Roles of Educational and Health Human Capital Accumulation in Economic Growth

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Abstract

Accumulation of human capital plays an essential role in creating economic growth. This article covers two types of human capital: educational and health human capital. Using standard OLS and IV estimations, we examine the growth effects that result from the accumulation of both types of capital. Also, our findings confirm that qualitative factors are important for economic growth, in addition to strictly monetary factors. Interestingly, we also find that health expenditures have a positive impact on growth even in advanced economies.

Keywords: Economic growth; Educational human capital; Health human capital; Qualitative factors.

JEL classification numbers: C21; I10; I20; O40.

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1. Introduction

The role of human capital accumulation in enhancing economic growth is a central issue in research on modern macroeconomics. In this article, we examine the accumulation of two types of human capital: educational and health human capital.

The generation of educational capital is influenced by two key factors. The first factor is investment in education through public and private expenditures. Such investments likely affect the overall quality of school education and contribute to the accumulation of human capital. In this respect, educational investments can be considered a measure of monetary efforts to increase the level of human capital at both the national and individual levels. The second factor is the current level of educational human capital stock, which plays an important role in increasing human capital in the future. For instance, having an educated population increases the amount of education provided in the home by parents. The level of educational human capital also represents an alternative measure of labour quality. Therefore, in our analysis we use the results from an international achievement test by Hanushek and Kimko (2000) as a proxy variable for current educational capital. This variable serves as a qualitative measure of human capital generation.

The present study focuses on educational and health capital and empirically investigates their effects on economic growth. Both educational and health human capital are essential factors in the accumulation of future human capital. As noted above, we consider the qualitative factor of labour force, in addition to the monetary factor of educational investment, in our examination of the evolution of educational capital. Well-known research by Glomm and Ravikumar (1992) specified a concrete mechanism for the accumulation of educational human capital using new growth theory. Consequently, we rely on their specifications as the basis for our empirical model. In their model, the level of individual human capital (E_{t+1}) is defined by three factors:

$$E_{t+1} = f(B, X_t, E_t)$$

where we have eliminated the time fraction for school education from the original model. B, X_t and E_t are the technological efficiency parameter for educational human capital production, the quality level of the education system and the amount of individual human capital accumulated by a person's parents, respectively. Expanding this specification, it is considered that both B and X have become functions of spending on education, s^e, as investment in education directly affects both of these education-related variables. Also, the amount of individual human capital E (i.e., the current level of educational human capital) is captured through test scores in this article.[1] On the basis of these factors, our regression analysis uses the data on educational expenditures and test scores to examine the effects of educational capital on economic growth.

The second key factor we consider in this study is the accumulation of health capital. Except for a few pioneering studies (e.g., Mushkin, 1962), the role of health capital within the economy has not been widely examined in the literature. Only recently has the effect of health capital on economic growth and development been seriously studied (e.g., Knowles and Owen, 1995; McDonald and Roberts, 2002; van Zon and Muysken, 2005). To examine the impact of human capital comprehensively, we focus on health capital accumulation as measured by improvements in health status. In the regression analysis, we use health expenditures as a related variable for the evolution of health capital.

Based on the model of Mankiw *et al.* (1992, hereinafter MRW), a well-known standard framework in growth econometrics, we construct a dataset that differs from related works such as Rivera and Currais (1999a, b) and Webber (2002), and attempt an OLS estimation that explicitly considers both educational (qualitative and quantitative) and health human capital. To consider the probable endogeneity between the health and income (GDP) variables and to check the robustness of the OLS regressions, we then use instrumental variables (IV) estimation on our OLS models.

Finally, although the present study addresses an important issue, we say definitely that the present study is just a preliminary consideration. What seems to be insufficient is as follows:

- **Data and sample.** Due to the characteristics of the data (the OECD Health Data; the data on education quality by Hanushek and Kimko), our dataset is insufficient in terms of sample size and sample period. To improve the reliability of estimation, it is necessary to introduce a panel dataset into our analysis. Moreover, the adequacy of the health variable (health expenditures) calls for further investigation.

- **Object country group.** Although this is associated with the above, it is insufficient to study economic growth with only the limited sample of advanced economies, and thus we need to include developing economies in dataset.

2. Empirical Specification

Following MRW, Knowles and Owen (1995) and others, we present the following empirical

1) To simplify our empirical study, we set aside the subjective factor of individual learning at school and at home.

model. First, the aggregate production function is specified as a standard Cobb–Douglas technology:

$$Y_{it} = K_{it}^{\alpha} H_{it}^{\beta} E_{it}^{\gamma} (A_{it} L_{it})^{1-\alpha-\beta-\gamma} \tag{1}$$

where Y, K, H, E, A and L are aggregate output, physical capital, health human capital, educational human capital, technology and labour force, respectively. The subscripts i and t represent country and time, respectively. The parameters α, β and γ denote the relevant capital shares in the production function ($\alpha > 0$, $\beta > 0$, $\gamma > 0$ and $\alpha + \beta + \gamma < 1$).[2] Here, defining $y \equiv Y/AL$, $k \equiv K/AL$, $h \equiv H/AL$ and $e \equiv E/AL$, we obtain the following production function per effective unit of labour:

$$y_{it} = k_{it}^{\alpha} h_{it}^{\beta} e_{it}^{\gamma} \tag{2}$$

Next, as in MRW and Knowles and Owen (1995), we assume $L_{it} = L_{i0} \exp(n_i t)$ and $A_{it} = A_t = A_0 \exp(gt)$. In each equation, n_i represents the rates of population growth in country i and g represents exogenously given technological progress. By using these equations, we can specify the processes for the accumulation of physical capital, and health and educational human capital in the following equations, respectively:

$$\frac{\mathrm{d}k_{it}}{\mathrm{d}t} = \dot{k}_{it} = s_{it}^{k} y_{it} - (n_{it} + g + d) k_{it} \tag{3}$$

$$\frac{\mathrm{d}h_{it}}{\mathrm{d}t} = \dot{h}_{it} = s_{it}^{h} y_{it} - (n_{it} + g + d) h_{it} \tag{4}$$

$$\frac{\mathrm{d}e_{it}}{\mathrm{d}t} = \dot{e}_{it} = s_{it}^{e} y_{it} - (n_{it} + g + d) e_{it} \tag{5}$$

A fraction of income is assumed to be invested in physical capital (s^k), health human capital (s^h) and educational human capital (s^e). Moreover, d denotes a common depreciation rate for the three types of capital. Resulting from this, Equations 2, 3, 4 and 5 make up our estimation model.

Applying the condition $\dot{k}_{it} = \dot{h}_{it} = \dot{e}_{it} = 0$ to Equations 3, 4 and 5 and considering Equation 2, one can then solve the system of the three equations on k_i^*, h_i^* and e_i^* simultaneously. Therefore, the steady-state values for the three types of capital are

$$k_i^* = \left(\frac{(s_i^k)^{1-\beta-\gamma} (s_i^h)^{\beta} (s_i^e)^{\gamma}}{n_i + g + d} \right)^{1/(1-\alpha-\beta-\gamma)} \tag{6}$$

2) Restrictions on capital shares in the production function are needed to guarantee the existence of steady-state equilibrium in this type of model.

$$h_i^* = \left(\frac{(s_i^k)^{\alpha}(s_i^h)^{1-\alpha-\gamma}(s_i^e)^{\gamma}}{n_i + g + d} \right)^{1/(1-\alpha-\beta-\gamma)} \tag{7}$$

$$e_i^* = \left(\frac{(s_i^k)^{\alpha}(s_i^h)^{\beta}(s_i^e)^{1-\alpha-\beta}}{n_i + g + d} \right)^{1/(1-\alpha-\beta-\gamma)} \tag{8}$$

Henceforth, we define $\phi \equiv 1 - \alpha - \beta - \gamma$ for notational convenience. By using Equation 2 and Equations 6, 7 and 8, we can obtain the alternative expression of the production function per effective labour unit:

$$y_{it} = (s_{it}^k)^{\alpha/\phi}(s_{it}^h)^{\beta/\phi}(s_{it}^e)^{\gamma/\phi} \left(\frac{1}{n_{it} + g + d} \right)^{(\alpha+\beta+\gamma)/\phi} \tag{9}$$

Given the relation $y_{it} = Y_{it} / A_t L_{it}$, taking logarithms on both sides of Equation 9 allows the following equation to be derived:

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) = \ln A_t + \frac{\alpha}{\phi}\ln s_{it}^k + \frac{\beta}{\phi}\ln s_{it}^h + \frac{\gamma}{\phi}\ln s_{it}^e - \frac{\alpha+\beta+\gamma}{\phi}\ln\left(n_{it} + g + d\right) \tag{10}$$

where $\ln A_t = \ln A_0 + gt$. As in numerous empirical studies employing the MRW framework, Equation 10 is the benchmark model for estimation. As noted before, two types of education-related variable are employed in this study: s^e (investment share) and e^* (labour force quality). Equation 10 includes only s^e, therefore, another specification is necessary for our estimation. Solving Equation 8 for s_i^e and substituting it into Equation 10, we obtain

$$\begin{aligned} \ln\left(\frac{Y_{it}}{L_{it}}\right) = \ln A_t + \frac{\alpha}{1-\alpha-\beta}\ln s_{it}^k + \frac{\beta}{1-\alpha-\beta}\ln s_{it}^h + \frac{\gamma}{1-\alpha-\beta}\ln e_i^* \\ - \frac{\alpha+\beta}{1-\alpha-\beta}\ln\left(n_{it} + g + d\right) \end{aligned} \tag{11}$$

As Equation 10 includes the share of educational investment, this can be considered as the *quantitative* specification of education capital, ceteris paribus. In contrast, Equation 11 includes labour force quality and can be viewed as the *qualitative* specification.

To examine the impact on growth of the different types of capital (and other related factors), we need a suitable growth equation that considers transitional dynamics. Let us begin by examining the case of Equation 10. Based on the conversion method used by MRW to convert from level to growth equation, our growth equation that imposes a coefficient constraint is represented by

$$\begin{aligned} \ln\left(\frac{Y_{it}}{L_{it}}\right) - \ln\left(\frac{Y_{i0}}{L_{i0}}\right) = \pi \ln A_0 + gt + \frac{\pi\alpha}{\phi}(\ln s_{it}^k - \ln(n_{it} + g + d)) \\ + \frac{\pi\beta}{\phi}(\ln s_{it}^h - \ln(n_{it} + g + d)) + \frac{\pi\gamma}{\phi}(\ln s_{it}^e - \ln(n_{it} + g + d)) - \pi \ln\left(\frac{Y_{i0}}{L_{i0}}\right) \end{aligned} \tag{12}$$

where $\pi \equiv 1 - \exp(-\lambda t)$.[3] In Equation 12, Y_{i0}/L_{i0} represents real GDP per worker at the initial year and $\lambda = (n + g + d)(1 - \alpha - \beta - \gamma)$ represents the rate of the convergence. Similarly, the second growth equation corresponding to Equation 11 can be written as

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) - \ln\left(\frac{Y_{i0}}{L_{i0}}\right) = \pi \ln A_0 + gt + \frac{\pi\alpha}{1-\alpha-\beta}(\ln s^k_{it} - \ln(n_{it}+g+d)) + \frac{\pi\beta}{1-\alpha-\beta}(\ln s^h_{it} - \ln(n_{it}+g+d)) + \frac{\pi\gamma}{1-\alpha-\beta}\ln e^*_i - \pi\ln\left(\frac{Y_{i0}}{L_{i0}}\right) \tag{13}$$

where π is defined as in Equation 12.[4]

To proceed with the regression analysis, we must specify the estimation equations exactly. Following MRW and others, we now assume $\pi \ln A_0 = a + \epsilon_{it}$, where a is common and constant across countries and ϵ_{it} is a country specific stochastic term. By including gt in a, the following two growth equations can be derived:

$$\Delta \ln \hat{y}_i = a + \beta_1(\ln s^k_{it} - \ln(n_{it}+g+d)) + \beta_2(\ln s^h_{it} - \ln(n_{it}+g+d)) + \beta_3(\ln s^e_{it} - \ln(n_{it}+g+d)) + \beta_4 \ln \hat{y}_{i0} + \epsilon_{it} \tag{14}$$

$$\Delta \ln \hat{y}_i = a + \beta_1(\ln s^k_{it} - \ln(n_{it}+g+d)) + \beta_2(\ln s^h_{it} - \ln(n_{it}+g+d)) + \beta_3 \ln e^*_i + \beta_4 \ln \hat{y}_{i0} + \epsilon_{it} \tag{15}$$

where Δ is the change in the variable from 0 to t and $\hat{y}_i$ corresponds to Y_i/L_i in Equations 12 and 13.[5]

3. Data and Empirical Results

Our dataset includes 24 OECD countries and the sample period is from 1960 to 2000.[6] The dataset is constructed from various sources. Real GDP per worker ($\hat{y}$; 1960 and 2000) and investment share for physical equipment (s^k; 5-year average of 1960–2000) are extracted from

3) The null hypothesis of the constraint is that the sum of the coefficients on $\ln s^k$, $\ln s^h$, $\ln s^e$ and $\ln(n + g + d)$ equals zero. This constraint is tested by F-test (see Table 2). Because of the test results, the constrained model is preferred for all estimations. Consequently, we only report the results of the constrained model in this article.

4) The null hypothesis of the constraint is that the sum of the coefficients on $\ln s^k$, $\ln s^h$ and $\ln(n + g + d)$ equals zero. Thus, the term $\ln e^*$ is free from the constraint in this case.

5) Following the literature, we assume a constant rates of technological progress and a common depreciation for the three types of capital ($g + d = 2 + 3 = 5\%$).

6) These countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

Table 1. Descriptive statistics

Variable	Mean	SD	Min	Max
$\ln(\hat{y}_{2000}/\hat{y}_{1960})$	0.945	0.391	0.239	1.950
s^k (%)	23.244	4.157	13.278	30.924
s^h (%)	7.765	1.714	4.467	12.833
s^e (%)	5.604	0.960	2.900	6.900
e_1^*	49.823	5.718	35.060	60.650
e_2^*	54.904	7.750	37.240	67.060

Note: N=24.

the Penn World Table Version 6.2. The rate of population growth (n; average of 1960–2000), total expenditure on health as a percentage of GDP (s^h; average of 1990, 1995 and 2000) and total public and private expenditure for educational institutions as a percentage of GDP (s^e; average of 1995 and 2000) are from the OECD Health Data 2006. For qualitative information on educational human capital, we use data on labour quality from Hanushek and Kimko's (2000) international achievement test score measures in science and mathematics (e_1^* and e_2^*).[7] Several instrumental variables are also considered, which will be discussed later. Table 1 shows descriptive statistics for the sample.[8]

The baseline estimations are performed with OLS and are corrected by White's heteroskedasticity-consistent covariance matrix. These results are reported in Table 2 in columns (1) through (3). Column (1) corresponds to Equation 14, and columns (2) and (3) correspond to Equation 15. First, since the coefficients of $\ln \hat{y}_0$ are negative and highly significant in columns (1) to (3), we can confirm the conditional convergence property as a commonly observed feature. In both columns (1) and (2), the variable for health expenditures is insignificant, indicating the possibility that many advanced countries have already attained basic public health. In column (1), the rates of investment for education are significant at the 10% level, which shows that educational expenditures have an important role in growth processes even in the advanced countries. In column (2), the qualitative measure of labour force is used instead of the rates of educational investment. The coefficient for $\ln e_1^*$ is highly significant, representing the importance of human capital accumulation *via* education on long-term growth. However, note that in column (3) the variable e_2^* (in place of e_1^*) is

7) Our e_1^* and e_2^* correspond to $QL1^*$ and $QL2^*$ in Hanushek and Kimko (2000), respectively. For a more detailed explanation, see Hanushek and Kimko (2000).

8) A few missing variables are extrapolated by using other year's data from the same source and the World Development Indicators 2007.

Table 2. OLS and IV estimation

Dependent variable: $\Delta \ln \hat{y}$

	(1)	(2)	(3)	(4)	(5)	(6)
Method	OLS	OLS	OLS	IV	IV	IV
Constant	7.857^{a}	4.991^{a}	6.073^{a}	8.035^{a}	5.315^{a}	6.223^{a}
	(1.042)	(1.535)	(1.329)	(1.087)	(1.452)	(1.295)
$\ln \hat{y}_0$	-0.776^{a}	-0.729^{a}	-0.779^{a}	-0.793^{a}	-0.768^{a}	-0.812^{a}
	(0.098)	(0.103)	(0.111)	(0.100)	(0.093)	(0.098)
$\ln s^k/(n+0.05)$	0.436^{b}	0.396^{c}	0.391	0.413^{c}	0.329	0.328
	(0.201)	(0.222)	(0.250)	(0.206)	(0.210)	(0.246)
$\ln s^h/(n+0.05)$	0.333	0.418	0.481^{c}	0.392	0.546^{b}	0.575^{b}
	(0.240)	(0.245)	(0.254)	(0.254)	(0.224)	(0.240)
$\ln s^e/(n+0.05)$	0.395^{c}			0.388		
	(0.216)			(0.227)		
$\ln e_1^*$		0.619^{b}			0.648^{b}	
		(0.282)			(0.273)	
$\ln e_2^*$			0.454			0.511^{c}
			(0.298)			(0.284)
$\bar{R}^2$	0.771	0.766	0.756	0.770	0.763	0.754
$\bar{R}^2$ (first stage)				0.846	0.844	0.854
F-test (p-value)	.566	.521	.527	.702	.807	.695
Sargan test (p-value)				.627	.190	.145
α	0.225	0.257	0.237	0.208	0.200	0.191
β	0.172	0.271	0.291	0.197	0.332	0.335
γ	0.204	0.401	0.275	0.195	0.394	0.298
λ (%)	3.7	3.3	3.8	3.9	3.7	4.2

Notes : N=24. White heteroskedasticity-consistent standard errors are shown in parentheses. Superscripts a, b and c denote significance at the 1%, 5% and 10% levels, respectively. $\bar{R}^2$ at the first stage is the $\bar{R}^2$ when one regresses health expenditures on the relevant instruments. In the Sargan test, the null hypothesis is that instrumental variables have no correlation with the error term.

insignificant, and the rate of investment in health becomes significant, in contrast to columns (1) and (2). From the coefficients of determination and the implied values (α, β, γ and λ) in the OLS part (1) to (3), the overall performance of each estimation seems to be fairly good in comparison with estimations in previous studies. Concentrating on columns (1) and

(2) in particular, we can find that education is more important than investment in health care services for economic growth in advanced countries. Among the education measures used, the qualitative aspect is especially important. This finding is consistent with recent common findings.

Endogeneity (causality) problems often arise between health expenditures and income, which is a potential issue with our analysis. To deal with this problem, we employ instrumental variables (IV) estimation, following Rivera and Currais (1999a, b) and Webber (2002). Initially, we selected food consumption (fruits and vegetables), alcohol consumption, AIDS incidence and percentage of total population 65 years old and over as our instrumental variables. Because of the problem of weak instruments, we only used the last two instruments.[9] The results using the IV estimation are reported in Table 2 in columns (4) to (6).[10]

Initially, our two instruments appeared to be valid upon examination of columns (4) to (6) because of the first-stage $\bar{R}^2$ and the results of the Sargan test. In column (4), the two investment variables on health and education are insignificant, which is contrary to our expectations. However, the estimated coefficients, factor shares and convergence coefficient of column (4) are similar to those of column (1). In regard to the education factor, in column (5) the qualitative variable e_1^* is added in place of the quantitative variable. The health and education variables are highly significant, unlike in column (2), although education has a stronger impact on economic growth than health. The result for the health variable changes significantly as a result of using the instrumental variables. Column (6) shows the result of the IV estimation that includes the alternative measure of education quality (e_2^*) in addition to physical and health capital investments. In comparison with the OLS estimation of column (3), both the size and significance of the health variable are greater and the education variable also becomes significant at the 10% level. Finally, we can also confirm conditional convergence through the estimated coefficients of columns (4) to (6).[11]

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9) For more detailed discussion on the endogeneity problem in growth econometrics, see Temple (1999). Also, on the problem of weak instruments, see Murray (2006).

10) Along with columns (1) to (3), column (4) corresponds to Equation 14 and columns (5) and (6) correspond to Equation 15.

11) The convergence coefficients we obtained in this article lead to somewhat rapid processes of convergence as compared with the early research such as Barro and Sala-i-Martin (1992). The values of our convergence coefficients are reasonable based on more recent research such as Evans (1997).

4．Concluding Remarks

On the basis of this investigation, we would like to conclude with the following three points. First, variables for both health and education capital showed positive effects on growth in the sample countries. First and most importantly, health expenditures had a positive impact on growth even in these advanced countries, which have already ensured a basic level of public health. Further study on this point is necessary. Second, the variables for health and education capital did not show much difference in their effect on growth. Third, we confirmed the importance of including qualitative educational factors based on the evidence of models (2), (5) and (6). For advanced countries in particular, this evidence indicates that it is important to improve education quality through the evaluation of achievement. We expect that the importance of such qualitative factors should also hold for health care services.

As mentioned in the introduction, it must be noted that the results obtained in this study are only preliminary ones. To enhance the reliability of the analysis, the following extension is considered. In general, suitable instrumental variables are difficult to find in growth econometrics. Therefore, the fixed effects estimations under a cross-country panel data are worth attempting as an important alternative.

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