

Contents lists available at [ScienceDirect](#)

Research in Economics

journal homepage: www.elsevier.com/locate/rie

Endogenous human capital formation, distance to frontier and growth

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ARTICLE INFO

Article history:

Received 11 January 2013

Accepted 12 November 2013

Available online 26 November 2013

Keywords:

Economic growth

Endogenous labor composition

Imitation–innovation

Convergence

Wage inequality

ABSTRACT

We examine human capital's contribution to economy-wide technological progress through two channels – imitation and innovation – innovation being more skill-intensive than imitation. We develop a growth model based on the endogenous ability-driven skill acquisition decision of an individual. It is shown that skilled human capital is growth enhancing in the “imitation-innovation” regime and in the “innovation-only” regime whereas unskilled human capital is growth enhancing in the “imitation-only” regime. Steady state exists and, in the long run, the economy converges to the world technology frontier. In the diversified regime, technological progress raises the return to ability and generates an increase in wage inequality between and within groups – consistent with the pattern observed across countries.

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1. Introduction

1.1. Background

The relationship between level of education and economic growth has been much debated upon. [Krueger and Lindahl \(2001\)](#) find that education is statistically significant and positively associated with subsequent growth only for countries with lowest levels of education, and is insignificant and negative for countries with middle and high levels of education. That is, an inverted U-shaped relationship is found to exist between the level of education and the growth rate of an economy.¹ The relationship is insignificant when the regression is run for the Organization of Economic Cooperation and Development (OECD) countries alone. This finding is apparently puzzling – basic education helps growth but the relationship between the two dies down as the country progresses in terms of education.

A possible explanation for this phenomenon could be that education favors the adoption of new technologies but the aggregate level of human capital does not matter, or its impact gets weaker as the economy progresses toward the frontier, as noticed by [Nelson and Phelps \(1966\)](#). On the other hand, according to [Romer \(1990\)](#), education favors the innovation of new technologies. But [Nelson and Phelps \(1966\)](#) seem to have ignored the fact that a country can also improve its technology level through innovation, while [Romer \(1990\)](#) overlooks the fact that technology improvement can be possible through imitation from the world technology frontier, especially for a technologically backward economy. [Benhabib and](#)

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¹ This finding is similar to [Durlauf and Johnson \(1995\)](#) and [Kalaitzidakis et al. \(2001\)](#).

Spiegel (1994) and Barro (1998) find that the catch-up component of growth is the dominant factor for the technologically backward economy. To find a possible explanation to the puzzle posed by Krueger and Lindahl (2001), we need to focus on both – economy's distance to the world technology frontier and on the composition of its human capital (as much as on its level).

The cross-country analysis of Vandenbussche et al. (2006) and the cross US-state analysis of Aghion et al. (2009) bring out the role of appropriate institutions in analyzing the relationship between the growth and the composition of human capital in the diversified regime (that is, where an economy performs both imitation and innovation for further technology improvement). Using a theoretical model, they show that skilled human capital has a higher growth-enhancing effect closer to the technology frontier but unskilled human capital is the main source of growth for a technologically backward economy.² Furthermore, Vandenbussche et al. (2006) provide evidence in favor of this prediction using a panel data set covering 19 OECD countries covering the time period 1960 and 2000. Unlike earlier research, they not only take into account the stock of human capital but also its composition, which makes a significant difference to their analysis. They are able to solve the puzzle posed by Krueger and Lindahl (2001) by showing that education has a positive and significant impact on economic growth even for an economy with high level of education. Aghion et al. (2009) confirm the same prediction in respect of cross-US-state panel data.

The main drawback of both these studies is that they assume that there exists an exogenously given composition of skilled–unskilled human capital. They only seem to consider the benefit of skilled human capital and ignore the fact that there is a cost associated with skill acquisition. Also, the growth enhancing composition of skilled human capital cannot be the same for an economy, irrespective of its distance to the frontier. We attempt to fill this important gap by endogenizing skill composition, based on individual's decision to acquire education or not. Di Maria and Stryszowski (2009) also endogenize the composition of human capital in the above discussed setup but the purpose of their analysis is entirely different. They want to examine the impact of migration on the process of growth. They do not characterize the importance of different compositions of human capital on economic growth as we do in this paper. Moreover, the modeling setup of endogenizing the education decision of our model is completely different from Di Maria and Stryszowski (2009). Unlike them, we assume that education decision is not only affected by the cognitive ability of an individual but also by the opportunity cost of education, that is, the outside scope of income of an individual. Furthermore, Aghion et al. (2009) and Vandenbussche et al. (2006) only characterize the intermediate economies, which perform both types of research activities – imitation and innovation. Unlike our research, they are entirely silent about the growth enhancing education policy of sufficiently advanced and backward economies, which may be completely specializing in either imitation or innovation activities alone.

The distinguishing features of our research are

1. Unlike Vandenbussche et al. (2006) and Aghion et al. (2009), we consider heterogeneous agents, and by endogenizing individual's schooling decision, the composition of skilled and unskilled human capital in any time period is ascertained. Further, we characterize the specialized economies – which perform either only-imitation or only-innovation activities.
2. Under the assumption that innovation is skilled human capital-intensive, in the diversified regime, the level of skilled human capital increases and that of unskilled human capital decreases as the economy progresses, ascribable to the rising importance of innovation. However, this increase in the share of skilled human capital in the overall human capital composition is missing in Aghion et al. (2009) and Vandenbussche et al. (2006) works. As a consequence, the shift of both skilled and unskilled human capital from imitation to innovation activity is relatively more pronounced in our case than in their work. Later in Section 3.5.3, we elaborate on how this changes the growth enhancing policy of the diversified regime as prescribed by Aghion et al. (2009) and Vandenbussche et al. (2006). On the other hand, in our research, there exists a fixed composition of skilled and unskilled human capital in the only-imitation and only-innovation regimes, since further technology improvement has a similar impact on both types of human capital.
3. By considering both the cost and the benefit associated with choosing to be skilled, we show that skilled human capital is growth enhancing for an economy which performs both imitation and innovation activities and only-innovation activity, while unskilled human capital is growth enhancing for an economy which performs only-imitation activity. Our findings contradict the policy prescription of Vandenbussche et al. (2006) and Aghion et al. (2009), since according to them, unskilled human capital is growth enhancing for a relatively technologically backward economy, which performs both imitation and innovation activities. They did not characterize the specialized economies – which perform either only-imitation or only-innovation activities. Also, since the motivation of the study is entirely different for Di Maria and Stryszowski (2009), they also do not say anything about the growth enhancing education policy of an economy irrespective of its distance to the frontier. Furthermore, we contradict the theory of Grossman and Helpman (1991) according to whom skilled human capital is growth enhancing whereas unskilled human capital is growth depressing irrespective of the economy's distance to frontier.
4. The dynamics of the stylized economy show that by implementing an appropriate education policy, in the long run an economy will converge to the world technology frontier irrespective of its distance to the frontier.
5. Moreover, in the cone of diversified region, as an economy progresses technologically, the average income of skilled human capital rises while that of unskilled human capital falls. Consequently, this raises the income inequality between skilled and unskilled human capital groups. Since technology improvement has a heterogeneous effect on individuals'

² Here unskilled human capital implies those individuals who have technical skill but do not acquire the general purpose technology. That is individuals with primary/secondary education are considered as an unskilled worker and people with tertiary education as a skilled worker.

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