

NUTRITIONAL LEVEL, PHYSICAL AND HUMAN CAPITAL COMPLEMENTARITY WITHIN LABOR AUGMENTING SOLOW TYPE MODEL

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ABSTRACT

One of important issue in economic growth is whether the convergence occurs. Besides occurrence of convergence, another important problem in the theory of economic growth is whether the growth of output per capita depends on the ratio of physical to human capital (K/H). This paper provides evidence for imbalance effects of (K/H) on growth rate besides convergence issue in a sample of 36 countries. This dependence tends to change in size of convergence rate where with the conditions on (K/H) ratio, convergence rate increases.

Keywords: economic growth; human capital; physical capital, JEL classification: O4

1. INTRODUCTION

We set the importance of physical to human capital ratio in augmenting-labor Solow type model rather than their level. It is believed that the growth of output depends on the physical to human capital ratio. If there is an imbalance effect between physical and human capital then empirically findings of convergence rate would be more accurate. The imbalance effect is symmetric if physical to human capital ratio is significantly below or above its steady-state value. The asymmetric imbalance effect is represented by an asymmetric U-shaped dependence or if the output growth depends equally positively or equally negatively on the physical to human ratio (Duczynski,2003).

Barro and Sala-i-Martin (1995) and Mankiw et.al. (1992) present roundabout evidence that growth depends positively on the physical to human capital ratio. Islam (1995) mentions that the coefficients of human capital proxy are negative in his own findings. Therefore, this negative sign of human capital is considered for applying the physical to human capital ratio in growth study. Ramcharan (2004) and Lee (2007) highlight the complementarities between human capital and physical capital are the characteristic of the production procedure since equipment requires qualified workers to manage them and qualified mechanics to fix them. While contemporary productive agriculture requests an educated agriculture workforce where workers who can read

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instructions on a fertilizer bag, absorb information contained in literature distributed by extension agents and understand the contents of a repair manual for agricultural equipment and modern services require people who can make simple calculations quickly and accurately. If countries that give main concern to physical capital while abandoning its human capital, they will soon realize that the returns to physical capital are lower than they need to be then they will have lower output. Lee (2007) also reveal that introducing improved methods of production, new ways of doing things and introducing more complex and sophisticated products are difficult if buyers, workers and consumers have insufficient training and education to enable them to understand the new technology.

In this paper, we aim to extend the existing evidence by examining the dependence of the per capita output growth for 1990 and 2000 on the initial level of per capita GDP and physical to human capital ratio for 36 countries. We deal with data in the following section. In section 3, we describe the model and we present the results. The last section discusses the conclusions.

2. DATA

We have used data for 1990 and 2000 for 36 countries where 1980' per-capita GDP level data is picked up for starting initial income level. Changing in physical capital to education data is calculated as changing in Electric power consumption (kWh) to Education (E) data (EL/E). Electric power consumption (kWh) shown as (EL) stands for physical capital proxy and Education (E) data is the total educated people who took average Years of School from Educational Attainment of the Aged 15. Total population variables are taken from World Development Indicators to have population growth rate. GDP per capita and total populations and electric power consumption (kWh) are taken from World Bank's World Development Indicators¹. Education (E) data comes from the Barro- Lee data set. Per capita dietary energy supply (DES) is taken from FAO² to calculate the worker effort level.

3. CONVERGENCE

How fast the average poor becomes rich, how fast the average rich becomes poor and whether the poor grows faster than rich and is the subject matter of convergence approach which is widely used in the literature (Barro and Sala-i-Martin, 1995; Levine and Renelt, 1992). Mostly, the convergence occurs conditionally at the rate of two percent per year (Kalyoncu, 1998). We set our model ratio of K/H with labor augmenting technology and the model is defined according to equation (1), (2) and (3), where $0 < \alpha < 1$.

¹ <http://devdata.worldbank.org>

² <http://www.fao.org/News/1998/981204-e.htm>

$$Y = \left(\frac{K}{H}\right)^\alpha (AeL)^{1-\alpha} \tag{1}$$

where Y, e, L, K, H and A stands for output, the average level of worker effort (the effectiveness of labor) in a country, the number of workers, physical capital, human capital and the level of productivity, respectively. α shows the share of physical-human capital in the production function. In terms of model dynamics, A_t , L_t and e_t are growing at a constant rate of g , of n and of γ , respectively.

$$\frac{\dot{A}}{A} = g \text{ and } \frac{\dot{L}}{L} = n \text{ and } \frac{\dot{e}}{e} = \gamma \tag{2}$$

Suppose a fixed fraction of output “s” is invested and the depreciation rate of capital ratio is δ then the dynamics of physical to human capital ratio accumulation is given by:

$$\left(\frac{K}{H}\right)_t = sY_t - \delta \left(\frac{K}{H}\right)_t \tag{3}$$

We show $f(k) = \frac{Y}{eL}$ and $k = \frac{K/H}{AeL}$

$$k = sf(k) - (n + g + \delta + \gamma)k \tag{4}$$

$$\beta = (1-\alpha)(n+g+\delta+\gamma) \tag{5}$$

In terms of panel specification; we should set absolute case in equation (6) and conditional case in equation (7).

$$\frac{1}{T} \ln\left(\frac{y_{it}}{y_{it-T}}\right) = a - \left(\frac{1-e^{-\beta T}}{T}\right) \ln(y_{it-T}) \tag{6}$$

$$\frac{1}{T} \ln\left(\frac{y_{it}}{y_{it-T}}\right) = \left(\frac{1-e^{-\beta T}}{T}\right) \ln(y^*) - \left(\frac{1-e^{-\beta T}}{T}\right) \ln(y_{it-T}) \tag{7}$$

where y^* stands for steady state value of per capita income. Firstly, we set the per capita income with the worker effort level. Therefore, the change in the stock of (K/H) is proxied with (electricity consumption to education data) and we can write steady state per capita income as

$$\ln(y^*) = \ln\left(\frac{Y}{eL}\right)^* = \ln(A) + \frac{\alpha}{1-\alpha} \ln(s) \tag{8}$$

$\ln(A)$ is assumed to be constant, thus, we will show the conditional convergence regression as.

$$\frac{1}{T} \ln \left(\frac{y_t}{y_{t-T}} \right) = \text{Constant} + \frac{\alpha}{1-\alpha} \left[\frac{1-e^{-\beta t}}{T} \right] \text{Ln}(s) - \frac{\alpha}{1-\alpha} \text{Ln}(n+g+\delta+\gamma) \quad (9)$$

$$- \left[\frac{1-e^{-\beta t}}{T} \right] \ln(y_0)$$

$$e^i = (4.34 * 10^{(-4)}) * (x_c^i) - (4.16 * 10^{(-8)}) * (x_c^i)^2 \quad (10)$$

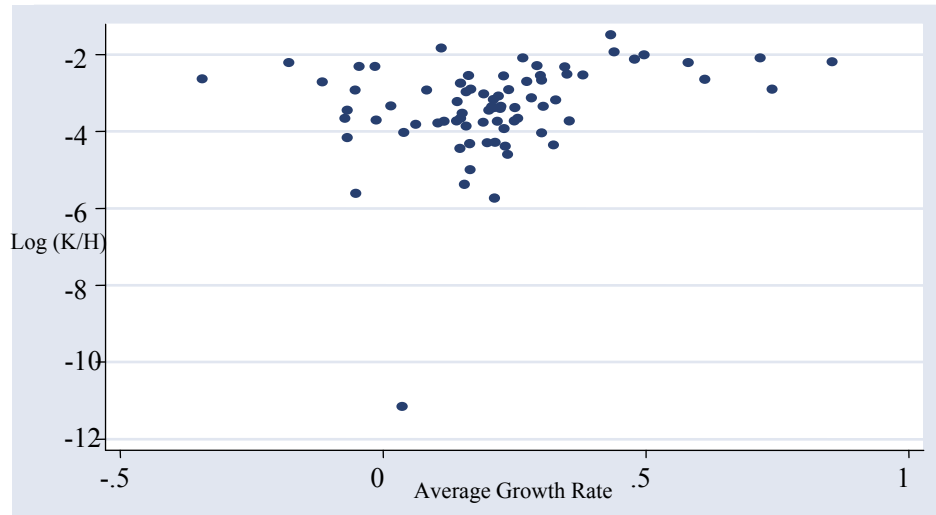
where e_i is efficiency units of labor for worker i and x_c^i is the daily calorie intake at the individual level. It is assumed that all workers are identical in a country, so “ e ” shows countries’ efficiency units of labor from an average worker and x_c denotes DES

Table 1: Convergence and Imbalance Effects (OLS)

Dependent variable: GDP per-capita average growth rate		
$\log(y_{t-T})$	-0.031	-0.073
	(2.04)*	(3.75)**
$\text{Ln}(s)$		0.042
		(2.36)*
$\text{Ln}(n+g+\delta+\gamma)$		-0.089
		(2.57)*
Constant	0.462	0.418
	(3.58)**	(2.08)*
Observations	72	72
R-squared	0.06	0.19
Convergence rate	0.027003	0.054812
Absolute value of t statistics in parentheses * significant at 5%; ** significant at 1%		

We have observed significant absolute convergence and the convergence occurs around 3% per year from 1980 to 2000. Even though the economic growth theory has unclear suggestion concerning the imbalance effect and there is no characteristic growth model in which the production growth depends homogeneously negatively on the (K/H) ratio, our empirical model suggests that there is significantly positive relationship between economic growth and (K/H). The convergence rate increases with the conditions where the rate is 5.5% per year from 1980 to 2000. With (EL/E), convergence rate at least twice greater than the most of findings in literature. One-sector endogenous growth models forecast a U-shaped dependence of production growth on the inverse ratio of physical to human capital (see Barro and Sala-i-Martin, 1995). A related forecast is valid for the growth rate of production of physical goods in two-sector endogenous growth models (such as the Uzawa-Lucas model). On the other hand, for a broad notion of production (if the value of gross investment in human capital is added to the production of physical belongings), the growth rate depends certainly on the inverse ratio of physical to human capital (see Barro

and Sala-i-Martin, 1995). In the figure below, the graph shows positive relationship and no u-shaped interaction



The figure 1: The dependence of average per-capita GDP growth on the ratio of log of (EL/E)

The model restriction is also emphasized as in the equation (11) and the results are shown in Table 2.

$$\frac{1}{T} \ln \left(\frac{y_t}{y_{t-T}} \right) = Constant + \frac{\alpha}{1-\alpha} \left[\frac{1 - e^{-\beta t}}{T} \right] \langle \ln(s) - \ln(n+g+\delta+\gamma) \rangle \quad (11)$$

$$- \left[\frac{1 - e^{-\beta t}}{T} \right] \ln(y_0)$$

Table 2: Restricted Convergence Regression and Imbalance Effects (OLS)

Dependent variable: GDP per-capita average growth rate	
log(y _{t,T})	-0.062
	(3.56)**
Ln(s)- Ln(n+g+δ+γ)	0.051
	(3.15)**
Constant	0.24
	-1.7
Observations	72
R-squared	0.18
Convergence rate	0.048243
Alpha value	0.451327
Convergence rate	
Absolute value of t statistics in parentheses * significant at 5%; ** significant at 1%	

The convergence occurs and the restriction is hold. The coefficient of (K/H) is higher in the restricted model and the convergence rate is lower but the convergence rate is still greater than 2%. Therefore, the alpha level is higher in the restricted model. Overall, with the worker effort consideration for raw labor, the convergence rate is higher than usual findings (Kalyoncu, 1998).

4. CONCLUSION

The main objects of the paper is how well physical to human capital ratio fits in the empirical growth study besides the convergence issue since whether the growth rate of output depends positively or negatively on the ratio of physical to human capital is a fundamental problem in the theory of growth. This paper provides evidence that this dependence tended to be positive in the sample of 36 countries for the years 1990 and 2000. This study's facts may be consistent with two sector models of endogenous growth with large adjustment costs for changing human capital and models of technological diffusion. Examining the direct relationship between the physical to human capital ratio and the output growth seems to fit well, which provide only indirect evidence for the imbalance effect.

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