economic growth. In contrast, leading regions are typically dynamic, they are often urban and centrally located, they are technologically more advanced, and they display relatively rapid rates of economic growth. We now have a fairly large literature on leading and lagging regions. Therefore, before we proceed to the specific contributions of this note, let us first briefly survey this literature.

Desmet and Ortin (2007) study uneven development in a model with two regions and two sectors. In their model, whether the lagging or the leading region profits from technological change is uncertain. Because of the presence of this kind of randomness, these researchers demonstrate that it may make sense for the lagging region to remain underdeveloped. Chronic labor shortages in the remote regions of Queensland, Australia are the focus of Becker et al. (2013). They point out that the remoteness of the regions under study makes it difficult to attract and retain labor. Hence, businesses and communities will need to work together to ameliorate the problems created by these acute labor shortages.

Dawid et al. (2014) study the effect of policies designed to foster technology adoption and improvements in the human capital stock, on the economic performance of what they call stronger and weaker regions. They demonstrate that the impact of such policies depends fundamentally on the extent to which the labor markets in the two regions are integrated. Batabyal and Nijkamp (2014b) examine the economic performance of lagging and leading regions when there is a technology gap between these two regions. Their analysis demonstrates that in spite of the existence of the technology gap, on the balanced growth path (BGP), the physical to effective human capital ratio is identical in both regions. Batabyal and Nijkamp (2018) study an aggregate economy consisting of a leading and a lagging region. They show that relative to the leading region, the lagging region's initial economic disadvantages are magnified on the BGP.

Three recent papers have shed some light on the topic of spatial spillovers between leading and lagging regions. Kalirajan (2004) studies the economic performance of leading and lagging states in India. He contends that the quality of the available human capital and infrastructure will determine the extent to which there are growth spillover effects from the leading to the lagging states. Smulders (2004) analyzes an endogenous growth model where the two regions being studied are countries. Ho shows that capital market integration hurts (aids) the leading (lagging) region if domestic spillovers are more salient than international spillovers and differences in research and development (R&D) are small. Finally, Rodriguez-Pose and Crescenzi (2008) analyze an empirical model of R&D, spillovers, innovation, and the genesis of regional growth in Europe. They point out that a key role of spillovers relates to the transmission of economically productive knowledge. Even so, it is important to comprehend that these spillovers are subject to potent distance decay effects.

The various studies discussed in the preceding three paragraphs have certainly advanced aspects of our understanding of the working of leading and lagging regions in different parts of the world. Even so, to the best of our knowledge, there are no studies in the extant literature that have examined the working of leading and lagging regions when (i) there are spatial spillovers between these two regions and (ii) the source of these spillovers is the level of public investment in a local public good. [1]

Given this lacuna in the literature, the objective of this note is to analyze the nature of the spatial spillovers in an aggregate economy consisting of a leading and a lagging region. The spillovers stem from the provision of a local public good. What this means is that if the leading region provides the public good then the lagging region obtains some spillover benefits and vice versa. Section 2 delineates the theoretical framework. Section 3 first solves for the Nash equilibrium levels of the local public goods in the two regions when the public investment decisions are simultaneous. Next, this section determines the equilibrium welfare level in each region. On the assumption that the public investment decisions are centralized, section 4 computes the levels of the local public goods that maximize aggregate welfare. Section 5 describes an interregional transfer scheme that leads each region to choose non-cooperatively in a Nash equilibrium the same public investment levels as those that arise in section 4. Section 6 concludes and then discusses two ways in which the research delineated in this note might be extended.

2. The Theoretical Framework

Consider an aggregate economy consisting of a leading and a lagging region. Following the nomenclature in Batabyal and Nijkamp (2018), we denote the leading region with the subscript L and the lagging or *remote* region with the subscript R. The government in each of these two regions can undertake some public investment in a local public good. This investment improves the quality of the lives and hence the welfare of the people living in these two regions. In the model of this note, public investment in either of the two regions under study leads to some spatial spillovers. In other words, if the leading region (L) provides the local public good then the lagging region (R) obtains some spillover benefits and vice versa.

In principle, the local public good in the two regions can be any one of several possibilities including, but not limited to, the provision of police, the provision of radio and television signals, and the provision of a public park. However, for concreteness, in the remainder of this note we shall think of the local public good as *public education*. As such, the spillovers we have mentioned arise from the fact that it is possible for a citizen of the leading (lagging) region to migrate and either work or live in the lagging (leading) region.[2] Now, in reality, we expect most of the spillovers to be experienced by the leading region because many more citizens from the lagging region are likely to migrate to the leading region in search of better

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[1] As noted by Hindriks and Myles (2013, p. 208), a local public good "has the feature that its benefits are restricted to a particular geographical area and it cannot be enjoyed outside of that area."

[2] We shall use the terms "local public good" and "public education" interchangeably in the remainder of this note.

economic opportunities. Even so, in the interest of generality, we allow the spillovers to exist from the lagging to the leading and from the leading to the lagging regions.

Finally, let g_L and g_R denote the public good levels in the leading and in the lagging regions. In addition, let the welfare function in each region be given by

$$U^i(g_i, g_j) = 2\{\alpha\sqrt{g_i} + \beta\sqrt{g_i g_j}\} - \gamma g_i, \tag{1}$$

for $i \neq j,\ i,j = L,R,\ \ \alpha > 0$,and $\gamma > \beta > 0$. Our next task is to solve for the Nash equilibrium levels of the local public goods in the two regions when the public investment decisions are simultaneous.

3. The Nash Equilibrium Local Public Good Levels

In this section, the governments in the leading and in the lagging regions make their public investment decisions *simultaneously*. We know that the welfare level in region i as a function of the two public good levels g_i and g_j is given by equation (1). Therefore, differentiating both sides of equation (1) with respect to g_i gives us

$$\frac{\partial U^i(g_i, g_j)}{\partial g_i} = \frac{\alpha}{\sqrt{g_i}} + \frac{\beta g_j}{\sqrt{g_i g_j}} - \gamma. \tag{2}$$

Simplifying equation (2), the first-order necessary condition for the optimal choice of g_i is

$$\frac{\alpha}{\sqrt{g_i}} + \frac{\beta g_j}{\sqrt{g_i g_j}} = \gamma. \tag{3}$$

Equation (3) can also be expressed as

$$\alpha + \beta\sqrt{g_j} = \gamma\sqrt{g_i}. \tag{4}$$

Given equation (4), the best response function of the government in region i to public good level g_j is

$$g_i = \frac{(\alpha + \beta\sqrt{g_j})^2}{\gamma^2}. \tag{5}$$

Similarly, the best response function of the government in region j to public good level g_i is

$$g_j = \frac{(\alpha + \beta\sqrt{g_i})^2}{\gamma^2}. \tag{6}$$

Now, the Nash equilibrium levels of the two regional public goods g_L and g_R are given by solving equations (5) and (6) simultaneously. That said, the reader should note that because of the symmetry in our theoretical framework, we can write the two Nash equilibrium levels we seek as $g_L = g_R = g_{NE}$ which solves, after dropping the subscripts, the equation

$$\alpha + \beta\sqrt{g} = \gamma\sqrt{g}. \tag{7}$$

Simplifying equation (7), we get a distinct value for g_{NE} and that value is

$$g_{NE} = \left(\frac{\alpha}{\gamma - \beta}\right)^2 > 0, \tag{8}$$

for $\alpha > 0$ and $\gamma > \beta > 0$ Inspecting equation (8) we see that there is no corner solution in our model. In other words, it is optimal in both the leading and in the lagging region to provide a *strictly positive* level of the local public good that is public education.

Our second and final task in this section is to ascertain the equilibrium welfare level in each region. We do this in three steps. First, substitute the result in equation (8) into the leading and the lagging region welfare functions given in equation (1). This gives us

$$U^i(g_{NE}, g_{NE}) = 2\{\alpha\sqrt{g_{NE}} + \beta\sqrt{g_{NE}, g_{NE}}\} - \gamma g_{NE}. \quad (9)$$

Second, using equation (8), equation (9) can be simplified. This simplification yields

$$U^i(g_{NE}, g_{NE}) = 2\alpha\left(\frac{\alpha}{\gamma-\beta}\right) + (2\beta-\gamma)\left(\frac{\alpha}{\gamma-\beta}\right)^2. \quad (10)$$

Finally, simplifying equation (10), we get

$$U^i(g_{NE}, g_{NE}) = \gamma\left(\frac{\alpha}{\gamma-\beta}\right)^2 > 0. \quad (11)$$

Inspecting equations (8) and (11) we see that because the Nash equilibrium levels of public education in the two regions are positive, *so is* the equilibrium level of welfare in each of the two regions under study. In addition, the equilibrium welfare level in each region is a *constant* multiple of the Nash equilibrium public education levels. In symbols, we have $U^i(\cdot,\cdot) = \gamma g_{NE}$. We now proceed to compute the levels of the local public goods that maximize *aggregate* welfare on the assumption that the public investment decisions in the leading and in the lagging regions are centralized.

4. Aggregate Welfare

Aggregate or total welfare in the two regions under study is given by $U^L(g_L, g_R) + U^R(g_R, g_L)$. This specification tells us that mathematically, the task before us is to solve

$$max_{\{g_L, g_R\}} U^L(g_L, g_R) + U^R(g_R, g_L). \quad (12)$$

The two first-order necessary conditions for an optimum are given by

$$\frac{\partial U^L(\cdot,\cdot)}{\partial g_L} + \frac{\partial U^R(\cdot,\cdot)}{\partial g_L} = \left(\frac{\alpha}{\sqrt{g_L}} + \frac{\beta g_R}{\sqrt{g_L g_R}} - \gamma\right) + \frac{\beta g_R}{\sqrt{g_L g_R}} = 0, \quad (13)$$

and

$$\frac{\partial U^R(\cdot,\cdot)}{\partial g_R} + \frac{\partial U^L(\cdot,\cdot)}{\partial g_R} = \left(\frac{\alpha}{\sqrt{g_R}} + \frac{\beta g_L}{\sqrt{g_L g_R}} - \gamma\right) + \frac{\beta g_L}{\sqrt{g_L g_R}}. \quad (14)$$

Observe that in both equations (13) and (14), the last ratio term denotes the spillover benefit that accrues to each region from the provision of the local public good. We can now write these two equations differently. This gives us

$$\frac{\alpha}{\sqrt{g_L}} + \frac{2\beta g_R}{\sqrt{g_L g_R}} = \frac{\alpha}{\sqrt{g_R}} + \frac{2\beta g_L}{\sqrt{g_L g_R}} = \gamma. \quad (15)$$

Inspection of equation (15) and some thought together tell us that the solution we seek must be symmetric. In other words, it must be the case that we have $g_L = g_R = g_A$ where the subscript *A* denotes the fact that we are now studying the "aggregate welfare" maximization case. Using this preceding condition, we reason that the optimal local public good levels in the leading and in the lagging regions solve

$$\frac{\alpha}{\sqrt{g}} + 2\beta = \gamma, \quad (16)$$

where we have omitted the subscripts because of symmetry. Simplifying equation (16), we obtain

$$g_A = \left(\frac{\alpha}{\gamma - 2\beta}\right)^2 > g_{NE}, \qquad (17)$$

and we suppose that $\gamma > 2\beta$

Equation (17) tells us that in the Nash equilibrium studied in section 3, there is *underprovision* of the local public good (public education) in the two regions under study. This underprovision result arises because in the case studied in section 3, the government in the leading (lagging) region *ignores* the spatial spillover benefit stemming from its provision of public education for the lagging (leading) region. Our final task in this note is to delineate an interregional transfer scheme that leads the government in each region to choose non-cooperatively in a Nash equilibrium the same public investment levels as those we have obtained in this section.

5. An Interregional Transfer Scheme

The interregional transfer scheme we have in mind is based on public investment in the *other* region that induces each of the two regions to select non-cooperatively in a Nash equilibrium the same public investment levels as those obtained in section 4. To this end, suppose that each region $i, i = L,R$, receives a subsidy σ_i per unit of the provision of the local public good g_i In this case, the i_{th} region's welfare is

$$U^i(g_i, g_j) + \sigma_i g_i. \qquad (18)$$

As such, the first-order necessary condition for an optimum for the leading region---see equations (2) and (3)---becomes

$$\frac{\partial U^L(g_L, g_R)}{\partial g_L} + \sigma_L = 0. \qquad (19)$$

Now if we set the subsidy equal to the spillover benefit so that $\sigma_L = \partial U^R(\cdot,\cdot)/\partial g_L > 0$, then we obtain

$$\frac{\partial U^L(g_L, g_R)}{\partial g_L} + \frac{\partial U^R(g_R, g_L)}{\partial g_L} = 0. \qquad (20)$$

From equation (13), we know that equation (20) represents the condition for the efficient provision of the local public good. Therefore, by setting the subsidy equal to the spillover benefit, we can alter the Nash equilibrium studied in section 3 and ensure an efficient allocation of public investment in the leading and in the lagging regions. This completes our discussion of spillovers between a leading and a lagging region induced by the provision of a local public good.

6. Conclusions

In this note, we analyzed spatial spillovers in an aggregate economy consisting of a leading and a lagging region where the source of the spillovers was the provision of a local public good. In particular, if the leading region provided the public good then the lagging region obtained some spillover benefits and vice versa. We first solved for the Nash equilibrium levels of the local public goods in the two regions when public investment decisions were simultaneous; next, we determined the equilibrium welfare levels in each region. Second, on the supposition that the public investment decisions were centralized, we calculated the levels of the local public goods that maximized aggregate welfare. Finally, we described a subsidy based interregional transfer scheme that led the government in each region to choose non-cooperatively in a Nash equilibrium the same public investment levels as the ones that arose when decision making about public investment was centralized.

The analysis in this note can be extended in a number of different directions. Here are two potential extensions. First, it would be useful to analyze how differences in the magnitudes of the two spillover benefit terms influence migration decisions between the leading and the lagging regions. Second, it would be helpful to explicitly model the financing of the subsidy and to study how a "revenue neutrality" condition affects interactions between the leading and the lagging regions. Studies that analyze these facets of the underlying problem about economic differences between leading and lagging regions will provide additional insights into the connections between remote versus central location on the one hand and the efficient provision of local public goods on the other.

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