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Human capital and economic growth: Cross-country evidence from low-, middle- and high-income countries

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Abstract: The study examines the relationship between human capital and economic growth by using a cross sectional sample of 106 countries to calculate an average over the period 2002–08. Sensitivity analysis on the core model found that the results are robust in terms of inclusion of relevant variables. However, the returns of human capital vary with countries having different income levels. The study found that the low-income countries can get higher returns than the other countries in case of investing in human capital. The study also tested the hypotheses of unconditional and conditional income convergence across nations. The results indicate that human capital either resists income divergence across nations or supports convergence.

Key words: human capital, economic growth, education, convergence, cross section, sensitivity analysis

I Introduction

Does human capital really affect economic growth in the long run? This question necessitates the incorporation of human capital directly in the growth equation or indirectly as a factor that affects technological progress. In answering the question, there are numerous studies on the determinants of economic growth. However, the quest is still going on. Exogenous as well as endogenous theories of growth acknowledge the effect of human capital on economic growth, though the theoretical channels through which human capital is supposed to affect growth are different.

The theoretical contribution of human capital in growth process is very clear. However, empirical findings have been mixed. There have been several studies conducted on the subject

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by using cross section analysis, time series analysis and by using the panel data approach. However, the results varied greatly under different kinds of specifications. The role of human capital has also been found to be insignificant in some of the studies and strangely enough, human capital is found to be inversely related with growth in some of the studies (Benhabib and Spiegel, 1994; Pritchett, 2001). These unexpected results are generally attributed to be an outcome of the quality of data, measurement issues or the proxy adopted to capture the effect of human capital.

In most of the studies on the subject, human capital is proxied through an education, health, nutrition or experience indicator though none of these are capable to proxy human capital perfectly. The present study is different among all previous studies in that after analyzing the issue at an aggregate level, the study performed a detailed sensitivity analysis by inclusion of the variable approach and the sample size approach on the full sample. The study also performed a sensitivity analysis inclusion of variable approach on the sub-sample of low-income countries.

The article is organized into five sections. Following the introduction, Section II reviews selected literature on the cross-country empirical studies; Section III explains the data and methodology. Section IV analyses the findings of the estimation, and Section V concludes the study.

II Review of literature

Nelson and Phelps (1966) discussed the variation in the marginal product of education in different economies. The authors argued that the usual form of the production function implicitly suggests that the highly educated person is a perfect substitute for the less educated one. However, a highly educated person is likely to have more substitutability for specific kinds of capital goods than an uneducated or low educated labourer. The authors asserted that the inclusion of human capital as a factor of production in the growth equation is a mis-specification, as education increases the speed of technological diffusion in an economy and the technological diffusion affects economic growth. Their article discussed the two models, which suggest that marginal product of education will be positive if technology is increasing. It implies that the countries with more technological progress would have had a higher rate of return to education.

Barro (1991) examined the relationship between economic growth and various possible explanatory input factors. The study was conducted by using regression analysis on the sample of 98 countries for the period 1960–85. The study found that the real per capita GDP is inversely related to initial real GDP per capita only if the initial level of human capital is accounted for.

The study also found a positive relationship between economic growth and initial human capital, and an inverse relationship between economic growth and market distortions. The study found that poor countries can converge towards the richer countries if they have a high level of human capital per person with respect to their per capita GDP.

Mankiw, Romer and Weil (1992) empirically tested Solow's growth model with and without human capital as an explanatory variable for economic growth. The authors applied the ordinary least square (OLS) technique on a data set of 121 countries for the period 1960–85. The study employed a standard Cobb–Douglas production function with labour, physical capital and human capital as inputs. The authors constructed a new proxy for human capital, named 'School'. The proxy variable was constructed by taking the percentage of working age population (12 to 17) enrolled in secondary schools. This percentage was then multiplied by the working population that is of school age (15 to 19). The model, without human capital, explained around 50 per cent and the model, with human capital, explained around 80 per cent income variation in the sample countries. In light of the findings, the authors recommended

the augmented Solow model for further studies on economic growth.

Benhabib and Spigel (1994) analyzed the role of human capital in light of exogenous and endogenous growth theory by using a data set from Summers and Heston (1991). At first, the authors employed a standard Cobb–Douglas aggregate production function and ran the growth accounting regression. The human capital was found to be insignificant in the growth regression and the finding was robust as tested through six different specifications. The role of human capital was examined again by using another specification in light of endogenous growth theory. This specification assumed that the total factor productivity growth depends on the stock of human capital in a country. This specification found a significant and positive role of human capital in economic growth.

Gemmell (1996) evaluated the role of human capital on the economic growth in a cross-country sample of developed and underdeveloped countries. The study adopted the Mankiw *et al*. (1992) framework by using the same Summers and Heston (1991) data set and OLS technique as used in Mankiw *et al*. (1992). However, the study adopted a different measure of human capital. In the study, the human capital was divided into primary, secondary and tertiary human capital proxied through the enrolment rates at these levels. The study found a positive and significant role of human capital on economic growth.

Bernanke and Gurkaynak (2001) re-examined the Mankiw *et al*. (1992) framework by using an extended data set. The authors applied the ordinary least square (OLS) method on the same variables which were used in Mankiw *et al*. (1992) with a data set from 1960 to 1995. The results through the extended data set greatly differ from Mankiw *et al*. (1992). The authors found that the long-run growth is correlated with behavioural variables (like saving rate) and they concluded that the long-run growth is in fact endogenous, not exogenous.

Middendorf (2005) empirically investigated the contribution of human capital to economic growth by applying the panel data approach to 29 OECD countries during the period 1965–2000. The initial model found a significant and positive effect of human capital on economic growth. In order to address the possible endogeneity and heterogeneity in the sample, the author adopted an instrumental variable approach and the results of this approach made the previous results doubtful. The estimation results explained that the role of human capital on economic growth greatly varied with different proxies of human capital. The study results thus question the role of human capital on economic growth in relatively homogenous OECD (Organisation for Economic Co-operation and Development) countries.

III Data and methodology

The relationship between human capital and economic growth is examined by using a data set of 106 countries for the average of the period 2002–08. The data set has been taken from the World Development Indicators (World Bank, 2011) and the average value of these seven years' observations is used in order to adjust fluctuations. Out of the 106 countries, 31 are categorized as low-income, 39 are lower middle-income, 23 are upper middle-income, 7 are high-income non-OECD and 6 are high-income OECD countries, according to the World Bank classification. The descriptive statistical information pertaining to this data set is presented in Table 1.[1]

The first four variables in Table 1 are used in the full sample model as well as in the model for low-income countries, while the other variables are used in the sensitivity analysis of the two core models. The last variable (GDP per capita in 1980) is used to test the convergence hypotheses.

Table 1 shows that the average growth rate of GDP per worker (taken as a proxy for economic growth)[2] is around 4 per cent per year, ranging from around –3.4 per cent to around

Table 1 Descriptive statistics

Variables	*Mean*	*Std. Dev*	*Minimum*	*Maximum*	*Coeff. of Var*	*Sample*
GDP per worker Growth rate (in percentage)	3.928	2.668	–3.348	12.973	67.923	106
Labour force (in millions)	21.052	84.629	0.04	760	402	106
GFCF (percentage of GDP)	21.912	5.136	9.646	39.58	23.439	106
Gross enrolment rate	64.007	28.346	9.21	113.573	44.286	106
Inflation (in percentage)	6.895	4.1	0.457	18.384	59.463	100
Export (percentage of GDP)	40.3	24.844	7.012	190.779	61.648	106
FDI (percentage of GDP)	4.85	3.965	–5.613	18.8	81.753	105
Trade (percentage of GDP)	89.371	46.93	26.792	371.383	52.511	106
Government consumption (percentage of GDP)	15.353	6.076	4.773	41.551	39.575	105
GDP per capita in 1980 (in constant US 2000 $)	3,230.428	7,998.831	135.4	61,374.8	247.609	81

Source: Authors' estimation.

13 per cent. Average labour force in the data set is around 21 million, with the highest coefficient of variation in the series, which reflects the vast diversification in the demography of the countries in the sample. Gross fixed capital formation as a percentage of GDP is used as a proxy for capital in accordance with the similar studies.

The average value of gross fixed capital formation as a percentage of GDP is around 20 per cent with the lowest coefficient of variation in the data set. Gross enrolment rate for secondary education is taken as a proxy for human capital in the study. The average enrolment rate in the data set is around 64 per cent with standard deviation of around 28 per cent. The average enrolment rate for Sweden is 113, which is the highest among all countries in the sample.

The data for inflation, export as percentage of GDP, foreign direct investment as a percentage of GDP, trade as a percentage of GDP and Government consumption as a percentage of GDP are used in the sensitivity analysis, as these variables have been used in several studies on the same area. The growth equation to be estimated in the cross country sample is given below.

$$Y_i = \beta_0 + \beta_1 L_i + \beta_2 K_i + \beta_3 H_i + U_i \qquad (1)$$

In this growth equation, Y_i is the growth rate of real GDP per worker for country i; K_i is Physical capital for the country i, proxied through gross fixed capital formation as a percentage of GDP; L_i represents the labour force for the country i; while H_i is the gross enrolment rate in secondary education as a proxy for human capital for the country i.

IV Estimation of results

To estimate the strength of the relationship between these variables, the OLS method is applied on the sample of 106 countries and the results thus obtained are reported in Table 2.

As shown in Table 2, around 31 per cent variation in the growth of GDP per worker is explained by the variation in labour, physical capital and human capital. The coefficient of human capital is found to be positively related

Table 2 Cross-country regression results for full sample

Independent variables		*Coefficient*	*t-statistic*	*Prob.*
Constant		–2.502	–2.390	0.019
L		0.005	1.702	0.092
K		0.226	5.021	0.000
H		0.021	2.796	0.006
Observations	106		Adjusted R^2	0.314
F-Statistics	17.049		Prob. (*F*-statistic)	0.000

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

with GDP growth as theoretically expected, and is statistically significant at 1 per cent level of significance. The overall model is also statistically significant at 1 per cent level of significance. The results confirm the contribution of human capital in the economic growth across nations; however, the presence of large variation in the data as a reflection of the diverse socio-economic structure of the countries in the sample demands the testing for the robustness of the obtained results. The appropriate way to check the consistency in the obtained results is to perform sensitivity analysis.

1 Sensitivity analysis

The estimates obtained through growth regressions could be sensitive to many factors like the inclusion of additional variables (Levine and Renelt, 1992), the variation in the sample size and the variation in the proxies used to capture the effect of any specific factor. The study analyzes the robustness by using the inclusion of the variable approach and sample size approach. The procedure of these two approaches and their findings are presented in the next section.

Sensitivity analysis through inclusion of variables: In order to find the consistency of the coefficients in the growth equation, a traditional method is to include the other related variables one after another, and two or more variables at the same time, in the original model. If the inclusion of the variable leaves the initial coefficient almost unchanged, the initial results are considered as consistent. The theoretically relevant variables are selected from different studies on the subject (Khawar, 2005; Middendorf, 2005). Following the same procedure, the other related variables such as foreign direct investment (FDI), inflation (INF), trade as a percentage of GDP (TGDP), exports as a percentage of GDP (XGDP) and government consumption as a percentage of GDP (GCGDP) are included in the original model as presented in equation (2).

$$Y_i = \beta_0 + \beta_1 K_i + \beta_2 L_i + \beta_3 H_i + \beta_4 Z_i + U \quad (2)$$

The original four variables in the core model would remain included in the model, while the variable Z_i represents a subset of the variables that are theoretically related with the growth for country *i*. The results of the sensitivity analysis, using the inclusion of variable(s) approach, are presented in Table 3.

The detailed sensitivity analysis comprises of 20 models including the core model.[3] One additional variable is used in models 2 to 6, while two additional variables are included simultaneously in the models 7 to 14. The effect of including three additional variables simultaneously is examined in models 15 to 20.

The coefficient of human capital is 0.021 in the original model. As reported in Table 3,

Table 3 Sensitivity analysis: Inclusion of variable(s) approach

Model	*Sample*	*Additional variable(s)*			*Coefficient of H*	*t-Stat (prob)*		*Adjusted R^2*	*F-Stat*	*Prob.*
Core Model	106	...			0.021	2.796	(0.006)	0.314	17.049	0.000
Model 2	105	FDI			0.021	2.679	(0.009)	0.323	13.410	0.000
Model 3	101	INF			0.020	2.547	(0.012)	0.308	12.113	0.000
Model 4	106	TGDP			0.021	2.628	(0.010)	0.309	12.727	0.000
Model 5	106	XGDP			0.020	2.459	(0.017)	0.312	12.886	0.000
Model 6	105	GCGDP			0.022	2.938	(0.004)	0.333	14.003	0.000
Model 7	101	INF	FDI		0.019	2.512	(0.014)	0.317	10.298	0.000
Model 8	105	XGDP	FDI		0.021	2.560	(0.012)	0.316	10.621	0.000
Model 9	105	TGDP	FDI		0.021	2.715	(0.008)	0.318	10.698	0.000
Model 10	104	GCGDP	FDI		0.021	2.839	(0.005)	0.347	11.950	0.000
Model 11	100	GCGDP	INF		0.021	2.641	(0.010)	0.293	9.207	0.000
Model 12	105	GCGDP	XGDP		0.020	2.605	(0.011)	0.330	11.253	0.000
Model 13	105	GCGDP	TGDP		0.021	2.708	(0.008)	0.330	11.246	0.000
Model 14	101	TGDP	INF		0.019	2.384	(0.019)	0.303	9.686	0.000
Model 15	100	GCGDP	INF	FDI	0.020	2.644	(0.001)	0.308	8.360	0.000
Model 16	104	GCGDP	TGDP	FDI	0.022	2.822	(0.006)	0.341	9.879	0.000
Model 17	104	GCGDP	XGDP	FDI	0.022	2.758	(0.007)	0.341	9.866	0.000
Model 18	101	XGDP	FDI	INF	0.019	2.396	(0.019)	0.310	8.494	0.000
Model 19	101	TGDP	FDI	INF	0.020	2.502	(0.014)	0.311	8.510	0.000
Model 20	100	TGDP	GCGDP	INF	0.019	2.452	(0.017)	0.290	7.742	0.000

Source: Authors' estimation.

the coefficient of human capital is found to be statistically significant in all the 19 additional models. The magnitude ranged from 0.019 to 0.022. Sensitivity analysis shows that the results obtained are robust.

Sensitivity analysis through sample size variation: Another approach to check the consistency of the core model is to vary the sample size and analyze the variation in the coefficients of the variables. For the purpose of this analysis, the full sample is divided into four categories. The first category is the low-income countries and consists of 70 countries.[4] The second model comprises of low- and middle-income countries, and includes 93 countries. The third model represents low-, middle- and high-income non-OECD countries, and includes 100 observations. The results of these three models are compared with the results of the full sample that represents low-, middle- and high-income non-OECD and high-income OECD countries, comprising of 106 countries. The results of a sensitivity analysis by using the sample size approach are reported in Table 4.

The model having low-, middle- and high-income (non-OECD and OECD) countries with 106 observations is the core model in Table 4. All models had explanatory power ranging from 31 to 32 per cent approximately. The overall model is found to be statistically significant in all the cases reported in Table 4. It

Table 4 Sensitivity analysis: Sample size approach

	Low-income countries			*Low- and middle-income countries*			*Low, middle- and high-income non-OECD countries*			*Low-, middle- and high-income (non-OECD and OECD) countries*		
	Coefficient	*t-value*	*Prob*	*Coefficient*	*t-value*	*Prob*	*Coefficient*	*t-value*	*Prob*	*Coefficient*	*t-value*	*Prob.*
Constant	–1.973	–1.650	0.104	–2.033	–1.872	0.064	–2.389	–2.234	0.028	–2.502	–2.389	0.019
L	0.005	1.769	0.082	0.005	1.865	0.066	0.005	1.729	0.087	0.005	1.702	0.092
K	0.196	3.678	0.001	0.197	4.141	0.000	0.217	4.651	0.000	0.226	5.021	0.000
H	0.024	2.136	0.036	0.025	2.845	0.006	0.023	2.835	0.006	0.021	2.796	0.006
Observations		70			93			100			106	
Adjusted R^2		0.323			0.309			0.315			0.314	
F-Statistics		11.959			14.720			16.209			17.049	
Probability		0.000			0.000			0.000			0.000	

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

can be noted that all factors of production are statistically significant and positively related with economic growth. As one moves from the full sample model to the model consisting of low-income countries, the magnitude of physical capital decreases. This indicates that the income of a country has an association with the magnitude of physical capital to effect the economic growth. In other words, the richer a country is, the higher the returns of physical capital it would obtain. It can also be noted that the coefficient of human capital has a slight overall upward trend if one moves from the full sample model to the model having low-income countries.

From the sensitivity standpoint, the results are sensitive to the sample size; however, the trend in the coefficient of human capital indicates that the returns of human capital are higher in the low-income countries than in the full sample. If this trend is consistent, it could help in highlighting the need of investment in human capital in the low-income countries.

To check the consistency of the results obtained from the low-income countries' growth regression, the sensitivity analysis is performed on 70 low-income countries by using equation (2). The results are reported in Table 5.

Sensitivity analysis through sample size variation (low-income countries): To perform sensitivity analysis, eight additional models are used and the obtained coefficients of human capital are compared with the coefficient of human capital in the core model. Model 2 to 4 used one additional variable at a time; model 5 and 6 used two additional variables at a time; while model 7 to 9 used three variables simultaneously. Table 5 shows that the coefficient of human capital had a very slight movement range, from 0.023 to 0.025 as compared with the value 0.024 in the core model. This indicates that the results are robust in the low-income country model.

2 Unconditional convergence

Convergence hypothesis asserts that per capita income across countries converges with time. This income convergence is an outcome of the negative relationship between growth rate of per capita GDP and initial level of income per person. Both exogenous and endogenous growth theories predict convergence under different conditions (Koopmans, 1965; Mankiw *et al*., 1992; Solow, 1956).

Table 6 presents the findings on unconditional convergence in low-, middle- and high-income countries.[5] The results show

Table 5 Sensitivity analysis (low-income countries)

Model	*Sample*	*Additional variable(s)*			*Coefficient of H*	*t-stat (prob)*	*Adjusted R^2*	*F-Stat*	*Prob.*
Core Model	70	...			0.024	2.136 (0.037)	0.323	11.959	0.000
Model 2	70	FDI			0.025	2.263 (0.027)	0.359	10.647	0.000
Model 3	70	TGDP			0.023	1.914 (0.060)	0.313	8.861	0.000
Model 4	69	GCGDP			0.023	2.109 (0.039)	0.337	9.652	0.000
Model 5	70	XGDP	FDI		0.025	2.144 (0.036)	0.349	8.394	0.000
Model 6	69	GCGDP	FDI		0.024	2.275 (0.026)	0.393	9.803	0.000
Model 7	67	TGDP	FDI	INF	0.023	1.929 (0.058)	0.327	6.336	0.000
Model 8	69	GCGDP	TGDP	FDI	0.025	2.139 (0.036)	0.383	8.047	0.000
Model 9	69	GCGDP	XGDP	FDI	0.024	2.122 (0.038)	0.383	8.041	0.000

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

Table 6 Unconditional convergence

	Low-income countries			*Middle-income countries*			*Full sample*		
	Coefficient	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*
Constant	3.132554	5.595013	0.000000	3.745190	7.613345	0.000000	3.532326	12.574660	0.000000
Y80	0.000215	0.336580	0.737900	0.000123	0.507535	0.614100	0.000007	0.200145	0.841900
Observations		51			50			81	
Adjusted R^2		–0.018054			–0.015384			–0.012145	
F-Statistics		0.113286			0.257592			0.040058	
Probability		0.737871			0.614104			0.841882	

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

that the role of initial per capita GDP is highly insignificant in determining the long-run economic growth. The positive coefficients of initial income indicate divergence among countries in all the three categories, though the divergence is statistically negligible. The finding of no unconditional convergence across countries is similar to the findings of Mankiw *et al*. (1992). The next section tests whether there is evidence of any conditional convergence across countries. In addition, if there is evidence of such convergence, does human capital have some role to play?

3 Conditional convergence

Conditioned on physical and human capital: Table 7 presents the effect of initial per capita income of a country on long-run growth if physical and human capital is also taken into account. In case of low-income countries, coefficient of initial income is positive and statistically significant at 1 per cent in the model without human capital. Though the magnitude is quite low, the positive value shows divergence within poor countries. The coefficient of initial income is negative in the model with human capital. The negative sign indicates convergence; however, the convergence coefficient is statistically insignificant. In middle-income countries, without accounting for human capital, the coefficient of initial income shows statistically significant divergence among countries at 10 per cent level of significance.

When human capital is accounted for, the coefficient of initial income becomes insignificant with almost five times higher *p*-value. The inclusion of human capital in all four models increases the explanatory power of the model. Table 8 presents the full sample findings of conditional convergence if physical and human capital is accounted for.

Full sample regression shows that physical and human capital is positively related with long-run growth. The explanation power of the model increased with the inclusion of human capital. In the model without human capital, the coefficient of initial income shows divergence across nations, though the divergence parameter is statistically insignificant. The coefficient of initial income in the model with human capital also indicates diversion among nations though the divergence parameter in this model is also statistically insignificant. It can be noted that the degree of statistical insignificance of divergence parameter is far higher in the model with human capital.

Conditioned on labour, physical capital and human capital: As Table 9 presents, in case of low-income countries without accounting for human capital, labour and physical capital are positively and significantly related with growth. The model explains around 47 per cent income variation across low-income countries. The initial income coefficient is positive with a very low value, which implies slight divergence among relatively wealthy countries within the group of low-income countries. However, the divergence parameter is statistically insignificant. The inclusion of human capital in the model changes the direction of initial income coefficient. The coefficient becomes negative, which implies convergence, though this convergence parameter is statistically insignificant too. The model without human capital for middle-income countries shows that labour and physical capital are positively and significantly related with growth. The coefficient of initial income is positive and statistically significant at 5 per cent, though the value is quite low. This indicates slight divergence between relatively wealthy countries and the rest of the countries within the group of middle-income countries. When human capital is accounted for, the coefficient of initial income becomes statistically insignificant, which indicates that the presence of human capital is necessary to at least counter the income divergence among middle-income countries.

Table 10 presents convergence conditioned on labour, physical capital and human capital for the full sample. The model without human capital shows that labour and physical capital are positively related with growth and the

Table 7 Conditional convergence (depending on physical and human capital)

	Low-income countries						*Middle-income countries*					
	Without human capital			*With human capital*			*Without human capital*			*With human capital*		
	Coefficient	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*
Constant	–3.171900	–2.889900	0.005800	–3.559400	–3.261300	0.002100	–2.764000	–1.842000	0.072000	–4.155000	–2.487000	0.017000
K	0.294600	6.219500	0.000000	0.276000	5.836600	0.000000	0.272000	4.514000	0.000000	0.267000	4.510000	0.000000
H	—	—	—	0.026500	1.846600	0.071100	—	—	—	0.026000	1.749000	0.087000
*Y*80	0.000200	0.419300	0.005800	–0.000500	–0.884000	0.381200	0.000000	1.769000	0.083000	0.000000	0.787000	0.435000
Observations	51			51			50			50		
Adjusted R^2	0.424500			0.452000			0.276600			0.307000		
F-Statistics	19.441200			14.748200			10.368400			8.234300		
Probability	0.000000			0.000000			0.000200			0.000200		

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

Table 8 Conditional convergence (depending on physical and human capital)

	Full sample					
	Without human capital			*With human capital*		
	Coefficient	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*
Constant	–3.125104	–3.201208	0.002000	–3.872941	–3.793453	0.000300
K	0.307069	7.002217	0.000000	0.295805	6.83485	0.000000
H	—	—	—	0.016700	2.085616	0.040300
*Y*80	0.000022	0.832707	0.407600	0.000001	0.023763	0.981100
Observations	81			81		
Adjusted R^2	0.370552			0.396471		
F-Statistics	24.54773			18.5179		
Probability	0.000			0.000		

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

Table 9 Conditional convergence (depending on labour, physical and human capital)

	Low-income countries						*Middle-income countries*					
	Without human capital			*With human capital*			*Without human capital*			*With human capital*		
	Coefficient	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*
Constant	–2.125460	–1.878140	0.066600	–2.553520	–2.165700	0.035600	–0.795745	–0.508003	0.613900	–2.159430	–1.262894	0.213100
L	0.006020	2.421160	0.019400	0.005060	1.950000	0.057300	0.006790	2.811441	0.007200	0.006659	2.820773	0.007100
K	0.227500	4.296490	0.000100	0.225690	4.282890	0.000100	0.171173	2.563602	0.013700	0.167774	2.570870	0.013500
H	—	—	—	0.017900	1.221630	0.228100	—	—	—	0.024531	1.787675	0.080600
*Y*80	0.000480	1.004960	0.320100	–0.000080	–0.115660	0.908400	0.000407	2.053623	0.045700	0.000225	1.027670	0.309600
Observations	51			51			50			50		
Adjusted R^2	0.477440			0.482860			0.369266			0.398002		
F-Statistics	16.227630			12.671320			10.562420			9.098905		
Probability	0.000000			0.000000			0.000021			0.000018		

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

Table 10 Conditional convergence (depending on labour, physical and human capital)

	Full sample					
	Without human capital			*With human capital*		
	Coefficient	*t-value*	*Prob.*	*Coefficient*	*t-value*	*Prob.*
Constant	–2.391406	–2.298187	0.024300	–3.138696	–2.915650	0.004700
L	0.004354	1.844508	0.069000	0.004371	1.893506	0.062100
K	0.267577	5.550438	0.000000	0.256127	5.398025	0.000000
H	—	—	—	0.016751	2.126810	0.036700
*Y*80	0.000023	0.907309	0.367100	0.000002	0.081302	0.935400
Observations		81			81	
Adjusted R^2		0.389358			0.416077	
F-Statistics		18.003230			15.251090	
Probability		0.000018			0.000018	

Source: Authors' estimation.
Note: Dependent variable is the growth rate of GDP per worker.

coefficients are statistically significant, too. The coefficient of initial income is positive though very small. This indicates slight divergence among countries; however, the coefficient is statistically insignificant.

The model with human capital shows that labour, physical and human capital are positively related with growth and that the coefficients are statistically significant, too. The coefficient of initial income is again positive and has very low value. The statistical insignificance of divergence variable is far higher in the model with human capital.

V Conclusion and implications

The study examined the theoretical relationship between human capital and economic growth in a cross section of 106 countries. It is found that human capital is positively related with economic growth. However, the rate of return on human capital is higher in the low-income countries as compared with the overall returns of human capital across the world. The results obtained from the full sample model and the model having low-income countries are found to be robust when including the other growth-related variables.

The study also tested the unconditional and conditional convergence assertions of various exogenous and endogenous growth models. The conditional convergence assertions were tested by focusing on the role of human capital in the income convergence across nations. In all the 12 models used to test conditional convergence, it is found that human capital paves the way for convergence across countries. Without human capital, the low-income countries exhibit statistically insignificant divergence. If human capital is accounted for, the divergence coefficient is turned into convergence coefficient, though this convergence is also statistically insignificant.

In case of middle-income countries, the models without human capital show statistically significant divergence among countries. When human capital is accounted for, the divergence coefficient becomes statistically insignificant.

The coefficient of initial income shows divergence across countries in full sample model without human capital. However, the divergence is statistically insignificant. After incorporating human capital as an input in the full sample models, the statistical insignificance of divergence coefficient almost doubles.

The convergence models show that the presence of human capital works in favour of convergence or against divergence across countries. The results show that if the divergence without human capital is statistically significant, it becomes insignificant when human capital is included in the model. If the divergence is already insignificant without human capital, inclusion of human capital in the model either turns the divergence into insignificant convergence across countries or increases the insignificance of divergence.

This study shows that investment in human capital is necessary for all the countries, especially for the middle- and low-income countries. The finding is consistent with some of the earlier studies where human capital is found to be a necessary element for the poor countries to catch up with the richer countries (Barro, 1991). Investing in human capital would pay through either supporting the convergence or by resisting the divergence across countries. The results show that the low-income countries should allocate more resources for the enhancement of human capital in order to ensure higher economic growth, as well as for at least resisting the income divergence across countries. The richer countries could get more returns by allocating the resources to physical capital, perhaps because they have relatively more human capital than physical capital endowment. There is a need to re-examine the relationship by adopting the time series approach on different low-, middle- and high-income countries so that the country-specific factors could also be accounted for.

Appendix 1

	Low-income countries				
1	Bangladesh	22	Mozambique	43	El Salvador
2	Benin	23	Nepal	44	Georgia
3	Burkina Faso	24	Niger	45	Guatemala
4	Burundi	25	Rwanda	46	Guyana
5	Cambodia	26	Solomon Islands	47	Honduras
6	Chad	27	Tajikistan	48	India
7	Comoros	28	Tanzania	49	Indonesia
8	Congo, Dem. Rep.	29	Togo	50	Jordan
9	Eritrea	30	Uganda	51	Lesotho
10	Ethiopia	31	Zambia	52	Maldives
11	Gambia, The	32	China	53	Moldova
12	Ghana	33	Congo, Rep.	54	Mongolia
13	Guinea	34	Nicaragua	55	Morocco
14	Guinea-Bissau	35	Armenia	56	Pakistan
15	Kenya	36	Belize	57	Paraguay
16	Kyrgyz Republic	37	Bolivia	58	Philippines
17	Lao PDR	38	Cameroon	59	Senegal
18	Madagascar	39	Cape Verde	60	Sri Lanka
19	Malawi	40	Djibouti	61	Sudan
20	Mali	41	Ecuador	62	Swaziland
21	Mauritania	42	Egypt, Arab Rep.	63	Syrian Arab Republic

(Appendix 1 continued)

(Appendix 1 continued)

	Low-income countries				
64	Thailand	66	Tunisia	68	Uzbekistan
65	Tonga	67	Ukraine	69	Vanuatu
				70	Yemen, Rep.

	Middle-income countries				
1	Albania	9	Colombia	17	Mauritius
2	Algeria	10	Costa Rica	18	Mexico
3	Argentina	11	Fiji	19	Peru
4	Bosnia and Herzegovina	12	Iran, Islamic Rep.	20	Romania
5	Botswana	13	Jamaica	21	St. Lucia
6	Brazil	14	Kazakhstan	22	Suriname
7	Bulgaria	15	Libya	23	Turkey
8	Chile	16	Malaysia		

	High-income countries				
1	Croatia	5	Malta	9	Poland
2	Cyprus	6	Saudi Arabia	10	Slovak Republic
3	Hong Kong SAR, China	7	United Arab Emirates	11	Sweden
4	Latvia	8	Greece	12	Switzerland
				13	United Kingdom

Notes

1. For complete list of the countries, see Appendix 1.
2. Growth rate is calculated by using the values for GDP per capita (constant US$2,000).
3. Due to unavailability of data, the number of observations decreases slightly as reported in Table 3.
4. Lower middle-income countries are also included in the 'low-income countries' category for sensitivity analysis.
5. For unconditional and conditional convergence testing, lower middle-income countries are added into higher middle-income countries and the group is named as middle-income countries.

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