Artificial Intelligence Based Technologies and Economic Growth in a Creative Region[1]

by

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

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Artificial Intelligence Based Technologies and Economic Growth in a Creative Region

Abstract

We analyze aspects of economic growth in a stylized, high-tech region Γ with two distinct features. First, the residents of this region are high-tech because they possess skills. Using the language of Richard Florida, these residents comprise the region's creative class and hence they possess creative capital. Second, the region is high-tech because it uses an artificial intelligence (AI)-based technology and we explicitly model the use of this technology. In this setting, we first derive expressions for three growth related metrics. Second, we use these metrics to show that the economy of high-tech region Γ converges to a balanced growth path (BGP). Third, we compute the growth rate of output per effective creative capital unit on this BGP. Fourth, we study how heterogeneity in initial conditions influences outcomes on the BGP by introducing a second high-tech region Δ into the analysis. At time $t = 0$, two key savings rates in region Γ are twice as large as in region Δ. We compute the ratio of the BGP value of income per effective creative capital unit in region Γ to its value in region Δ. Finally, we compute the ratio of the BGP value of skills per effective creative capital unit in region Γ to its value in region Δ.

Keywords: Artificial Intelligence, Creative Capital, Creative Class, Economic Growth, Skills

JEL Codes: R11; O33

1. Introduction

1.1. Preliminaries

The 21st century has witnessed an unprecedented surge in technological advancements, with artificial intelligence (AI) emerging as a transformative force across various sectors (Korinek and Stiglitz 2021). The integration of AI-based technologies into regional economies has sparked significant changes, leading to increased efficiency, innovation, and economic growth (Li *et al*. 2022).

One of the primary ways in which AI contributes to regional economic growth is through enhanced productivity (Czarnitzki *et al*. 2023). The automation of routine tasks, data analysis, and decision-making processes enables businesses to operate more efficiently. As AI-based technologies continue to evolve, industries can optimize their operations, reduce costs, and allocate resources more effectively. This heightened productivity, in turn, leads to increased output and economic expansion.

In manufacturing, for example, AI-powered robotics streamline production processes, resulting in higher output levels and improved product quality (Hedelind and Jackson 2011). This not only boosts the competitiveness of local industries but also attracts foreign investment, fostering economic growth within a region. Similarly, the incorporation of AI in agriculture through precision farming techniques maximizes crop yields, contributing to food security and supporting rural economies (Bhat and Huang 2021).

AI acts as a catalyst for innovation, fostering a climate conducive to entrepreneurship and economic development. Start-ups and established businesses alike leverage AI technologies to create novel products and services, disrupting traditional industries and generating economic value (Brem *et al*. 2023). Regions that actively embrace AI-driven innovation often experience a surge in entrepreneurial activities, leading to job creation and economic diversification. In addition, the ability of AI-based technologies to augment rather than replace human capabilities has led to the creation of new job opportunities (Jarrahi *et al*. 2022). As a result, roles such as AI specialists, data scientists, and machine learning engineers have become integral components of the evolving job market. This means that regions that actively support the development of these skills are likely to witness a positive correlation between workforce transformation and economic growth.

Given this background about AI-based technologies, consider two significant points made by the urbanist Richard Florida (2002, 2005). First, regions that want to thrive economically in this era of globalization need to do all they can to attract members of the creative class.[5] Second, attracting these members is important because they possess creative capital, which is the "intrinsically human ability to create new ideas, new technologies, new business models, new cultural forms, and whole new industries that really [matter]" (Florida, 2005, p. 32). Put differently, the creative capital possessing members of the creative class are a basic driver of regional economic growth and development.

If one subscribes to this Floridian view of regional economic growth and development then it seems natural to ask about the prospects for regional economic growth when entrepreneurial creative class members use transformative AI-based technologies to manufacture knowledge goods in a region. Will the use of AI-based technologies contribute positively to economic growth? If yes then what are the properties of this kind of growth? Finally, can one say

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5 The creative class "consists of people who add economic value through their creativity" (Florida, 2002, p. 68). This class is composed of professionals such as doctors, lawyers, scientists, engineers, university professors, and, notably, bohemians such as artists, musicians, and sculptors.

anything meaningful quantitatively about the impact that the use of AI-based technologies is likely to have on regional growth? We maintain that even though these are very interesting questions to analyze from a research perspective, unfortunately, to the best of our knowledge, they have received *no* theoretical attention in the regional science literature. Therefore, we now proceed to briefly review the related issues that have been addressed in the literature and then we state our specific objectives in this paper.

1.2. Literature review and objectives

1.2.1. Review

In a relatively early "taking stock" paper, Openshaw (1992) first reviews the development of AI methods in the late 1980s and the early 1990s and then discusses how these developments can improve our understanding of pattern description, relationship seeking, and genetic optimization. Moore (1994) shows how associative memory techniques drawn from the AI literature can be gainfully employed to identify the parameters of dynamical systems.

Tolidis and Dimopoulou (2012) focus on land use planning and land policy in mountainous areas. They point out that AI-based tools give rise to multiple benefits for multi-site land use allocation procedures. Chain *et al*. (2019) assess the literature on interindustry interdependence and the geographical concentration of firms. They point out that what they call the traditional methods of regional science are increasingly been supplanted by techniques from spatial statistics, econophysics, and AI.

Leigh *et al*. (2020) study some of the ways in which advances in robotics and AI-based technologies have influenced jobs in economies. Their analysis reveals that robots have contributed positively to manufacturing employment at the metropolitan level in the United States. Schintler and McNeely (2022) analyze the nature of the relationship between urban resilience and AI, coupled with big data. Can regions use AI to further the goal of specializing in green technologies? Cicerone *et al*. (2023) contend that the answer is yes, but only if the region under consideration is already somewhat specialized in green technologies.

Li *et al*. (2023) study whether AI is related to the higher performance of new ventures in emerging economies. Using panel data, these authors demonstrate that having what they call an AI orientation is positively related to new venture performance. Finally, Calzada *et al*. (2023) empirically explore what it means for the citizens of a city to have the right to have digital rights where digital rights include the right to adopt AI.

Our review of the contemporary literature on the use of AI-based technologies in a variety of regional settings yields two basic conclusions. First, this literature is overwhelmingly either empirical or based on case studies. Second, this literature has paid virtually *no* theoretical attention to the connections between the use of AI-based technologies and economic growth in a region that is creative in the sense of Richard Florida.

1.2.2. Objectives

Given this lacuna in the literature, in this paper, we analyze aspects of economic growth in a stylized, high-tech region with two distinct features. The modeled residents of this region are themselves high-tech because they possess skills. Put differently, these residents comprise the region's creative capital possessing creative class. In addition, the region under study is high-tech because it uses an AI-based technology and we model the use of this technology.

We describe our dynamic model which is adapted from Mankiw *et al.* (1992) and Batabyal and Nijkamp (2019) and then we derive analytic expressions for three growth related metrics. Second, we use these metrics to show that the economy of high-tech region Γ converges to a balanced growth path (BGP). Third, we compute the growth rate of output per effective creative capital unit on this BGP. Fourth, we study how heterogeneity in initial conditions affects outcomes on the BGP by introducing a second high-tech region Δ into the analysis. At time $t = 0$, two key savings rates in region Γ are twice as large as in region Δ. We compute the ratio of the BGP value of income per effective creative capital unit in region Γ to its value in region Δ. Finally, we compute the ratio of the BGP value of skills per effective creative capital unit in region Γ to its value in region Δ.

The remainder of this paper is organized as follows. Section 2 describes our theoretical model of high-tech region Γ in detail. Section 3.1 derives analytic expressions for three growth related metrics. Section 3.2 first uses these metrics to demonstrate that the economy of high-tech region Γ converges to a BGP and then computes the growth rate of output per effective creative capital unit on this BGP. Section 3.3 computes the BGP values of the AI-based technology and skills per effective creative capital unit. Section 4.1 starts the study of heterogeneity in initial conditions. Specifically, this section first introduces a second high-tech region Δ into the analysis. At time $t = 0$, two salient savings rates in region Γ are set twice as large as in region Δ. In this setting, this section computes the ratio of the BGP value of income per creative capital unit in region Γ to its value in region Δ. For the values of the four savings rates in section 4.1, section 4.2 computes the ratio of the BGP value of skills per creative capital unit in region Γ to its value in region Δ. Section 5 concludes and then discusses three ways in which the research presented in this paper might be extended.

2. The Theoretical Structure

Consider a stylized creative region that we denote by Γ. At any time t, this region produces a high-tech good that is produced, *inter alia*, by using an AI-based technology. Examples of such goods include, but are not limited to, smartphones, autonomous vehicles, and smart speakers and personal assistants. AI-based technologies are integrated into the production of smartphones to augment features such as facial recognition and camera capabilities. These devices use AI-based algorithms for image processing, language understanding, and personalization. The manufacture of autonomous vehicles relies heavily on AI-based technologies. From the design and simulation phases to the production of components, AI-based technologies play a key role. Advanced driver-assistance systems (ADAS) and self-driving capabilities are made possible through the integration of AI-based technologies in the production process. Finally, smart speakers and personal assistants such as Amazon's Alexa or Google Assistant, are produced using AI-based technologies. Natural language processing (NLP) and machine learning algorithms enable these devices to comprehend and respond to user commands, making them an integral part of "smart" home ecosystems.

Let us denote the output of the high-tech good under consideration by $Y(t)$. This high-tech good is also the final consumption good whose price is normalized to unity at all points in time. To clearly model the nexus between the creative class and the working of creative regions discussed in section 1, we assume that the high-tech good mentioned above is produced by creative capital units $C(t)$ working with an AI-based technology denoted by $A(t)$. In addition, we suppose that the total amount of *skills* possessed by the individual creative capital units is given by $S(t)$.[6] Along with the AI-based technology in our creative region, we presume that there also exists a different kind of technology or *knowledge* and that this knowledge enhances or

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[6] The skills or $S(t)$ we have in mind represent characteristics that the individual creative capital units possess that are specific to the high-tech good $Y(t)$. Hence, the possession of these skills enables the individual creative capital units to produce this high-tech good efficiently. One possible source of these skills is ongoing research and development (R&D) about the high-tech good under study. When looked at in this way, even though we are not modeling R&D directly, we are describing an upshot of this R&D.

makes more productive the individual creative capital units. Let us denote this creative capital enhancing knowledge by $K(t)$ and let $K(t)C(t)$ denote an *effective* creative capital unit.

The output $Y(t)$ of the high-tech good is given by a production function that has the Cobb-Douglas form. We can write this function as

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

where the parameters $\alpha > 0, \beta > 0$, and $\alpha + \beta < 1$.[7] The equations of motion for the four factors of production that are used to manufacture the high-tech good are given by the differential equations

$$\frac{dK(t)}{dt} \equiv \dot{K}(t) = gK(t), \tag{2}$$

$$\frac{dC(t)}{dt} \equiv \dot{C}(t) = nC(t), \tag{3}$$

$$\frac{dA(t)}{dt} \equiv \dot{A}(t) = \zeta_A Y(t) - \delta A(t), \tag{4}$$

and

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The way in which we have modeled the impact of the AI-based technology $A(t)$ on the output of the high-tech good $Y(t)$ is distinct. As noted by Gries and Naude (2022), there are other ways of modeling the impact of AI-based technologies on the production of final consumption goods. One such approach is the task-approach to labor markets initiated by Autor (2013).

$$\frac{dS(t)}{dt} \equiv \dot{S}(t) = \zeta_S Y(t) - \delta S(t), \tag{5}$$

and we have $g > 0, n > 0$, and $\delta > 0$.

In our subsequent analysis, we shall be particularly interested in the coefficients $\zeta_A \in (0, 1)$ and $\zeta_S \in (0, 1)$. Specifically, ζ_A is the *constant* proportion of the output of the final consumption good that is *saved* to create a more powerful AI-based technology in creative region Γ. Similarly, ζ_S is the *constant* proportion of the output of the final consumption good that is *saved* to create more skills in the same region. The initial values of the four factors of production $K(0), A(0), C(0)$, and $S(0)$ are given exogenously and they are all positive. Finally, let the values of output, the AI-based technology, and skills per effective creative capital unit (sometimes called the intensive values) be given by $y(t) = Y(t)/K(t)C(t)$, $a(t) = A(t)/K(t)C(t)$, and $s(t) = S(t)/K(t)C(t)$. This concludes the description of our stylized creative region. We now proceed to derive closed-form expressions for three growth related metrics and these metrics are $y(t), \dot{a}(t)$, and $\dot{s}(t)$.

3. One Creative Region

3.1. Three growth metrics

3.1.1. An expression for y(t)

Our first task is to derive an expression for output per effective creative capital unit or $y(t)$ as a function of the AI-based technology per effective creative capital unit $a(t)$ and skills per effective creative capital unit $s(t)$. Substituting equation (1) into the definition of $y(t)$, we get

$$y(t) = \frac{A(t)^{\alpha} S(t)^{\beta} \{K(t)C(t)\}^{1-\alpha-\beta}}{K(t)C(t)}. \tag{6}$$

Now using the definitions of $a(t)$ and $s(t)$ given above, we can rewrite equation (6) as

$$y(t) = \frac{\{K(t)C(t)a(t)\}^{\alpha}\{K(t)C(t)s(t)\}^{\beta}\{K(t)C(t)\}^{1-\alpha-\beta}}{K(t)C(t)}. \tag{7}$$

Canceling the term $K(t)C(t)$ from the numerator and the denominator of equation (7), we obtain the expression for $y(t)$ that we seek. That expression is

$$y(t) = a(t)^{\alpha}s(t)^{\beta}. \tag{8}$$

3.1.2. *An expression for the derivative $\dot{a}(t)$*

Taking the derivative of both sides of the defining equation for $a(t)$ with respect to time t, we get

$$\dot{a}(t) = \frac{\dot{A}(t)K(t)C(t) - A(t)\{\dot{K}(t)C(t) + K(t)\dot{C}(t)\}}{\{K(t)C(t)\}^2}. \tag{9}$$

Utilizing the definition $a(t) = A(t)/K(t)C(t)$ we can rewrite equation (9) to give us

$$\dot{a}(t) = \frac{\dot{A}(t)}{K(t)C(t)} - \left\{\frac{\dot{K}(t)}{K(t)} + \frac{\dot{C}(t)}{C(t)}\right\}a(t). \tag{10}$$

Substituting from equations (2), (3), and (4) into equation (10) and then rewriting, we get

$$\dot{a}(t) = \zeta_A y(t) - (g + n + \delta)a(t). \tag{11}$$

Let us now substitute the value of $y(t)$ from equation (8) into equation (11). This gives us the expression for $\dot{a}(t)$ that we seek. Specifically, we obtain

$$\dot{a}(t) = \zeta_A a(t)^{\alpha} s(t)^{\beta} - (g + n + \delta)a(t). \tag{12}$$

3.*1.3. An expression for the derivative* $\dot{s}(t)$

Let us begin by differentiating both sides of the defining equation for skills per effective creative capital unit or $s(t)$ with respect to time t. Doing this, we get

$$\dot{s}(t) = \frac{\dot{S}(t)K(t)C(t) - S(t)\{\dot{K}(t)C(t) + K(t)\dot{C}(t)\}}{\{K(t)C(t)\}^2}. \tag{13}$$

Using the definition $s(t) = S(t)/K(t)C(t)$, equation (13) can be rewritten as

$$\dot{s}(t) = \frac{\dot{S}(t)}{K(t)C(t)} - \left\{\frac{\dot{K}(t)}{K(t)} + \frac{\dot{C}(t)}{C(t)}\right\} s(t). \tag{14}$$

Now, substituting from equations (2), (3), and (5) into equation (14) and then rewriting, we obtain

$$\dot{s}(t) = \zeta_S y(t) - (g + n + \delta)s(t). \tag{15}$$

Let us now substitute the value of $y(t)$ from equation (8) into equation (15). This gives us the expression for $\dot{s}(t)$ that we seek. That expression is

$$\dot{s}(t) = \zeta_S a(t)^{\alpha} s(t)^{\beta} - (g + n + \delta)s(t). \tag{16}$$

This completes the derivation of analytic expressions for $y(t)$, $\dot{a}(t)$, and $\dot{s}(t)$. Our next task is to demonstrate that the economy of creative region Γ converges to a BGP and to then calculate the growth rate of output per creative capital unit on the BGP.

3.2. BGP convergence

To demonstrate that creative region Γ converges to a BGP, we need to first comprehend the attributes of the set of points in (a, s) space where $\dot{a}(t) = \dot{s}(t) = 0$. To this end, let us first work with equation (12). To obtain the $\dot{a}(t) = 0$ locus, we set the right-hand-side (RHS) of this equation equal to zero and then perform a couple of steps of algebra to isolate $a(t)$. Doing this, we obtain

$$a(t) = [\zeta_A\{g + n + \delta\}^{-1}]^{1/(1-\alpha)} s(t)^{\beta/(1-\alpha)}. \tag{17}$$

We can now use equation (17) to calculate the first and the second derivatives of $a(t)$ with respect to $s(t)$. Doing this, we deduce that $da(t)/ds(t) > 0$ and that $d^2a(t)/ds(t)^2 < 0$. These last two results together tell us that the $\dot{a}(t) = 0$ locus is upward sloping and *concave* in (a, s) space.

We work with equation (16) next. To find the $\dot{s}(t) = 0$ locus, we set the RHS of this equation equal to zero and then isolate $s(t)$. Doing this, we get

$$a(t) = [\zeta_S^{-1}\{g + n + \delta\}]^{1/\alpha} s(t)^{(1-\beta)/\alpha}. \tag{18}$$

Once again, we use equation (18) to ascertain the first and the second derivatives of $a(t)$ with respect to $s(t)$. Upon finishing the needed calculations, we observe that $da(t)/ds(t) > 0$ and that $d^2a(t)/ds(t)^2 > 0$. Given the signs of these two derivatives, we infer that the $\dot{s}(t) = 0$ locus is upward sloping and *convex* in (a, s) space.

The information we have just ascertained about the $\dot{a}(t) = 0$ and the $\dot{s}(t) = 0$ loci can be presented together in a phase diagram. This is shown in figure 1. This figure clearly

Figure 1 about here

demonstrates that the economy of creative region Γ converges to a stable BGP at the point marked E. Inspecting this figure, we obtain three additional results. First, if we exclude the origin where $a = s = 0$, we see that the stable BGP at point E is *unique*. Second, $a(t) = A(t)/K(t)C(t)$ is constant on the BGP. This tells us that the AI-based technology per creative capital unit or $A(t)/C(t) = a(t)K(t)$ must be growing at the *same* rate as the creative capital enhancing technology or knowledge, which is g. Third, skills per effective creative capital unit or $s(t) = S(t)/K(t)C(t)$ is also constant on the BGP. Hence, skills per creative capital unit or $S(t)/C(t) = s(t)K(t)$ must also be growing at the *same* rate as the creative capital augmenting technology, which is, once again, g.

Our last task in this section is to compute the growth rate of output per creative capital unit on the above described BGP. To do so, we divide both sides of the production function given in equation (1) by $C(t)$. This gives us

$$\frac{Y(t)}{C(t)} = \{\frac{A(t)}{C(t)}\}^{\alpha}\{\frac{S(t)}{C(t)}\}^{\beta} K(t)^{1-\alpha-\beta}. \quad (19)$$

We already know that the ratios $A(t)/C(t)$, $S(t)/C(t)$, and the creative capital enhancing technology $K(t)$ all grow at rate g on the BGP. Also, the production function in equation (1) displays constant returns to scale. These last two points collectively tell us that the output of the high-tech good per creative capital unit in creative region Γ also grows at rate g on the BGP. We now move on to calculate the BGP values of the AI-based technology and skills per effective creative capital unit in terms of the savings rates ζ_A, ζ_S, and the other parameters of our model.

3.3. BGP values of a(t) and s(t)

We begin by denoting the two BGP values we seek by $a^{BGP}$and s^{BGP} respectively. Upon solving equations (17) and (18) simultaneously, we obtain

$$\{s^{BGP}\}^{\frac{1-\beta}{\alpha}-\frac{\beta}{1-\alpha}} = [\zeta_A\{g+n+\delta\}^{-1}]^{\frac{1}{1-\alpha}}[\zeta_S\{g+n+\delta\}^{-1}]^{\frac{1}{\alpha}}. \quad (20)$$

Observe that the exponent on s^{BGP} in equation (20) can be written as $(1-\alpha-\beta)/\{\alpha(1-\alpha)\}$. Hence, raising both sides of equation (20) to the reciprocal of this rewritten exponent, we obtain our desired expression for s^{BGP} as a function of ζ_A, ζ_S, and the other parameters of the problem. That expression is

$$s^{BGP} = \zeta_A^{\frac{\alpha}{1-\alpha-\beta}}\zeta_S^{\frac{1-\alpha}{1-\alpha-\beta}}[\{g+n+\delta\}^{-1}]^{\frac{1}{1-\alpha-\beta}}. \quad (21)$$

To find the equivalent expression for a^{BGP}, we substitute the expression for s^{BGP} from equation (21) into equation (17). This gives us

$$a^{BGP} = \zeta_A^{\frac{1}{1-\alpha}}[\{g+n+\delta\}^{-1}]^{\frac{1}{1-\alpha}}[\zeta_A^{\frac{\alpha}{1-\alpha-\beta}}\zeta_S^{\frac{1-\alpha}{1-\alpha-\beta}}[\{g+n+\delta\}^{-1}]^{\frac{1}{1-\alpha-\beta}}]^{\frac{\beta}{1-\alpha}}. \tag{22}$$

After a couple of steps of uncomplicated but tedious algebra, equation (22) can be rewritten as

$$a^{BGP} = \zeta_A^{\frac{1-\alpha-\beta+\alpha\beta}{(1-\alpha)(1-\alpha-\beta)}}\zeta_S^{\frac{\beta}{1-\alpha-\beta}}[\{g+n+\delta\}^{-1}]^{\frac{1-\alpha-\beta+\beta}{(1-\alpha)(1-\alpha-\beta)}}. \tag{23}$$

The exponent on ζ_A in equation (23) can be simplified because $(1-\alpha-\beta+\alpha\beta) = (1-\alpha)(1-\beta)$. Using this simplification, we get the sought after expression for a^{BGP} as a function of the savings rates ζ_A, $\zeta_{S,}$ and the other parameters of the problem. That expression is

$$a^{BGP} = \zeta_A^{\frac{1-\beta}{1-\alpha-\beta}}\zeta_S^{\frac{\beta}{1-\alpha-\beta}}[\{g+n+\delta\}^{-1}]^{\frac{1}{1-\alpha-\beta}}. \tag{24}$$

Our next task is to analyze the effect of heterogeneity in certain initial conditions on the BGP values of some key variables.

4. Two Creative Regions

4.1. Ratio of BGP value of income per effective creative capital unit in region Γ to region Δ

To study the impact of heterogeneity, we now focus on two creative regions. These two regions are region Γ, which we have been studying thus far, and a second creative region Δ. Creative region Δ is different from creative region Γ in two important ways. Specifically, both ζ_A and ζ_S are twice as large in region Γ as in region Δ. To conduct the inquiry below in an analytically tractable manner, it will be necessary to make two assumptions. To this end, we first assume that apart from the differences in regions Γ and Δ that we have just mentioned, these two regions are identical in all other aspects. Second, we assume that $\alpha = 1/3$ and $\beta = 1/2$ in the remainder of this section.

Observe that because the creative capital enhancing technology $K(t)$ is the same in both the regions under study, we can compare the output of the high-tech (and final consumption) good per effective creative capital unit. Using equation (8), the ratio of the output of the high-tech good on the BGP in creative region Γ to creative region Δ is given by

$$\frac{y_{\Gamma}^{BGP}}{y_{\Delta}^{BGP}} = \{\frac{a_{\Gamma}^{BGP}}{a_{\Delta}^{BGP}}\}^{\alpha}\{\frac{s_{\Gamma}^{BGP}}{s_{\Delta}^{BGP}}\}^{\beta}. \quad (25)$$

From the discussion above, we know that $\alpha = 1/3$ and that $\beta = 1/2$. Hence, substituting these two values in equations (24) and (21), we get

$$a^{BGP} = \zeta_A^3 \zeta_S^3 [\{g + n + \delta\}^{-1}]^6 \quad (26)$$

and

$$s^{BGP} = \zeta_A^2 \zeta_S^4 [\{g + n + \delta\}^{-1}]^6. \quad (27)$$

Now, substituting equations (26) and (27) into equation (25) and then rewriting, we get

$$\frac{y_{\Gamma}^{BGP}}{y_{\Delta}^{BGP}} = \left\{\frac{\zeta_{A\Gamma}\zeta_{S\Gamma}}{\zeta_{A\Delta}\zeta_{S\Delta}}\right\}\left\{\frac{\zeta_{A\Gamma}\zeta_{S\Gamma}^2}{\zeta_{A\Delta}\zeta_{S\Delta}^2}\right\}. \quad (28)$$

By assumption, we have $\zeta_{A\Gamma} = 2\zeta_{A\Delta}$ and $\zeta_{S\Gamma} = 2\zeta_{S\Delta}$. Except for these two key differences, the economies of creative regions Γ and Δ are identical in every other way. Therefore, substituting these assumptions about the two savings rates in equation (28), we get $y_{\Gamma}^{BGP}/y_{\Delta}^{BGP} = 32$.

This result plainly demonstrates one powerful way in which initial differences in the two savings rates in the two creative regions matter. In particular, we see that even though creative region Γ saves only twice the amount that creative region Δ does to create a more powerful AI-based technology and skills, this 2-fold initial difference between the two regions leads to a *32-fold* difference in the BGP output per effective creative capital unit between these same two regions. In other words, relatively *minor* initial differences in the two savings rates translate into a substantially *amplified* impact on the BGP values of output per effective creative capital unit.

The extent to which a region is creative can be measured by looking at the skills possessed by the various creative capital units in this region. In this regard, it is true that existing regions generally differ in the extent to which they are creative and this difference can be ascribed to, *inter alia*, dissimilar skill acquisition processes. Therefore, consistent with the comparative exercise carried out in this section, we can examine how initial differences in ζ_A and ζ_S across the two regions Γ and Δ influence the ratio of the BGP value of skills per effective creative capital unit in these same regions. We now move on to answer this query.

4.2. Ratio of BGP value of skills per effective creative capital unit in region Γ to region Δ

Let us begin by recognizing that it is possible to compare the amount of skills per effective creative capital unit in the two creative regions because the creative capital enhancing technology $K(t)$ is, once again, the same in both regions. Using equation (27), the BGP ratio of skills in region Γ to those in region Δ is given by

$$\frac{s_{\Gamma}^{BGP}}{s_{\Delta}^{BGP}} = \frac{\zeta_{A\Gamma}^{2}\zeta_{S\Gamma}^{4}}{\zeta_{A\Delta}^{2}\zeta_{S\Delta}^{4}}. \tag{29}$$

As in section 4.1, we postulate that $\zeta_{A\Gamma} = 2\zeta_{A\Delta}$ and that $\zeta_{S\Gamma} = 2\zeta_{S\Delta}$. Substituting these four values into equation (29), we get $s_{\Gamma}^{BGP}/s_{\Delta}^{BGP} = 64$.

This result demonstrates a second powerful way in which initial differences in the two savings rates in the two creative regions affect BGP outcomes. In particular, we see that even though creative region Γ saves only twice the amount that creative region Δ does to create a more powerful AI-based technology and skills, this 2-fold initial difference between the two regions leads to a *64-fold* difference in the BGP value of skills per effective creative capital unit between these same two regions. Consistent with the finding in section 4.1, once again we see that relatively *minor* initial differences in the two savings rates translate into a substantially *amplified* impact on the BGP values of skills per effective creative capital unit.

The policy implications of the comparative exercises in this and the preceding section for creative regions are threefold. First, for a given creative region, *ceteris paribus*, increasing the proportion of the output of the final consumption good that is used to generate a more powerful AI-based technology and skills in the creative capital units *now* will result in substantially *amplified* benefits in terms of increased output and skills per effective creative capital unit *later*. Second, consider a creative region that is lagging behind another creative region in terms of output and skills per effective creative capital unit. For such a region to get ahead, it will need to *increase* the two constant proportions or, equivalently, the two savings rates denoted by ζ_A and

ζ_S.[8] Finally, the size of the amplification effect on output and skills that we have been discussing thus far can be easily calculated by a policymaker in a creative region for the general case of a *z-fold initial* difference between the relevant savings rates in any two creative regions. To this end, suppose that we have $\zeta_{A\Gamma} = z\zeta_{A\Delta}$ and $\zeta_{S\Gamma} = z\zeta_{S\Delta}$ where z is any arbitrary positive integer that is greater than two. In this instance, straightforward calculations reveal that $y_\Gamma^{BGP}/y_\Delta^{BGP} = z^5$ and that $s_\Gamma^{BGP}/s_\Delta^{BGP} = z^6$. This completes our discussion of the nexuses between creative capital, an AI-based technology, and economic growth in creative regions.

5. Conclusions

In this paper, we examined the connections between creative capital, an AI-based technology, and economic growth in a stylized creative region Γ. We first described our model and then derived closed-form expressions for three growth related metrics. Second, we used these metrics to demonstrate that the economy of creative region Γ converged to a BGP and then we calculated the growth rate of output per effective creative capital unit on this BGP. Third, we computed the BGP values of the AI-based technology and skills per effective creative capital unit. Fourth, we analyzed how heterogeneity in initial conditions affected outcomes on the BGP by bringing into the analysis, a second creative region Δ. At time $t = 0$, two key savings rates in region Γ were twice as large as in region Δ. In this scenario, we calculated the ratio of the BGP value of income per effective creative capital unit in region Γ to its value in region Δ. Finally, for

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[8] Instead of working with the two savings rates, if we wanted to explore the impact that differences in productivity parameters such as g have on, say, the BGP output ratio studied in section 4.1 then one way to proceed would be as follows. First, for consistency, let $\alpha = 1/3$ and $\beta = 1/2$. Second, for analytical tractability, let $\zeta_{A\Gamma} = \zeta_{A\Delta}$ and $\zeta_{S\Gamma} = \zeta_{S\Delta}$. Finally, let $(g + n + \delta)_\Gamma = 2(g + n + \delta)_\Delta$. Because $(g + n + \delta)$ in creative region Γ is *twice* its corresponding value in creative region Δ, we expect BGP output in region Γ to be *lower* than the BGP output in region Δ. But how much lower? Using the above numerical assumptions, calculations of the sort performed in section 4.1 tell us that $y_\Gamma^{BGP}/y_\Delta^{BGP} = 1/32$. In words, even though $(g + n + \delta)$ in creative region Γ is twice what it is in creative region Δ, this relatively minor initial difference leads to a 1/32 contraction in the BGP output of creative region Γ relative to creative region Δ.

the same values of the four savings rates, we calculated the ratio of the BGP value of skills per effective creative capital unit in region Γ to its value in region Δ.

One can extend the analysis contained in this paper in several directions. One of the questions concerning the use of AI-based technologies is that their impacts on regional economic growth and development are likely to be probabilistic and *not* deterministic. As such, it would be useful to analyze an extension of the model used in this paper where the effects of using an AI-based technology on output are stochastic. Second, it would be useful to study policies that regional authorities can pursue to *diminish* the rather dramatic growth-related amplification effects we demonstrated here. Finally, in our model (see equation (1)) all four factors of production $\{A(t), S(t), K(t), C(t)\}$ were *essential* for producing the high-tech good $Y(t)$. In other words, it was not possible to produce the high-tech good by using none of the creative capital input $C(t)$. As such, it would be useful to ascertain whether there exist scenarios in which it makes economic sense to *substitute* an AI-based technology for the creative capital input, either at a point in time or over time. Studies that analyze these aspects of the underlying problem in creative regions will provide additional insights into the nexuses between alternate technological and regulatory factors on the one hand and sustainable economic growth and development on the other.

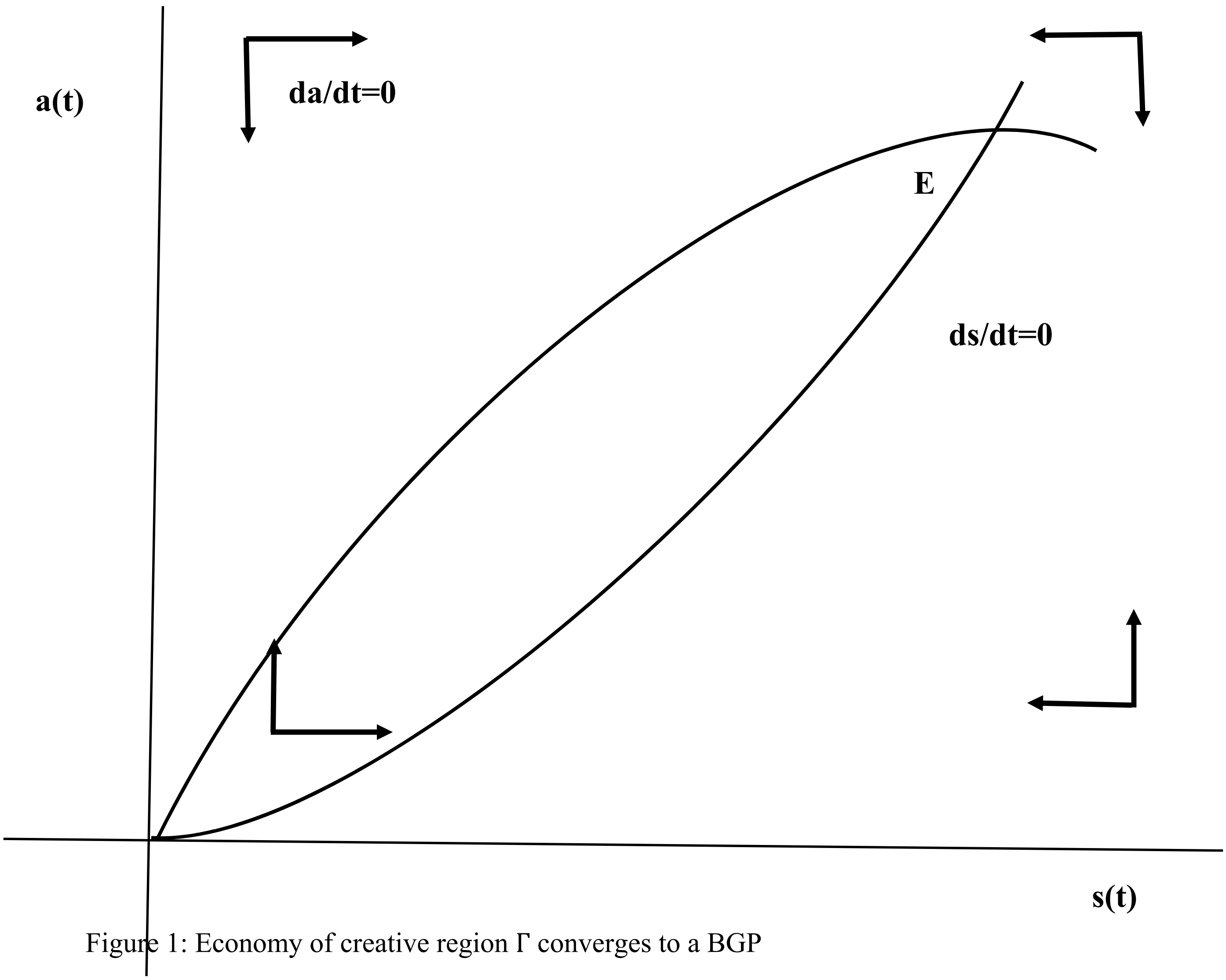

Figure 1: Economy of creative region Γ converges to a BGP

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