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Abstract

The literature on leading and lagging regions has paid scant attention to how *heterogeneity* between the two regions impacts the provision of a public good. Given this lacuna, our contribution is to construct a game-theoretic model of an aggregate economy consisting of a leading and a lagging region and to then analyze this model. We show how two kinds of heterogeneity affect the provision of a public good such as higher education. In addition, we focus on *decentralized* and *centralized* public good provision and comment on the resulting welfare implications. We obtain two key conclusions. First, under decentralization, there exist several situations in which it is optimal for only one region to provide the public good. Second, under centralization, this exclusive provision is not optimal but the amount of the public good provided can be larger or smaller than the amount provided under decentralization. Our research tells policymakers that *population size* and *values* differences between the two regions and the use of *majority voting* are key factors to consider when pondering the optimal provision of a public good.

Keywords: Centralization, Decentralization, Lagging Region, Leading Region, Public Good

JEL Codes: R11, R13, H41

1. Introduction

1.1. Preliminaries

Regional scientists and development economists have both been interested in studying the world's so called *leading* and *lagging* regions for quite some time (Batabyal and Nijkamp 2014a, Lall *et al.* 2009). In fact, as recently as 2018, participants in the World Bank sponsored "World Urban Forum" commented on the urgent need for understanding the forces that separate leading and lagging regions.[4] What are leading and lagging regions? Batabyal *et al.* (2019) helpfully explain that lagging regions are typically not dynamic, they are frequently rural or peripheral or remote, they are technologically backward, and they exhibit sluggish economic growth rates. In contrast, leading regions are more often than not dynamic, they are frequently urban and centrally located, they are technologically advanced, and they display relatively rapid rates of economic growth.

The extant literature on leading and lagging regions (on which more in section 1.2 below) is substantial and growing. Even so, there are gaps in this literature. One such gap stems from the fact that this literature has paid virtually *no* attention to the many ways in which *heterogeneity* between these two types of regions affects the provision of public goods---such as infrastructure, sanitation, secondary and higher education, a police force---upon which both types of regions are frequently dependent. Therefore, research is currently needed to shed light on the ways in which (i) regional characteristics and (ii) alternate delivery methods affect the provision of public goods in these two types of regions.

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Go to https://www.worldbank.org/en/events/2018/02/07/world-urban-forum for additional details on this point.

To this end, our contribution in this paper is twofold. First, we construct a game-theoretic model of an aggregate and integrated economy that consists of a leading and a lagging region. Second, we analyze this model in detail. In our analysis, we pay particular attention to the following two questions: Given regional *population* differences and differences in how much citizens in the leading and in the lagging region *value* a public good, does it make more sense to provide the public good in a *decentralized* or in a *centralized* manner? In addition, what is the role of *majority voting* by the citizens of the leading and the lagging region in determining how best to provide the public good? This said, in order to appreciate how the research delineated in our paper might help policymakers ascertain how best to account for regional heterogeneity when providing a public good in an actual instance, it will be helpful for the reader to first get an adequate flavor for the kinds of questions that have been studied in the existing literature. Therefore, we now briefly survey this literature on leading and lagging regions.[5]

1.2. Literature review

As far as economic performance is concerned, what factors are most likely to connect the leading and the lagging states within India? This question has been addressed by Kalirajan (2004). He contends that the quality of the available human capital and infrastructure will together determine the extent to which there are growth spillover impacts from the leading to the lagging states. Does it make sense to use an endogenous growth model to study leading and lagging regions when the regions being studied are countries? Smulders (2004) first shows that it does and then proceeds to point out that capital market integration hurts (helps) the leading (lagging) region if

[5] The literature under review here has concentrated on many different parts of the world including India, Europe, Brazil, and Queensland, Australia. We begin with a discussion about states in India because the dissimilar economic performance of many of these states allows one to examine this performance in terms of the "leading-lagging" dichotomy that we are studying in this paper. That said, it is important to point out that the focus of this review is not specific to India in any way.

domestic spillovers are more salient than international spillovers and gaps in research and development (R&D) are small. What role do spatial spillovers play in either helping or hindering regional economic growth? Rodriguez-Pose and Crescenzi (2008) shed light on this question by concentrating on regions within Europe. These researchers use an empirical model of R&D, spillovers, and innovation and point out that even though they are subject to distance-decay effects, spatial spillovers are an important vehicle for transmitting economically productive knowledge.

An issue of considerable interest to researchers is the potential for uneven development. Desmet and Ortin (2007) utilize a model with two regions and two sectors to analyze this issue. Interestingly, they show that the impact of technological change on either the leading or the lagging region is stochastic. The existence of this stochasticity leads these researchers to the surprising conclusion that in some scenarios, it may make sense for the lagging region to remain underdeveloped. Lall *et al.* (2009) and Becker *et al.* (2013) both address the role played by labor mobility in serving as a nexus between leading and lagging regions. Whereas Lall *et al.* (2009) focus on the migration decisions of working-age Brazilians, Becker *et al.* (2013) argue that the remote regions of Queensland in Australia are negatively affected by lengthy labor shortages. We learn that the existence of these shortages makes it very difficult to attract and retain labor. Hence, contend Becker *et al.* (2013), it will be incumbent upon businesses and communities to work together to reduce the problems created by these acute labor shortages.

Can a so called "technology gap" between a leading and a lagging region influence their economic performance? Batabyal and Nijkamp (2014b) demonstrate that the answer to this question is "no" in the sense that the physical to effective human capital ratio is the same in both the regions on the balanced growth path (BGP). What can be done to ameliorate the economic performance of "strong" and "weak" regions? Dawid *et al.* (2014) point out that in order to answer this question affirmatively, it will be necessary to concentrate on policies that promote technology adoption and improve the stock of human capital. Their analysis shows that the impact of such dual-purpose policies depends greatly on the extent to which the labor markets in the strong and in the weak regions are amalgamated.

Several researchers have now utilized a modeling framework in which the object of inquiry is an aggregate economy composed of one leading and one lagging region. Two recent examples of studies that employ this framework are Batabyal (2018) and Batabyal and Nijkamp (2019). Specifically, Batabyal (2018) examines the nature of the spatial spillovers in his aggregate economy. He first solves for the Nash equilibrium levels of the local public goods in the two regions when public investment decisions are concurrent and then determines the equilibrium welfare level in each region. Finally and addressing a different question, Batabyal and Nijkamp (2019) demonstrate that relative to the leading region, the lagging region's initial or time $t = 0$ economic disadvantages are magnified on the balanced growth path. This completes our review of the kinds of questions that have typically been studied in the extant literature on leading and lagging regions. We now describe how the remainder of this paper is arranged and, at the same time, comment on the specific contributions of our paper.

1.3. Schema and specific contributions

To reiterate, the primary objective of our paper is to analyze the effects that *two kinds* of heterogeneity have on the provision of a public good such as higher education in an aggregate and integrated economy consisting of a leading and a lagging region. To this end, section 2 describes the game-theoretic framework. In this framework, the *size* of the populations in the two regions and the *value* that the individuals resident in these two regions place on providing the public good in their region are dissimilar. Section 3 solves for the *decentralized* Nash equilibrium levels of the public good when the leading region is both larger and places a higher value on the public good. Section 4 studies the decentralized provision of the public good when the lagging region is larger but the value it places on the public good is lower. Section 5 examines the *centralized* provision of the public good in the aggregate economy with majority voting. Section 6 describes the *welfare* effects of centralization, first when the lagging region is larger and then when the leading region is larger. Section 7 provides some empirical evidence in support of the modeling framework used and conclusions reached in this paper. Finally, section 8 concludes and then discusses two ways in which the research delineated in this paper might be extended.

2. The Game-Theoretic Framework

Our first assumption is that the aggregate and integrated economy under study consists of a leading and a lagging region. Following the nomenclature in Batabyal (2018), we denote the leading region with the subscript L and the lagging or *remote* region with the subscript R. Our second assumption is that in each of these two regions, there are two goods, a private good denoted by z and a public good denoted by g. Our third assumption is that there are n_i identical citizens in region i and that $i = L, R$. The first kind of heterogeneity in our model stems from the stipulation that $n_R \neq n_L$.

Our fourth assumption is that each citizen in the aggregate economy possesses a fixed amount of the private good and that this fixed amount can be converted into a public good at marginal cost equal to unity. The utility function of *each citizen* in region i is given by

$$U_i = z_i + \zeta_i \log(g), \tag{1}$$

where $\zeta_i > 0$ is a measure of the *value*[6] that each citizen in region i places on the provision of the public good in his or her region.[7] The second kind of heterogeneity in our model arises from the proviso that $\zeta_R \neq \zeta_L$.

In principle, the public good in the two regions under study can be any one of several possibilities including, but not limited to, infrastructure, primary health care, sanitation, secondary education, higher education, and a police force. However, for concreteness, in the remainder of this paper we shall think of the public good as *higher education*. We now emphasize two points. First, we recognize that strictly speaking, higher education is not a pure public good because in either region, it is in principle possible to exclude some citizens from acquiring a higher education. That said, higher education does have many of the attributes of a public good---see Pasquerella (2016)---and it is likely to be underprovided because its social benefits generally exceed its private benefits. This is why we shall think of higher education as the public good in our model although we acknowledge that one can think of other examples well.

Second, we use calculus to conduct our subsequent mathematical analysis. This means that it must be possible to vary g continuously. As such, it is helpful to think of higher education as *all* post-secondary school education. When looked at in this way, varying g means providing alternate levels of higher education such as a community college only, a community college plus a four-year college, a community college, a four-year college, and a graduate institution, and so on and

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Later on, in sections 5 and 6 of our paper, we shall refer to this ζ_i or *value* parameter as a *preference* parameter. Put differently, the utility function in equation (1) can be thought of as a preference *function* and ζ_i is a value or preference *parameter* of the preference function.

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The utility function in equation (1) describes the utility of *any one* citizen in each of the two regions under study. In this regard, note that since all citizens within a particular region are *identical*, it does not matter which citizen's utility function we choose to conduct the analysis with. Second, since all citizens in a region are identical, to determine the utility of the entire region, we simply scale up using the population n_i of that region. Equation (1) is an example of a quasi-linear utility function and several precedents exist for using such a utility function when analyzing one or more aspects of public goods. See Cornes and Sandler (1985) and Batabyal and Beladi (2019) for two examples. See Hindriks and Myles (2013, pp. 553-558) for a textbook discussion of quasi-linear utility functions.

so forth.[8] Our next task is to solve for the decentralized Nash equilibrium[9] levels of the public good when the leading region is both *larger* and places a *higher* value on higher education.

3. Public Good Provision with a Strong Leading Region

By "strong," we mean that the conditions $\zeta_R < \zeta_L$ and $n_R < n_L$ both hold. Now, each region independently selects how much of the public good to provide.. This means that the common level of the public good is the sum of the two regional provisions or $g = g_R + g_L$. Let us denote the fixed endowment of the private good of each citizen in the leading region by $\hat{z}$**.** Also, let us think of the ratio $1/n_R$ as the per citizen marginal cost of providing the public good in the lagging region. Then, the utility of the lagging region as a function of the public good levels g_R and g_L is given by[10]

$$U_R(g_R, g_L) = \hat{z} - \frac{g_R}{n_R} + \zeta_R \log(g_R + g_L). \qquad (2)$$

Differentiating the utility function in equation (2) with respect to g_R, the first-order necessary condition for an optimum is

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We shall use the terms "public good" and "higher education" interchangeably in the remainder of this paper. Also, we emphasize the need to be clear about the following two points. First, since our analysis in this paper uses calculus, as noted earlier in the paragraph, it must be possible to vary the public good g continuously. Hence, it does *not* make sense to view g as a "discrete good." Second, in economics, the utility function is typically defined over goods and *not* on the monetary value placed on these goods. As pointed out in standard textbooks such as Hirshleifer *et al.* (2005, chapter 3) and Hindriks and Myles (2013, chapter 6), this applies to both private *and* public goods. This is why we work with the physical public and private goods themselves (g, z) and *not* with any monetary amounts placed on these goods.

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Loosely speaking, in a Nash equilibrium, every player in a game is doing the best that he or she can for himself or herself given that all the other players in this game are also doing the best that they can for themselves. For a technical definition of and more details about a Nash equilibrium, see Gibbons (1992).

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Note that in writing equation (2), we have *not* changed "the functional form of equation (1)." As a result of the explanation given in this paragraph, z_R in equation (1) can also be written as $\hat{z} - g_R/n_R$ in equation (2). In addition, because $g = g_R + g_L$, the expression after the addition sign in equation (1) for $i = R$ is identical to the expression after the addition sign in equation (2).

$$\frac{\partial U_R(g_R, g_L)}{\partial g_R} = \frac{\zeta_R}{g_R+g_L} - \frac{1}{n_R} = 0. \tag{3}$$

Simplifying equation (3), the reaction function of the lagging region is

$$g_R = \zeta_R n_R - g_L. \tag{4}$$

Using a similar line of reasoning, the utility function of the leading region as a function of the public good levels g_R and g_L is

$$U_L(g_R, g_L) = \hat{z} - \frac{g_L}{n_L} + \zeta_L \log(g_R + g_L), \tag{5}$$

where, as in the case of the lagging region, we shall think of the ratio $1/n_L$ as the per citizen marginal cost of providing the public good in the leading region. Differentiating equation (5) with respect to g_L, we get

$$\frac{\partial U_L(g_R, g_L)}{\partial g_L} = \frac{\zeta_L}{g_R+g_L} - \frac{1}{n_L} = 0. \tag{6}$$

Simplifying equation (6), the leading region's reaction function is

$$g_L = \zeta_L n_L - g_R. \tag{7}$$

The two inequalities $\zeta_R < \zeta_L$ and $n_R < n_L$ together tell us that $\zeta_R n_R < \zeta_L n_L$. Inspecting this last inequality along with the two reaction functions in equations (4) and (7), it follows that the optimal provision of the public good in a Nash equilibrium is given by

$$g_R = 0 \; and \; g_L = \zeta_L n_L. \tag{8}$$

To understand the result in (8), recall two points. First, the marginal cost of providing the public good is lower in the leading region $\{n_R < n_L \Rightarrow (1/n_R) > (1/n_L)\}$ and the value placed on the public good in this region is also higher $(\zeta_L > \zeta_R)$. Second, there is perfect substitutability in the two public good contributions. Therefore, in this case, it is optimal for *only* the leading region to provide higher education in our aggregate economy. Put differently, in the scenario studied in this section, there will be *no* higher education facilities in the lagging region.

We contend that the twin conditions $\zeta_R < \zeta_L$ and $n_R < n_L$ appropriately characterize the population and the value placed on higher education in many of the world's leading and lagging regions. If this contention is valid then our analysis thus far tells us that at least in some circumstances, the concerns of Kunaka and Arenas (2010), Goddard *et al.* (2012), and Pugh (2017), who have worried about the negative effects of poor educational facilities in lagging regions are largely misplaced. In fact, we have shown formally that when the leading region is larger, it places a higher value on the public good, and the public good contributions are characterized by perfect substitutability, it makes sense for this leading region to provide the public good *exclusively*. That said, this is not the only logical possibility. Therefore, we now analyze the decentralized provision of the public good when the lagging region is *larger* but the value it places on the public good is *lower*.[11]

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[11] Note that in section 3, we have studied the case of a "strong" leading region meaning that $\zeta_R < \zeta_L$ and n_R<n_L both hold. That said, we are very interested in studying the provision of the public good in our aggregate economy when the preceding two inequalities *do not both* hold. That is why in section 4 we study the case of a "less strong leading region" where $\zeta_R < \zeta_L$ but $n_R > n_L$ holds. Later on in the paper, in sections 5 and 6, we study the case where there is *centralized provision* of the public good in our aggregate economy. So, the point to note is that even though there is a leading and a lagging region in our paper, there are no "leader and follower dynamics." Obviously, there can be no such dynamics with centralized provision of the public good. This is why the choices made in the two regions in sections 3 and 4 are *simultaneous* and not sequential. Put differently, this is why there is no Stackelberg structure in the model of this paper. Finally, the reader should note that the analysis of private or market-based provision of the public good is beyond the scope of our paper.

4. Public Good Provision with a Less Strong Leading Region

By "less strong," we mean the conditions $\zeta_R < \zeta_L$ and $n_R > n_L$ hold. Some thought ought to convince the reader that in this scenario, there are three possibilities to consider. The first possibility is when the condition $\zeta_R n_R < \zeta_L n_L$ holds. When this happens, the provision of higher education is the same as that analyzed above in section 3. The second possibility arises when $\zeta_R n_R > \zeta_L n_L$. When this happens, the logic of the section 3 analysis still holds but the Nash equilibrium is reversed in the sense that we now have

$$g_L = 0 \; and \; g_R = \zeta_R n_R. \tag{9}$$

This means that the leading region ought not to provide any higher education and it is optimal for the lagging region to provide higher education exclusively.

The third and last possibility arises when the condition $\zeta_R n_R = \zeta_L n_L$ holds. In this instance, we have a symmetric Nash equilibrium. From equation (4) we get $g_R - g_L = \zeta_R n_R$. Similarly, simplifying equation (7), we get $g_L - g_R = \zeta_L n_L$. Since the right-hand-sides (RHSs) of the preceding two equations are equal in this third case, we obtain $g_R - g_L = g_L - g_R \Rightarrow 2g_R = 2g_L \Rightarrow g_R = g_L$. In other words, in the symmetric Nash equilibrium of interest, the two public good contributions satisfy

$$g_R = g_L \; and \; g_R + g_L = \zeta_L n_L. \tag{10}$$

The reader will observe that of the three possibilities that we have analyzed in this fourth section, it is optimal for both the leading and the lagging regions to provide the public good only when the knife-edge condition $\zeta_R n_R = \zeta_L n_L$ holds. Next, in section 5, we examine the *centralized* provision of the public good in the aggregate economy with majority voting.[12] In other words, we depart

[12] See Hindriks and Myles (2013, p. 626) for a textbook discussion of voting and the provision of education.

from the decentralized provision of higher education and analyze the *centralized* provision of higher education in the aggregate economy with majority voting.

5. Centralized Provision of the Public Good

In this case, the decision to provide the public good is made *jointly* for the leading and the lagging regions by a central authority. In addition, we suppose that majority voting determines the actual provision decision. This means that the provision of higher education is based on the *preference* of the median or larger region which turns out to be the leading region in section 3 and the lagging region in section 4. Note that although the centralized provision of higher education results in spreading the cost of provision more widely, at the same time, the *preference* of the larger region is imposed on the smaller region.[13]

Let us now ascertain the optimal provision of the public good in this centralized setting. As in section 3, when the leading region is the larger region, this region chooses g based on the preference of the median leading region citizen given by ζ_L. So, the relevant optimization problem now involves choosing g to solve

$$max_{\{g\}}\, \hat{z} - \frac{g}{n_R+n_L} + \zeta_L \log(g), \tag{11}$$

and it is understood that the cost of providing the public good is now spread over the entire population $n_R + n_L$ in the aggregate economy. Differentiating equation (11) with respect to g and

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What matters for the provision of the public good now is that the preference of the median voter in the larger region is imposed on the smaller region. We remind the reader that as noted in footnote 3 in section 2, we are using the words *value* and *preference* to refer to the ζ_i parameter of the utility or preference function given by equation (1). In this regard, it should be noted that ζ_i is exogenous to the analysis we undertake in this paper and nowhere are we choosing the value of this parameter.

then setting this derivative equal to zero gives us the first order necessary condition for an optimum. We get

$$\frac{\zeta_L}{g} - \frac{1}{n_R+n_L} = 0. \tag{12}$$

Simplifying equation (12), the majority voting equilibrium provision of the public good is

$$g = \zeta_L(n_R + n_L) > \zeta_L n_L. \tag{13}$$

Comparing equation (13) with equation (8) we see that relative to the decentralized Nash equilibrium in section 3, *more* higher education is now provided in the centralized setting. Note that this result arises because the leading region---which values higher education more---ends up being decisive in the majority voting equilibrium and, in addition, the cost of provision is spread over all the citizens in the aggregate economy.

In the scenario studied in section 4, we had $\zeta_R < \zeta_L$ and $n_R > n_L$. Now focusing on the centralized provision of the public good with majority voting, the larger lagging region chooses how much higher education to provide. In this case, the lagging region will select g based on the preference of the median citizen in the lagging region and this is given by $\zeta_R < \zeta_L$. The optimization problem now involves choosing g to solve

$$max_{\{g\}}\, \hat{z} - \frac{g}{n_R+n_L} + \zeta_R \log(g), \tag{14}$$

where, once again, the cost of providing the public good is spread over the entire population n_R+n_L in the aggregate economy. Differentiating equation (14) with respect to g, the first-order necessary condition for an optimum and the majority voting equilibrium provision of the public good is given by

$$g = \zeta_R(n_R + n_L). \tag{15}$$

To compare the centralized equilibrium provision described in equation (15) with the decentralized equilibrium provision discussed in section 4, it will be necessary to consider the three possibilities discussed in that section. First, if $\zeta_R n_R < \zeta_L n_L$ then the centralized Nash equilibrium is identical to the equilibrium discussed in section 4 and we have

$$g = g_L = \zeta_L n_L. \tag{16}$$

Comparing equations (15) and (16), we see that with centralization, the optimal provision of higher education can actually decline if

$$\zeta_R(n_R + n_L) < \zeta_L n_L \Leftrightarrow \zeta_R n_R < n_L(\zeta_L - \zeta_R). \tag{17}$$

The second possibility is that $\zeta_R n_R > \zeta_L n_L$. In this case, the centralized Nash equilibrium is given by

$$g = g_R = \zeta_R n_R. \tag{18}$$

In this second instance, equations (15) and (18) tell us that for the provision of the public good to decline with centralization, we must have $\zeta_R(n_R + n_L) < \zeta_R n_R$, which is clearly impossible.

The third and final possibility is that $\zeta_R n_R = \zeta_L n_L$. In this case, the centralized Nash equilibrium provision of the public good is given by

$$g = g_R + g_L = \zeta_L n_L. \tag{19}$$

For the public good provision in the centralized Nash equilibrium to be lower than the provision in the decentralized Nash equilibrium, we must have $\zeta_R(n_R + n_L) < \zeta_L n_L$, which is also impossible. So, the basic finding that emerges from our discussion of the three possibilities is that the optimal provision of the public good can decline with centralization if and only if the condition in (17) holds. Our final task in this paper is to delineate the welfare effects of centralization when first the lagging region is larger and then when the leading region is larger.

6. Welfare Effects of Centralization

Consider first the case in which the lagging region is larger than the leading region, i.e., when $n_R > n_L$. We know from equation (15) that the optimal provision of higher education under centralization is $g = \zeta_R(n_R + n_L)$. As such, the welfare from the provision of the public good in our aggregate economy is

$$U_R(g) + U_L(g) = 2\left\{\hat{z} - \frac{\zeta_R(n_R+n_L)}{n_R+n_L}\right\} + (\zeta_R + \zeta_L)\log\{\zeta_R(n_R + n_L)\}. \tag{20}$$

After some algebra, the RHS of equation (20) simplifies to

$$U_R(g) + U_L(g) = 2(\hat{z} - \zeta_R) + (\zeta_R + \zeta_L)\log\{\zeta_R(n_R + n_L)\}. \tag{21}$$

Next, suppose that the leading region is larger so that we have $n_L > n_R$. The optimal centralized public good provision is $g = \zeta_L(n_R + n_L)$ and we also have $\zeta_L(n_R + n_L) > \zeta_R(n_R + n_L)$. Therefore, welfare in our aggregate economy is given by

$$U_R(g) + U_L(g) = 2(\hat{z} - \zeta_L) + (\zeta_R + \zeta_L)\log\{\zeta_L(n_R + n_L)\}. \tag{22}$$

We now want to express the difference in the welfare in our aggregate economy, i.e., the welfare when the lagging region is decisive (is in the majority) less the welfare when the leading region is decisive (is in the majority). This difference is given by subtracting the RHS of equation (22) from the RHS of equation (21). Doing this, we get

$$2(\zeta_L - \zeta_R) + (\zeta_R + \zeta_L)\{\log(\zeta_R) - \log(\zeta_L)\}. \tag{23}$$

Now recall that we have $\zeta_L > \zeta_R$. This tells us that the first term in (23) is positive and that the second term is negative. The alternating signs of these two terms in the expression in (23) describe the tradeoff between what we can think of as "preference matching" on the one hand and the "duplication of costs" on the other. The general ambiguity of the expression in (23) notwithstanding, it is possible to shed more light on this expression in some special cases. To illustrate this point, we now focus on one particular case. Suppose that

$$\frac{\zeta_L-\zeta_R}{\zeta_R+\zeta_L} > \left|\frac{1}{2}\log\left(\frac{\zeta_R}{\zeta_L}\right)\right|. \tag{24}$$

In words, the ratio on the left-hand-side (LHS) of (24) is larger than the absolute value of the logarithmic term on the RHS. In this case, the difference in welfare is *positive* when the lagging region, which places a lower value on higher education but is larger, is decisive and hence can impose its preference about the provision of higher education in the aggregate economy. This completes our game-theoretic analysis of heterogeneity and the provision of a public good in leading and lagging regions.

7. Empirical Evidence

We have worked with a theoretical framework that looks at a leading and a lagging region as a part of an aggregate economy or, put differently, as an *integrated whole*. In particular, we have avoided analyzing either a leading or a lagging region in isolation. This line of thinking is entirely consistent with the position taken in the World Bank's 2009 *World Development Report: Reshaping Economic Geography.* As pointed out by Lall *et al.* (2009, p. 152), this report clearly contends "that policies should focus on integrating lagging and leading regions---and not be exclusively concerned with stimulating growth in lagging regions."

Second, we have emphasized the importance of *heterogeneity* in our modeling framework and have studied two kinds of heterogeneity. Specifically, the leading and the lagging regions in our model are different in terms of their populations and in terms of the values they place on the public good under study. Lall's (1999, p. 723) empirical work on leading and lagging regions in India supports our emphasis; he notes that "leading…and lagging regions are not homogeneous but are structurally different and need to be examined separately." Similarly, Rodriguez-Pose and Wilkie (2019, p. 5) point out that "No two regions, lagging or otherwise, are identical; they differ along socioeconomic, political, structural, and institutional lines."

Finally, we have pointed to the importance of providing public goods in leading as well as in lagging regions although, as our analysis shows, how much is provided depends on the specific nature of the provision decision. The empirical work of Lall (1999) on leading and lagging regions in India supports this perspective. He demonstrates that the provision of public goods (in his case economic infrastructure) "[appears] to influence economic productivity and social welfare…" (p. 719). For other conceptual and empirical studies that describe the importance of public goods for leading and particularly lagging regions, the reader should consult Liu (2016), OECD (2018), and Dittmar and Meisenzahl (2019).

8. Conclusions

In this paper, we analyzed how two kinds of heterogeneity affected the *decentralized* and the *centralized* provision of a public good such as higher education in an aggregate economy consisting of a leading and a lagging region. Specifically, the *size* of the populations in the two regions and the *value* individuals in these two regions placed on providing the public good in their region were dissimilar. We obtained two basic conclusions. First, under decentralization, there existed several circumstances in which it was optimal for only one region to provide the public good. Second, under centralization, this exclusive provision was not optimal but the amount of the public good provided could be larger or smaller than the amount provided under decentralization.

Our research tells policymakers to be cognizant of two key points. First, when pondering the provision of a public good in an aggregate and integrated economy, it is important to consider the *administrative level* at which the decision is being made. In centralized provision, majority voting makes sense but the use of this procedure will “shut out” the wishes of the smaller (in population) region. Second, in decentralized provision, so called “corner solutions” in which one regions gets none of the public good can arise. In fact, a scenario in which a lagging region is characterized by a “corner solution” may be of some concern because this may be indicative of the continued dependence of the lagging region on the leading region.

The analysis in this paper can be extended in a number of different directions. Here are two potential extensions. First, it would be useful to analyze the provision of a public good such as higher education in a model of an aggregate economy with at least three regions and where citizens are able to migrate between these regions when they believe there are quality differences in the public good across the different regions. Second, it would also be helpful to model regional characteristics in addition to differential population sizes and public good valuations to see how these additional attributes influence the provision of a particular public good. Studies that analyze these aspects of the underlying problem about economic differences between leading and lagging regions will provide additional insights into the nexuses between remote versus central location on the one hand and the efficient provision of public goods on the other.

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