The Magnification of a Lagging Region's Initial Economic Disadvantages on the Balanced Growth Path

Batabyal, Amitrajeet and Nijkamp, Peter

Department of Economics, Rochester Institute of Technology, JADS, Den Bosch, Netherlands

15 January 2019

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by

Amitrajeet A. Batabyal[2]

and

Peter Nijkamp[3]

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For their helpful comments on a previous version of this paper, we thank the Editor-in-Chief Yoshiro Higano, two anonymous reviewers, and participants in The Regional Science Academy Workshop in the Lulea University of Technology, Lulea, Sweden, in June 2018, the Annual Meeting of the Regional Science Association International's Japan Section in Hokkai-Gakuen University, Sapporo, Japan, in October 2018, and the Annual Conference of the North American Regional Science Council, San Antonio, Texas, in November 2018. In addition, Batabyal acknowledges financial support from the Gosnell endowment at RIT. The usual disclaimer applies.

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Department of Economics, Rochester Institute of Technology, 92 Lomb Memorial Drive, Rochester, NY 14623-5604, USA. E-mail: aabgsh@rit.edu

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Tinbergen Institute, Amsterdam, The Netherlands, A. Mickiewicz University, Poznan, Poland, and JADS, Sint Janssingel 92, 5211 DA's-Hertogenbosch, The Netherlands. E-mail: p.nijkamp@jads.nl

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Abstract

We analyze aspects of long run economic growth in stylized lagging and leading regions. Both regions use physical capital, research and development (R&D), and knowledgeable workers to produce a final consumption good. The lagging region faces two key economic disadvantages. Specifically, the constant fractions of the output of the final consumption good that are saved to enhance the stocks of physical capital and R&D are assumed to be *twice* as large in the leading region as they are in the lagging region. In this scenario, we perform three tasks. First, we determine the ratio of the balanced growth path (BGP) value of output per knowledgeable worker in the leading region to its value in the lagging region. Second, we ascertain the ratio of the BGP value of R&D per knowledgeable worker in the leading region to its value in the lagging region. Finally, we show the extent to which the lagging region's initial economic disadvantages are *magnified* on the BGP and then discuss some policy implications.

Keywords: Economic Growth, Lagging Region, Leading Region, Magnification Effect

JEL Codes: R11; O18

1. Introduction

1.1. Overview of the issues

Economists and regional scientists have both demonstrated that irrespective of whether one looks at a developed or a developing country, there are a number of inequalities between the various regions that make up the country under consideration. This understanding has given rise to great interest in analyzing the attributes of so called *lagging* and *leading* regions. As noted by Batabyal and Nijkamp (2014a), in this dichotomy, lagging regions are generally not dynamic, they are often rural or peripheral, they are technologically backward, and they display slow rates of economic growth. In contrast, leading regions are typically dynamic, they are often urban, they are technologically more advanced, and they display relatively rapid rates of economic growth.

The work of Baumol (1986), Lucas (1988), Kochendorfer-Lucius and Pleskovic (2009), and Alexiades (2013) tells us that the subject of lagging and leading regions is actually part of a broader literature on spatial disparities. A general theme emphasized by this literature is the *variability* or *divergence* in regional economic performance. In addition, this literature has also stressed the causal mechanisms that are responsible for persistent inequality between regions and the policy instruments one might use to ameliorate this inequitable state of affairs.

A perusal of the literature on spatial disparities makes it clear that if we are to shed meaningful light on regional differences then we need to first comprehend economic and geographical factors such as initial conditions, labor market inefficiencies, the availability of public services, labor mobility across regions, and technological change. As such, in this paper, we study how relatively small *initial differences* (at time $t = 0$) in the physical capital and the research and development (R&D) stocks between stylized lagging and leading regions lead to substantially *magnified* differences on the balanced growth path (BGP) for these two regions. Put differently, we demonstrate the extent to which the lagging region's initial economic disadvantages are *magnified* on the BGP. However, before we do this, let us first briefly review the pertinent literature.

1.2. Literature review

Desmet (2000) studies a perfect foresight model of an economy consisting of a lagging and an advanced region. In his model, externalities in the acquisition of skills cause specialization and uneven regional development. The upshot of this model feature is that when a new technology is introduced, this introduction can either reinforce or reverse the observed uneven regional development. Kalirajan (2004) focuses on India and notes that if one is to boost economic growth and promote growth spillovers from the leading to the lagging states, then it is necessary to pay attention to the quality of human capital in the various states. Nocco (2005) studies lagging and leading regions in terms of their initial technological gap and differences in what she calls trade costs. She studies conditions for the existence of interregional knowledge spillovers and notes that high trade costs result in the agglomeration of the modern sector in the leading region.

Desmet and Ortin (2007) examine uneven development in a model with two regions and two sectors. In their model, whether the lagging or the leading region benefits from technological change is uncertain. Because of the presence of this kind of uncertainty, these researchers show that it may make sense for the lagging region to remain underdeveloped. Becker *et al.* (2013) focus on the chronic shortages of labor in the lagging or remote regions of Queensland in

Australia. They point out that because it is difficult to attract and retain labor in these remote regions, it is essential that communities and businesses work together to overcome these acute labor shortages.

How might one promote economic development in the lagging regions of Germany? This question is studied by Alecke *et al.* (2013). On the basis of their empirical analysis, these authors contend that regional policy that concentrates on improving the productivity of the available labor ends up promoting economic development. Dawid *et al.* (2014) analyze the impact that policies designed to foster technology adoption and improve the human capital stock have on the economic performance of what they call stronger and weaker regions. They show that the impact of such policies depends greatly on the extent to which the labor markets in the two regions are integrated. Specifically, when the two labor markets are fully integrated, human capital stock improvement policies have positive (negative) effects on the stronger (weaker) region.

Batabyal and Nijkamp (2014b) analyze the economic performance of lagging and leading regions when there is a technology gap between these two regions. Their analysis demonstrates that despite the existence of the technology gap, on the BGP, the physical to effective human capital ratio is identical in both regions. Finally, Mitze *et al.* (2015) use German data to examine the link between collaborative R&D strategies and the innovation performance of small and medium firms in peripheral regions. Their empirical analysis shows that collaboration is important and that pursuing R&D collaboratively leads to higher outcome levels for metrics such as R&D and patent intensity.

We would now like to emphasize three points. First, the many studies discussed in this section have certainly advanced aspects of our understanding of the working of lagging and leading regions in different parts of the world. Second, many of these studies have pointed to the significance of R&D in particular and to innovation more generally in augmenting the economic prospects of the lagging regions being studied. Finally, the above two points notwithstanding, to the best of our knowledge, there are *no theoretical* studies that have analyzed how small *initial differences* in the physical capital and the R&D stocks between stylized lagging and leading regions lead to substantially *magnified* differences on the balanced growth path (BGP) for these two regions. The reader should note that this is the lacuna in the extant literature that we seek to fill with our analysis in the present paper.[4] We now proceed to discuss the specific contributions of our paper.

1.3. Contributions of our paper

Given the gap in the literature that we have just identified, the general objective of our paper is to use an intertemporal model adapted from Batabyal and Nijkamp (2019) to analyze aspects of long run economic growth in stylized lagging and leading regions. To this end, section 2 delineates our model of an aggregate economy that consists of a lagging and a leading region. Both regions use physical capital, R&D, and knowledgeable labor to produce a final consumption good. The lagging region faces two key economic disadvantages. Specifically, the constant fractions of the output of the final consumption good that are saved to augment (i) the stock of physical capital and (ii) the stock of R&D are *twice* as large in the leading region as they are in the lagging region. In other words, the leading region augments its physical capital and R&D stocks by *investing* twice as much as the lagging region. That said, it is important to

4 We recognize that there are many studies on lagging and leading regions. Examples of such studies include, but are not limited to, Batabyal and Beladi (2015a), Brown *et al.* (2017), Batabyal (2018), and Boltho *et al.* (2018). That said, the point is not that such studies do not exist. Instead, our point here is twofold. First, there are a relatively small number of studies that have a direct bearing on the central question that we analyze in this paper. Second, we have cited these relevant studies in the present paper.

comprehend the following four points. First, our central task in this paper is to formally demonstrate *the implications* of a certain set of initial conditions for economic growth on the BGP. These initial conditions concerning the stock of physical capital and the stock of R&D in the lagging and in the leading regions are *exogenous* to the analysis. As such, it is important to recognize that our objective here is *not* to alter these initial conditions or to study how these initial differences can be made to disappear over time. Second, in principle, one implication of our analysis could be that the initial conditions---or history---do not matter in terms of the BGP outcomes but this is *not* what we find. As we show in the remainder of this paper, the initial conditions have a dramatic and magnified impact on the BGP. Third, multiple equilibria are *not* an issue in the model that we analyze in this paper. Finally, note that we are *not* simply saying that "lower savings rates lead to lower gdp per capita." Instead, what we are doing is quantifying exactly how differences in initial conditions between the lagging and the leading regions lead to magnified effects on the BGP and hence to *divergence*. This notion of divergence is not just a theoretical curiosum but instead a practical policy concern. To see this, consider a finding of a recent World Bank report---see Farole *et al.* (2018, p. 38, emphases added)---that focuses on lagging regions in Europe. This report clearly says that "[t]he recent experience of *regional divergence* is not strictly a cyclical phenomenon. There are structural forces at play which are likely to push toward further divergence in the coming years…Among the most powerful of these divergent forces are *technology* and demography."

Section 3.1 in our paper computes the ratio of the BGP value of output per knowledgeable worker in the leading region to its value in the lagging region. Section 3.2 ascertains the ratio of the BGP value of R&D per knowledgeable worker in the leading region to its value in the lagging region. Section 4 first comments on the extent to which the lagging region's initial economic disadvantages are *magnified* on the BGP and then it discuss the policy implications of our research. Section 5 concludes and then discusses three ways in which the research delineated in this paper might be extended.

2. The Theoretical Framework

Consider an aggregate economy consisting of a lagging and a leading region. We denote the leading region with the subscript L and the lagging or *remote* region with the subscript R. In principle, these two regions can be different from each other in a variety of ways. That said, in the interest of mathematical tractability and to obtain concrete results, we shall model and analyze only two kinds of differences in this paper. The nature and the magnitude of these differences are fleshed out in the following three paragraphs.

At any time t, both regions produce a final consumption good denoted by $Y(t)$ and we suppose that the price of this good is normalized to unity at all points in time. This final consumption good is produced with three essential inputs.[5] As noted by Woo *et al.* (2017), differences in physical capital frequently characterize leading and lagging regions. To account for this point, the first essential input is physical capital $K(t)$. Many researchers such as Inzelt and Szerb (2006) and Cutrini and Valentini (2017) have pointed out that differential R&D levels are also an important way of distinguishing between lagging and leading regions. Therefore, we model this feature by supposing that the second essential input is R&D denoted by $D(t)$.[6] Finally, since people with distinct levels of knowledge are a significant part of both lagging and

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By "essential" we mean that if the value of any one of these three inputs is set equal to zero then the value of output is also zero. In other words, there is no way to produce output without using positive amounts of all three inputs.

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Our modeling of R&D as a stock variable is not without precedent. In this regard, note that Ulku (2004), Shanks and Zheng (2006), and Hall *et al.* (2010) have all studied R&D *stocks* in different settings.

leading regions, we assume that the third essential input is knowledgeable labor $A(t)L(t)$, where $A(t)$ is knowledge and $L(t)$ denotes raw labor.[7]

The production function for the output $Y(t)$ of the final consumption good in each region is given by the Cobb-Douglas functional form

$$Y(t) = K(t)^{\alpha} D(t)^{\beta} \{A(t)L(t)\}^{1-\alpha-\beta}, \tag{1}$$

where the parameters $\alpha > 0, \beta > 0$, and $\alpha + \beta < 1$.[8] The equations of motion for the inputs that are used to produce the final consumption good are given by the differential equations

$$\frac{dA(t)}{dt} = \dot{A}(t) = \gamma A(t), \tag{2}$$

$$\frac{dL(t)}{dt} = \dot{L}(t) = \nu L(t), \tag{3}$$

$$\frac{dK(t)}{dt} = \dot{K}(t) = s_K Y(t) - \delta K(t), \tag{4}$$

and

$$\frac{dD(t)}{dt} = \dot{D}(t) = s_D Y(t) - \delta D(t), \tag{5}$$

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7 The knowledge variable strengthens the raw labor variable in a multiplicative manner and hence the product of these two variables represents what we are calling "knowledgeable labor." Put differently, knowledgeable labor is the outcome of raw labor augmenting knowledge. Note that the knowledge variable of interest here is *distinct* from the R&D that we have discussed previously. Therefore, there is *no* double counting whatsoever of R&D. Finally, we would like to point out that approaches that are similar to the approach we employ in this paper to study knowledgeable labor have been used previously in the literature by Batabyal and Beladi (2015b, 2015c).

8 To obtain closed-form expressions for two salient ratios in section 3, it will be necessary to work with specific values of the share parameters α and β. As such, in section 3 we assume that $\alpha = 1/3$ and that $\beta = 1/2$.

where we have $\gamma > 0, \nu > 0$, and $\delta > 0$.[9] Equations (2) and (3) tell us that the stocks of knowledge $A(t)$ and raw labor $L(t)$ in both regions grow exponentially over time. Similarly, equations (4) and (5) describe the intertemporal evolution of the stocks of physical capital and R&D.[10]

The heterogeneity in the two regions under study is captured by the coefficients $s_K \in (0,1)$ and $s_D \in (0,1)$. In words, s_K (s_D) is the *constant* fraction of the output of the final consumption good that is *saved* to augment the stocks of physical capital (R&D). The leading region is different from the lagging region in two key ways. Specifically, the constant fractions of the output of the final consumption good that are saved to enhance the physical capital and R&D stocks are twice as large in the leading region (L) as they are in the lagging region (R). In symbols, we have $s_{KL} = 2s_{KR}$ and $s_{DL} = 2s_{DR}$.[11] The time $t = 0$ or initial values of the inputs $A(0), D(0), K(0)$, and $L(0)$ are assumed to be given exogenously and they are all positive.

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In the equations of motion described by equations (2)-(5), the stock variables do *not* depend explicitly on time. As such, these differential equations are autonomous. Note that this feature of our model is *not* atypical at all because it is very common to work with this sort of autonomous formulation in the growth theory literature. See the many examples in either Acemoglu (2009) or Romer (2012) for a more detailed corroboration of this point.

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Because $\alpha + \beta < 1$ in our model, this model is characterized by decreasing returns to scale and hence it is not an endogenous growth model. If, in contrast, we specify that $\alpha + \beta = 1$ then there would be constant returns to scale and the model would become an endogenous growth model. See Mankiw *et al.* (1992) for additional details on this point and see Romer (1986), Coe and Helpman (1995), and Jones (1995) for additional perspectives on, *inter alia*, the role of R&D in promoting economic growth. That said, for the central question that we wish to study in this paper---described in the last paragraph of section 1.2---it is *not* necessary to analyze an endogenous growth model. Finally, although the results of all theoretical papers depend on the assumptions made and on the modeling strategy utilized, we have tried to be as general as possible in our analysis while making the minimum number of assumptions to obtain tractable results. In this regard, we note that our use of the Cobb-Douglas production function in equation (1) is *not* unusual at all and that many papers in the growth theory literature also use this production function. See Mankiw *et al.* (1992) for a prominent example. See Romer (2012) for a textbook example of the repeated use of Cobb-Douglas production functions to study questions concerning economic growth.

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We realize that the analysis we conduct in this paper is based, in part, on using explicit numerical values for the α and the β parameters and that the two constant savings fractions are twice as large in the leading region as they are in the lagging region. We adopt this approach because of two reasons. First, consistent with our observation in footnote 8, it is *not* possible to illustrate the working of our model without using numerical values for *some* parameters and, in this regard, we have kept our use of numerical values to a minimum. Second, we use the "twice as large" values for the two constant savings fractions to help build intuition. We believe that it is easier to comprehend the impacts of "doubling differences" in initial conditions than it is to understand the effects of arbitrary differences in initial conditions. That said, we would like to point out that the magnification results we discuss in section 4 below are *general* in the sense that they hold for any positive integer $z > 2$ and not just for $z = 2$ or the "doubling" case. Finally, the reader should note that the practice of illustrating the working of a model with actual numbers is not without precedent. For instance, in their well-known paper on the empirics of economic growth, Mankiw *et al.* (1992) use actual numerical values for some of their model parameters to obtain results and to demonstrate the working of their model.

Finally, let the values of output, physical capital, and R&D per knowledgeable laborer or worker (the so called intensive values) be given by $y(t) = Y(t)/A(t)L(t)$, $k(t) = K(t)/A(t)L(t)$, and $d(t) = D(t)/A(t)L(t)$. This concludes the formal description of our theoretical framework. We now proceed to first compute the ratio of the BGP value of *output* per knowledgeable worker in the leading region to its value in the lagging region and then we calculate the ratio of the BGP value of $R\&D$ per knowledgeable worker in the leading region to its value in the lagging region.[12]

3. Output and R&D Ratios

3.1. The output ratio

Observe that because knowledge $A(t)$ is the same in the lagging and in the leading region, we can compare the outputs of the final consumption good per knowledgeable laborer or worker. To do this, we proceed in three steps. First, substitute equation (1) into the definition of $y(t)$ given in the preceding paragraph to obtain a ratio expression for $y(t)$. Second, use the definitions of $k(t)$ and $d(t)$ from the previous paragraph to rewrite the ratio expression for $y(t)$ obtained in the first step. Finally, cancel the term $A(t)L(t)$ from the numerator and the denominator of the ratio expression obtained in step 2. This gives us

$$y(t) = k(t)^{\alpha} d(t)^{\beta}. \tag{6}$$

To make further progress, it will be necessary to work with the BGP values of $k(t)$ and $d(t)$. Let us denote these values by k^{BGP} and d^{BGP}. To obtain these two values, we shall modify equations (21) and (24) in Batabyal and Nijkamp (2019). Modifying equation (21), we get

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Using the methodology of Batabyal and Nijkamp (2019), it can be shown that the economies of the leading and the lagging regions converge to a unique BGP. In other words, a BGP equilibrium in both economies exists.

$$d^{BGP} = s_K^{\frac{\alpha}{1-\alpha-\beta}} s_D^{\frac{1-\alpha}{1-\alpha-\beta}} \{\frac{1}{\delta+\gamma+\nu}\}^{\frac{1}{1-\alpha-\beta}}. \tag{7}$$

Similarly, modifying equation (24), we get

$$k^{BGP} = s_K^{\frac{1-\beta}{1-\alpha-\beta}} s_D^{\frac{\beta}{1-\alpha-\beta}} \{\frac{1}{\delta+\gamma+\nu}\}^{\frac{1}{1-\alpha-\beta}}. \tag{8}$$

Now observe that because knowledge $A(t)$ is the same in the lagging and in the leading region, we can compare the outputs of the final consumption good per knowledgeable worker in the two regions. Using equation (6), the ratio of the output of the final consumption good on the BGP in the leading region L to the lagging region R is given by

$$\frac{y_L^{BGP}}{y_R^{BGP}} = \left\{\frac{k_L^{BGP}}{k_R^{BGP}}\right\}^{\alpha} \left\{\frac{d_L^{BGP}}{d_R^{BGP}}\right\}^{\beta}. \tag{9}$$

We now use the assumption that $\alpha = 1/3$ and that $\beta = 1/2$. Hence we can substitute these two numerical values into equations (8) and (7). Doing this, we get

$$k^{BGP} = s_K^3 s_D^3 \left\{\frac{1}{\delta+\gamma+\nu}\right\}^6 \tag{10}$$

and

$$d^{BGP} = s_K^2 s_D^4 \left\{\frac{1}{\delta+\gamma+\nu}\right\}^6. \tag{11}$$

To make further progress with the model, we proceed in two steps. First, let us substitute equations (10) and (11) into equation (9). This gives us the ratio expression $y_L^{BGP}/y_R^{BGP} = \{s_{KL}s_{DL}/s_{KR}\,s_{DR}\}\{s_{KL}s_{DL}^2/s_{KR}\,s_{DR}^2\}$. Second, we utilize the two basic ways in which the leading region (L) is different from the lagging region (R). As noted in section 2, these key differences are described by the conditions $s_{KL} = 2s_{KR}$ and $s_{DL} = 2s_{DR}$. Substituting these two equations in the preceding ratio expression, we get

$$\frac{y_L^{BGP}}{y_R^{BGP}} = 32. \qquad (12)$$

Our next task in this third section is to examine how initial differences in s_K and s_D between the leading and the lagging regions impact the ratio of the BGP value of R&D per knowledgeable worker in these two regions.

3.2 The R&D ratio

We can compare the magnitudes of R&D per knowledgeable worker in the two regions because knowledge $A(t)$ is, once again, the same in the two regions. Now, using the methodology of section 3.1---see equation (11)---we get $d_L^{BGP}/d_R^{BGP} = s_{KL}^2 s_{DL}^4/s_{KR}^2 s_{DR}^4$. As in section 3.1, the heterogeneity between the leading and the lagging regions is described by the conditions $s_{KL} = 2s_{KR}$ and $s_{DL} = 2s_{DR}$. Therefore, substituting these two equations in the preceding ratio expression, we obtain

$$\frac{d_L^{BGP}}{d_R^{BGP}} = 64. \qquad (13)$$

We are now in a position to discuss the policy implications of the results contained in the two equations (12) and (13).

4. Discussion

We first focus on equation (12). The result in this equation describes one potent way in which initial differences in the two savings rates (s_K, s_D) between the leading and the lagging regions matter. In particular, we see that even though the leading region saves only twice the amount that the lagging region does to augment the stocks of physical capital and R&D, this 2-fold initial difference between the two regions leads to a *32-fold* difference in the BGP output per knowledgeable worker between these same two regions. In other words, relatively *small* initial differences in the two investment rates translate into a greatly *magnified* effect on the BGP value of output per knowledgeable worker.

Next, let us concentrate on the result contained in equation (13). This result demonstrates a second potent way in which initial differences in the two savings rates (s_K, s_D) in the leading and in the lagging regions affect BGP outcomes. In particular, we see that even though the leading region saves only twice the amount that the lagging region does to enhance the stocks of physical capital and R&D, this 2-fold initial difference between the two regions leads to a *64-fold* difference in the BGP value of R&D per knowledgeable worker between these same two regions. Consistent with our discussion in the preceding paragraph, once again we see that relatively *small* initial differences in the two savings rates translate into a greatly *magnified* effect on the BGP values of R&D per knowledgeable worker.

This comparative exercise leads to five policy implications. First, for a given region, *ceteris paribus*, increasing the proportion of the output of the final consumption good that is used to augment either the stock of physical capital or the stock of R&D *now* will lead to greatly magnified benefits in terms of increased output and R&D per knowledgeable worker *later*.[13] Second, consider a remote or peripheral region that is lagging behind a leading region in terms of output and R&D per knowledgeable worker. For such a remote region to get ahead, it will need to *increase* the two savings rates denoted by s_K and s_D. Third, an increase in the value of any one of the parameters (δ, γ, ν) will tend to reduce output on the BGP and hence setting policy to *reduce* the values of one or more of these three parameters is likely to raise BGP output in both the lagging and the leading regions.[14]

Fourth, we have not modeled spillovers---such as migration---between the leading and the lagging regions under study. Permitting such spillovers, possibly by improving transport links between the lagging and the leading regions, is likely to narrow the economic gap between these two regions.[15] Finally, the size of the magnification effect on output and R&D that we have been discussing thus far can be ascertained by a policymaker for the general case of a *z-fold initial* difference between the pertinent savings rates in a given lagging and a leading region. In this regard, suppose we have $s_{KL} = zs_{KR}$ and $s_{DL} = zs_{DR}$ where z is any positive integer bigger than two. In this case, routine calculations show that $y_L^{BGP}/y_R^{BGP} = z^5$ and that $d_L^{BGP}/d_R^{BGP} = z^6$. In words, suppose that the constant fractions of the output of the final consumption good that

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The point of this first policy implication is not to emphasize the obvious. In other words, we are *not* just saying that "saving and investing more leads to higher output." Instead, we are pointing to an explicit magnification effect on the BGP and we are also quantifying the exact nature of this magnification effect.

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Having stated this third policy conclusion, we would like to point out that in general, it is unlikely that an apposite regional authority will be able to control any one of these three parameters.

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We reiterate that our primary objective in this paper is to demonstrate how small differences in initial conditions that separate a leading and a lagging region can lead to dramatic and magnified impacts on the BGP. The reader should understand that our objective is *not* to study how spillovers such as migration or the potential movement of physical capital between two regions might affect economic growth on the BGP in these same two regions. That is why we do *not* study spillovers in this paper. Our modeling of the two savings fractions s_D and s_K as constants in the open interval (0, 1) is not without precedent. See, for instance, Mankiw *et al.* (1992) and Batabyal and Nijkamp (2019) for additional details on this point. Finally, the idea that allowing flows from one region to another can reduce disparities is *not* something that was believed to be true in the 1950s only. In fact, we now have evidence---see, for instance, Giannetti (2002)---that under some conditions, knowledge flows between regions can actually *reduce* disparities between them.

are saved to augment the physical capital and R&D stocks are z times as large in the leading region as they are in the lagging region. Then as far as output (R&D) per knowledgeable worker on the BGP is concerned, this z-fold initial difference will get magnified to a z raised to the fifth (sixth) power difference in the long run. This completes our discussion of the magnification of a lagging region's initial economic disadvantages on the BGP.

5. Conclusions

In this paper, we studied aspects of long run economic growth in stylized lagging and leading regions. The two regions studied used physical capital, R&D, and knowledgeable workers to produce a final consumption good. The lagging region faced two key economic disadvantages. In particular, the constant fractions of the output of the final consumption good that were saved to augment the stocks of physical capital and R&D were *twice* as large in the leading region as they were in the lagging region. In this setting, we performed three tasks. First, we determined the ratio of the BGP value of output per knowledgeable worker in the leading region to its value in the lagging region. Second, we ascertained the ratio of the BGP value of R&D per knowledgeable worker in the leading region to its value in the lagging region. Finally, we showed the extent to which the lagging region's initial economic disadvantages were *magnified* on the BGP and then discussed some policy implications.

The analysis in this paper can be extended in a number of different directions. Here are three possible extensions. First, consistent with the discussion in section 4, it would be useful to introduce one or more spatial spillovers into the model and then examine whether spillovers are able to attenuate the magnification effects that we demonstrated here. Second, we know that many lagging regions are rural and that they possess amenities that are largely absent in leading regions that are urban. As such, it would be helpful to analyze the impact that amenities have in mitigating economic disparities between lagging and leading regions over time. Finally, potentially using the methodology in Oladi and Gilbert (2011), one could analyze economic growth in leading and lagging regions when these regions are also open economies. Studies that analyze these aspects of the underlying problem about economic differences between lagging and leading regions will provide additional insights into the nexuses between remote versus central location on the one hand and sustainable economic growth on the other.

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