QUALITY OF EDUCATION AND HUMAN CAPITAL IN ECONOMIC GROWTH: AN INTERNATIONAL PERSPECTIVE

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Abstract

The role of human capital on economic growth has long been articulated in the theoretical literature. However, some of the empirical studies on the impact of human capital on economic growth do not find a significant positive correlation between the two partly because of the quality of the data used. The majority of the past studies used quantity of schooling as opposed to quality of schooling and individual skills as a proxy for human capital. Using comparable educational attainment dataset that accounts for quality of education across countries developed by Barro and Lee (2001), Hanushek and Kimko (2000), and Bosworth and Collins (2003) the current study finds evidence that the quality of education of the population rather than mere quantity of schooling is strongly correlated to earnings and economic growth. The empirical study estimates a benchmark cross-country growth regression and a simple production function using 43 years panel data from 84 countries.

Key Words: Education, Developing countries, Human capital, Economic growth
JEL Code: I21, J24, O40

I. INTRODUCTION

The impact of education on individual earning has been a research topic since the development of Mincer (1970, 1974) wage equation. A steady flow of literature over the last 40 years around the world has shown that more schooling is associated with higher individual earnings when applied to micro-level data and that the causal effect

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of rate of return of schooling on earnings is strong. As such, it is one of the top priorities of any government policy to invest in education in order to improve the economic conditions of its population. Although, schooling investments in developing countries over the last four decades increased the years of schooling but have not generated the promised economic outcome predicted by Mincer equation. For example, a large number of developing countries have raised the educational attainment levels of its population without any significant impact on economic wellbeing compared to developed countries. Bloom (2006) finds that the gap in education quality between the rich and the poor countries is large and does not show any signs of decrease over the last four decades. He contends that 75-95 percent of the world's children live in countries where education quality is far below the average level of OECD countries.

Recent empirical researches on growth literature argue that most of the cross-country studies in the past used various measures of quantity of schooling as a proxy for human capital in growth regressions which are inadequate. Cohen and Soto (2007) argues that due to the conceptual and empirical issues involving the measurement of human capital mostly a weak relationship between education and economic growth is observed in growth regressions (De La Fuente and Domenech 2002, 2006; Krueger and Lindahl 2001; Benhabib and Spiegal 1994; and Pritchett, 2001). Hanushek and Woessmann (2008) explain three mechanisms through which education affects economic growth – education increases human capital, leading to enhanced productivity and higher levels of output (neo-classical growth theories such as, Mankiw, Romer, and Weil 1992; Romer 1990b; Barro 1991); increases the research and development, innovation capacity of the nation promoting growth (Lucas 1988; Romer 1990a; Aghion and Howitt 1998); and helps to transmit and diffuse the knowledge necessary to understand the new technology promoting economic growth (Nelson and Phelps 1966; Benhabib and Spiegal 2005). Much of the researches in the past paid more attention to school attainments without any consideration to cognitive skill differences. The difference in cognitive skills may come from various factors including a variation in school quality generally measured as test scores. The school attainment variable does not accurately reflect the stock of human capital of the labor force or a change in the stock arising out of variations in educational and demographic conditions over time. Hence, it is not expected that a country would double its stock of human capital and output by increasing the average years of schooling for its population from 1-2 years. A number of recent studies argue that the international differences in economic growth over time is fully accounted for when human capital is measured as a difference in cognitive skills of the population instead of years of schooling (Hanushek and Woessmann 2008; Jemison et al. 2007; Cohen and Soto 2007). Cognitive skills are related to both quantity and quality of schooling hence, data on educational attainment understate the magnitude of variation in education and skill across nations.

The major objective of this study is to test the hypothesis that educational quality is a strong determinant of economic growth when quality enhanced education data are used in cross-countries growth regressions. The other objective is to test the stability of the relationship between growth of output per worker and educational quality using a panel data model which is free from endogeneity and measurement error, the two common problems as critics argue causing a weak relationship between the two.

The organization of the paper is as follows: The next section discusses the background literature on schooling and economic growth followed by a section on conceptual framework and the model. The fourth section discusses the dataset and the model results. The summary and conclusions are in the last section.

II. SCHOOLING AND ECONOMIC GROWTH

Although micro-Mincer wage regression establishes a positive causal effect of schooling on wages (Griliches 1977; Card 1999; Heckman et al. 2006) , the macro-Mincer return which is interpreted as the effect of human capital on the growth of GDP per worker is unclear in the growth accounting literature (Cuaresma 2009). For some countries with highest micro-Mincer coefficient the impact of schooling on aggregate income has been found to be insignificant. Further, years of schooling has been found to have no significant effect on income for countries with low educational quality (Soto, 2008). Cohen and Soto (2007) found over the last forty years the gap in human capital between rich and poor countries has been constant. Some of the early studies on cross country growth regressions using schooling data developed by Barro and Lee (1993, 2001) found significant positive relationship between initial endowment level of education and economic growth (Mankiw et al. 1992; Sala-i-Martin 1995; Barro 2001). For a review of literature on this issue please see Topel (1999, Kruger and Lindahl (2001), and Protchett (2006).

However, later studies examining the correlation between economic growth and increased educational attainment at the macro-level failed to find a significant relationship between the two (Benhabib and Spiegal 1994; Bils and Klenow 2000; Pritchet 2001; Easterly and Levine 2001; and Temple 2001). The lack of evidence for a strong and positive relationship between the years of education and economic growth broadly arises from three sources: firstly, cross-country aggregate data on years of schooling may represent lower social rate of return than private return in micro-Mincer wage regressions; secondly, measurement error in the data; and thirdly, cross-country differences in educational attainment fail to capture the difference in quality of education that exists among nations. A detail discussion on each of these issues can be found in Bosworth and Collins (2003), Krueger and Lindahl (2001), De La Fuente and Domenech (2006), Cohen and Soto (2007), Lutz et al., (2008) and Hanushek and Woessmann (2008).

In response to the measurement error problem, several studies have developed new estimates of educational attainment data for a large number of countries over a longer time span that begins from 1960 (Barro and Lee 1993; Barro 2001; Hanushek and Kimko 2000; Cohen and Soto 2001, 2007; Lutz et al. 2007). However, Bosworth and Collins (2003) argue that none of these data series generates better estimates when applied to their model compared to the educational quality data they built as an extension of the Hanushek and Kimko (2000) data.

An individual's life time earning potential depends upon his cognitive skills/knowledge, educational attainment, and experience acquired from the work environment and other sources. Individuals with higher levels of cognitive skills do better than those with less and nations with more skilled labor force grow faster than others. The fundamental idea for using educational quality as a proxy for human capital emanates from the notion that a year of schooling does not necessary deliver the same knowledge and skills across nations and over time. For example, the use of average years of schooling as a measure of education implicitly assumes that a year of schooling in Jamaica provides same knowledge and skills as a year of schooling in Japan. Further, it also assumes that formal schooling is the only source of cognitive skills while family, peers, and non-school factors have no effect on education outcome. Empirical studies that use quality adjusted cross-country education data for achievement scores on internationally administered tests found a strong positive impact of cognitive skill on economic growth (Hanushek and Kimko 2000; Hanushek, Lavy, and Hitomi 2008; Hanushek and Woessmann 2008, 2009a, 2009b; Hanushek and Zhang 2007; Bosworth and Collins 2003). Incorporating the information on international differences in Math and Science knowledge in labor quality Hanushek and Kimko (2000) find education quality has a causal impact on growth. Hanushek and Woessmann (2008) argue that even though most of the researchers find evidence that returns to cognitive skills may be larger in developing countries compared to the developed nations, but it does not preclude that any investment in public education is a productive investment.

The current study estimates a benchmark growth regression using a core set of explanatory variables which are found to be consistently related to economic growth in the literature. Specifically, this study investigates two important issues in growth regression: the impact of quality consistent education data on cross-country growth regression; and the impact of education on long-run economic growth using panel data. The author argues that unlike past studies, the present study finds a strong positive correlation between educational quality and economic growth mainly due to the use of improved data series and superior econometric model.

III. CONCEPTUAL FRAMEWORK AND THE MODEL

Following Hanushek and Woessmann (2008, 2009a) a simple growth model is developed in this study assuming a country's growth of per capita GDP (*q*) measured over a long period of time is a function of skills of the workers (*S*) (also called human capital) and other factors (X), which is assumed to include initial level of income, technologies, economic institutions, and other control variables.

$$q_i = \beta_1 S_i + \beta_2 X_i + \varepsilon_i \tag{1}$$

In its simplest form a linear relationship is assumed which is consistent with the basic endogenous growth model. Worker's human capital stock referred to as 'skills' (*S*) has one dimensional index. Education production function literature recognizes that an individual's skills are determined by a wide range of factors such as, family factors (*F*), years of schooling (*Y*), quality of schooling (*Q*), individual's innate abilities (*A*), and other relevant factors (*R*) such as, labor market experience, health etc.

$$S = \alpha F + \varphi(YQ) + \xi A + \psi R + \nu \qquad (2)$$

The term representing schooling combines years of schooling (*Y*) and quality of schooling (*Q*). Since human capital is a latent variable not directly observed, it is essential to define how to measure (*S*). Most of the studies in the past use quantity of schooling (*Y*) as a substitute for (S). However, most recent studies use cognitive skill component of human capital which is measured as the achievement scores in math, science, and reading tests (Hanushek and Woessmann 2008, 2009a, 2009b, 2000). Barro (2001) finds while both quantity of schooling and cognitive skills (test scores) matter for economic growth, impact of cognitive skills are more significant. Woessmann (2002, 2003) finds that the share of cross-country variations in levels of economic development due to variation in human capital increases when cognitive skills are factored into the earnings equation. Hanushek and Woessmann (2006) and Woessmann (2000) found one standard deviation difference on test performance is related to 1 percent difference in annual growth rate of GDP per capita.

The standard equation estimated in this study is expressed as:

$$\Delta \log(q_t) = \delta_0 + \delta_1 \Delta \log(k_t) + \delta_2 \Delta \log(h_t) + X_t \beta + \varepsilon_t \qquad (3)$$

Where *q* is output per worker, *k* is physical capital per worker, *h* is human capital per worker, *X* is a set of additional variables intend to capture convergence or endogenous growth effects, *ε* is the residual and *t* represents year of observation. In growth literature *X* typically includes initial levels of incomes, population, schooling, and other factors.

IV. THE DATASET AND THE EMPIRICAL RESULTS

This study uses a dataset that was originally prepared and used by Bosworth and Collins (2003). The original sources of the dataset are: World Development Indicators (WDI) of the World Bank, the PennWorldTable (PWT 6.3), and the population and labor force data compiled by Barro and Lee (2001). Due to non-availability of factor incomes (capital and labor) for individual countries Bosworth and Collins (2003) used fixed income-share weights to construct the indexes. Description of the variables used in the study is in Appendix-1 and the list of countries included and the subgroup/region they belong to is in Appendix-2. For the detail information on methodology and construction of the dataset readers might consult Bosworth and Collins (2003) also, Appendix-3 reproduced from the paper. The growth accounts are constructed for 84 countries representing 95 percent of the world's GDP and 85 percent of the population covering 43 years (1960-2003). The sample includes countries from all regions of the global economy with population more than 1 million. In order for the regression results are comparable to other studies in the growth literature this study uses a standard set of countries, standard time period, and a standard set of conditioning variables. These conditioning variables are a set of growth determinants that are found to have significant impact in a large number of studies.

Table 1 summarizes the variables used as determinants of growth in cross section analysis and Table 2 summarizes the variables used in panel data analysis. The 1960 level of income per capita is measured as a ratio to the U.S.'s level and serves to capture the convergence process. The table reveals that the growth of output, physical capital, life expectancy, and initial income per worker in Africa are lowest among all regions. The variable life expectancy in 1960 relative to the U.S. is included as a measure of initial health condition of the population. The table also includes variables measuring quantity and quality of education: average years of

Table 1: Summary of Variables Used in Cross-section Analysis by Region, 1960-2003

	World (84)	Deve.ing Countries (62	Africa (19)	East Asia (8)	Latin America (22)	Middle East (9)	South Asia (4)	Indul Countries (22)
Growth of output per worker	1.60	1.37	0.52	3.91	0.71	2.13	2.16	2.27
	1.42	*1.52*	*0.87*	*1.46*	*0.92*	*1.15*	*0.51*	*0.85*
rowth of physical capital per worker	0.81	0.76	0.34	2.21	0.44	1.00	1.03	0.98
	0.74	*0.81*	*0.60*	*0.73*	*0.46*	*0.49*	*0.37*	*0.47*
Growth of human capital per worker	0.33	0.34	0.25	0.48	0.33	0.45	0.32	0.33
	0.11	*0.12*	*0.11*	*0.12*	*0.06*	*0.12*	*0.06*	*0.08*
Income per capita In 1960	0.29	0.17	0.11	0.12	0.25	0.21	0.08	0.62
	0.24	*0.11*	*0.09*	*0.05*	*0.11*	*0.08*	*0.02*	*0.22*
Life Expectancy	55.22	49.90	41.59	52.54	55.44	52.79	47.04	70.26
	12.29	*9.67*	*5.93*	*9.67*	*7.64*	*9.98*	*8.97*	*2.24*
Average educational Attainment age 15+	3.85	2.65	1.55	3.48	3.57	2.34	1.85	7.25
	2.64	*1.66*	*1.12*	*1.04*	*1.35*	*2.32*	*1.43*	*1.83*
Log of population In 1960	8.99	8.87	8.64	10.16	8.29	8.69	10.99	9.34
	1.49	*1.48*	*0.91*	*1.76*	*1.24*	*1.49*	*1.56*	*1.53*
Growth rate of population	1.90	2.34	2.66	2.07	2.14	2.42	2.22	0.68
	0.95	*0.67*	*0.48*	*0.40*	*0.71*	*0.96*	*0.45*	*0.38*
Educational quality Index (BC)	35.11	27.81	29.60	52.84	17.38	32.62	15.70	55.72
	19.43	*17.01*	*14.50*	*12.77*	*12.51*	*11.17*	*7.94*	*7.02*
Average years of Schooling 15+(CS)	5.55	4.12	2.69	5.38	5.25	3.55	2.33	9.49
	3.05	*1.94*	*1.59*	*1.39*	*1.47*	*1.93*	*0.15*	*1.85*
Average years of Schooling 15+(SL)	6.43	5.21	3.86	6.44	6.17	4.87	4.47	9.46
	2.74	*1.87*	*1.63*	*1.01*	*1.47*	*1.77*	*2.38*	*2.18*
Measure of cognitive skill (HW)	4.53	4.19	3.74	4.75	3.88	4.12	4.28	4.97
	0.60	*0.61*	*0.50*	*0.68*	*0.39*	*0.43*	NA	*0.17*

Source: Bosworth and Collins (2003) data; Numbers in italics are regional standard deviations educational attainment of the population 15 or above years of age (quantity); and an educational quality index of the population (quality). The detail on how this index is constructed is on Appendix-3. Three additional education variables are included in the dataset - two variables on average years of schooling, one from Cohen and Soto (2007), and the other from Lutz et al. (2007) and a third variable on measuring cognitive skills (Hanushek and Woessmann 2009a). The underlying objective for including these three additional education variables is to check if any of these variables has a significant impact on the economic growth when applied to current dataset.

Table 3 reports cross country regression results under various model specifications using average annualized growth of output per worker as the dependent variable (equation 3). Column 1 shows that the growth in physical capital per worker explains 2/3rd of the variation in output per worker. When investment per worker variable is added (column 2), together they explain 70 percent of the variation in output per worker. Column 3 adds two additional variables – the growth of human capital per worker and the average educational attainment. Although both of these variables are statistically significant but did not improve the explanatory power of the regression. Column 4 reports the impact of educational quality variable in addition to school attainment variable. The education quality variable is statistically significant but the role of educational attainment variable becomes insignificant. The effect of using variables measuring both quality and quantity of education in the same regression produces similar results for Bosworth and Collins (2003) and Hanushek and Kimko (2000).

Table 2: Summary of Variables Used in Panel Data Analysis by Region, 1960-2003

Regions	Output per worker Index	GDP Index	Labor force Index	Capital stock Index	Measure of Education
World (84)	1.70	2.98	1.69	1.37	1.07
	0.95	*2.60*	*0.72*	*0.44*	*0.06*
Developing Countries (62)	1.59	3.16	1.86	1.35	1.07
	0.97	*2.92*	*0.75*	*0.47*	*0.06*
Industrial Countries (22)	2.01	2.49	1.23	1.44	1.07
	0.82	*1.18*	*0.29*	*0.34*	*0.52*
East Asia (8)	2.80	6.39	1.94	1.95	1.11
	1.90	*6.05*	*0.69*	*0.85*	*0.08*
Latin America (22)	1.32	2.55	1.88	1.22	1.07
	0.35	*1.43*	*0.79*	*0.21*	*0.05*
Africa (19)	1.23	2.28	1.81	1.20	1.05
	0.34	*1.19*	*0.65*	*0.27*	*0.05*
Middle East (9)	1.91	3.67	1.88	1.47	1.09
	0.82	*2.19*	*0.97*	*0.99*	*0.07*
South Asia (4)	1.62	3.00	1.69	1.35	1.06
	0.60	*1.99*	*0.50*	*0.33*	*0.05*

Source: Bosworth and Collins (2003) data; Numbers in parentheses in regions are countries in the subgroup; Numbers in italics are regional standard deviations

The impact of educational quality on output per worker remains robust when a set of conditioning variables are included in column 5. Each of the conditioning variables is statistically significant and improved the explanatory power of the regression by additional 10 percent. Consistent with the literature two other policy indicators, such as, the rate of inflation and a measure of trade openness are also tested for inclusion in the model. As in most of the studies due to endogeneity problem although both of the indicators have the expected sign but are not statistically significant. Hence, they are not reported in the table.

Column 6 includes 5 regional dummies (not reported on the table) and most of the regressors remained statistically significant.

Column 7, 8, and 9 reports the regression results that use same regressors except for the educational attainment variable. For example, column 7 uses educational attainment data measured as 'average years of schooling' from Cohen and Soto (2007); column 8 uses 'average years of schooling' data from Lutz et al. (2007); and column 9 uses quality adjusted 'cognitive skill' data from Hanushek and Woessmann (2009a). The purpose of using the same educational attainment data used by the past researchers is to explore whether these variables are significantly correlated to growth of output per worker in the current model. Except for the variable measuring cognitive skills (column 9) representing the quality of education, the other two educational attainment variables are found to be insignificant.

A conventional practice in the growth literature is to test the stability of the regression results in the presence of country heterogeneity. In other words, how confident are we on the sensitivity of the basic results/relationship reported in Table 3 in the presence of various country groupings. Column 1 in Table 4 reports the regression results for the world representing 84 countries and column 2 reports the results from 62 developing countries in the model. Column 3 reports 42 countries with above median-income per capita in 1960 and column 4 reports the similar information for 42 low-income countries. The regression results are in conformity with the across group regression results reported in Table 3. As expected growth convergence is more prominent for low-income countries implying countries with higher initial income per capita will have slower growth of output. Similar results were obtained by Cohen and Soto (2007) and Bosworth and Collins (2003) when applied to the cross-country regressions for the same study period.

There have been criticisms in the literature on the problem of endogeneity and measurement error in cross-country growth regressions because most of the studies use simple OLS regressions (Kenny and Williams 2001; Brock et al. 2003). Critics argue that in the absence of models using instrumental variables the estimated coefficients are likely to be biased from cross-country regressions. Further, it is also argued that the cross-county regressions do not exploit the impact of time dimensions (Cohen and Soto 2007). A limited number of studies in the past have attempted to address these issues using variety of estimation methods models such as, difference-in-difference approach, hierarchical linear models (HLM), panel data models, and generalized method of moments models (GMM) (Cohen and Soto 2007; Jamison et al. 2007; Hanushek and Woessmann 2009a). However, unlike the past studies that use aggregated cross-country data either at the beginning of each decade or at 5-year intervals and applied to a small number of countries, the current study uses yearly

Table 3: Educational Quality as a Determinant of Economic Growth, Cross-Country Regression, 1960 – 2003

	Dependent Variable = Average annualized growth of output per worker								
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)[a]	(7)	(8)	(9)
Constant	0.321*	-0.660*	-0.409	-0.485	-1.459	-1.310	-0.448	-1.655	-1.117
	(2.39)	(-1.97)	(-1.38)	(-1.69)	(-1.51)	(-1.32)	(-0.40)	(-1.36)	(-0.68)
Growth of physical capital per worker annual average	1.571*	1.430*	1.458*	1.345*	0.961*	0.960*	1.158*	1.036*	0.883*
	(12.87)	(11.52)	(11.55)	(10.44)	(7.78)	(7.75)	(8.92)	(7.60)	(4.78)
Growth of human capital per worker annual average	-----	-----	1.142*	0.777	0.797	0.915	1.162	1.693*	0.331
			(2.38)	(0.96)	(1.16)	(1.28)	(1.42)	(1.93)	(0.35)
Investment share per worker	-----	5.383*	-----	-----	-----	-----	-----	-----	-----
		(3.17)							
Average educational attainment age 15+, Initial value	-----	-----	0.113*	0.044	-----	0.434	-----	-----	-----
			(3.52)	(1.08)		(0.64)			
Educational quality Index	-----	-----	-----	0.016*	0.021*	0.019*	-----	-----	-----
				(2.66)	(4.26)	(3.94)			
Income per capita Initial Value	-----	-----	-----	-----	-2.724*	-2.889*	-1.972*	-2.194*	-2.594*
					(-5.08)	(-4.84)	(-2.86)	(-3.41)	(-4.37)
Life Expectancy Initial Value	-----	-----	-----	-----	0.034*	0.029*	0.017	0.035*	0.015
					(2.78)	(2.05)	(1.10)	(2.16)	(0.84)
Log of population Initial Value	-----	-----	-----	-----	0.107*	0.104	0.109**	0.143*	0.007
					(2.04)	(1.98)	(1.83)	(2.31)	(0.12)
Growth rate of population annual average	-----	-----	-----	-----	-0.412*	-0.408*	-0.505*	-0.487*	-0.451*
					(-3.60)	(-3.55)	(-3.81)	(-3.38)	(-3.19)
Average years of schooling 15+ (CS)[b]	-----	-----	-----	-----	-----	-----	0.054	-----	-----
							(0.86)		
Average years of Schooling 15+ (LU)[c]	-----	-----	-----	-----	-----	-----	-----	0.222	-----
								(0.39)	
Measure of cognitive skill (HW)[d]	-----	-----	-----	-----	-----	-----		-----	0.658*
									(2.63)
Adjusted-R^2	0.66	0.70	0.71	0.73	0.83	0.81	0.78	0.76	0.82
Countries	84	84	84	84	84	84	75	73	50

t-statistics are in parenthesis; [*]Variables are significant at 5% level; [**]Variables are significant at 10% or above levels
[a]-Includes 5 regional dummies not reported in the table; [b]-Average years of schooling form Cohen-Soto (2007) data
[c]-Mean years of schooling from Lutz et al. (2007) data; [d]-Average cognitive skill from Hanushek and Woessmann (2009) data

Table 4: Sensitivity analysis of Cross Country Regression 43 Year Period

Independent Variables	Dependent Variable = Average annualized growth of output per worker (1960-2003)			
	World	Developing Countries	High Income Countries	Low Income Countries
Constant	-3.528*	-4.090*	-1.605	-3.975**
	(-2.75)	(-2.64)	(-0.90)	(-1.89)
Educational quality Index	0.036*	0.037*	0.036*	0.033*
	(5.79)	(4.76)	(4.47)	(3.24)
Income per capita Initial Value	-5.165*	-7.057*	-4.200*	-8.226**
	(-8.31)	(-5.10)	(-6.47)	(-1.83)
Life Expectancy Initial Value	0.071*	0.089*	0.049*	0.097*
	(4.60)	(4.60)	(2.09)	(3.48)
Log of population Initial Value	0.252*	0.283*	0.143**	0.293
	(3.70)	(3.20)	(1.84)	(2.31)*
Growth rate of population annual average	-0.447*	-0.555*	-0.474*	-0.718*
	(-2.95)	(-2.76)	(-2.83)	(-2.18)
Adjuster-R^2	0.65	0.67	0.70	0.63
Countries	84	62	42	42

t-statistics are in parenthesis; *Variables are significant at 5% level; **Variables are significant at 10% or above levels; Samples for Low and High Income Countries are divided based on median income per capita in 1960; Sample for Developing Countries does not include 22 industrial countries.

dataset for 84 countries for 43 years (1960-2003). In other words, each country has 43 years of observations in the sample. The summary of the variables used is reported in Table 2.

A simple semi-log form of the aggregate production function is estimated using panel data which is written as follows:

$$Log(q_{it}) = \eta_1 K_{it} + \eta_2 L_{it} + \eta_3 E_{it} + \pi_i + \tau_t + \varepsilon_{it} \qquad (4)$$

where q is the output per worker index, K is the index for stock of physical capital, L labor force index, E educational index, ε is the error, i denotes country, and t denotes time, π_i and τ_t are respectively country and time specific effects.

The empirical results are reported in Table 5. The overall results are consistent with the cross-country growth regression results reported in Table 3. Most of the variables have expected signs and are statistically significant. As expected educational quality variable is positively and significantly correlated to output per worker for all regions. Except for Africa and Latin America, the explanatory powers of the regressors are high. Low value of Hausman test statistics justifies a random effect model as a better fit for the data than a fixed effect model.

Table 5: Panel Estimation – The Impact of Physical Capital and Labor Force Quality on Economic Growth 1960-2003

Dependent Variable = Log(output per worker)							
	Random Effect Coefficient Estimates[a]				Summary Statistics		
	Index of Capital	Index of Labor	Educational Quality	Constant	R^2	Hausman Statistic	Number of Observations
World (84)	0.016* (29.37)	-0.271* (30.37)	5.094* (48.53)	-4.662* (-44.89)	0.81	19.08	3696
Developing Countries (62)	0.016* (27.21)	-0.219* (-18.61)	4.251* (26.93)	-3.889* (-25.40)	0.78	9.23	2728
Industrial Countries (22)	0.052* (19.31)	-0.239* (-9.31)	4.819* (38.92)	-4.422* (-37.63)	0.90	20.79	968
East Asia (8)	0.006* (6.11)	0.011 (0.20)	5.442* (12.55)	-5.342* (-13.13)	0.87	9.55	352
Latin America (22)	0.070* (14.06)	-0.217* (-10.77)	1.647* (6.41)	-1.329* (-5.33)	0.62	1.28	968
Africa (19)	0.041* (11.26)	-0.091* (-3.81)	0.843* (2.45)	-0.677* (-2.07)	0.63	1.12	836
Middle East (9)	-0.006 (-1.23)	-0.218* (-7.76)	5.678* (18.30)	-5.216* (-16.40)	0.70	6.19	396
South Asia (4)	0.038* (8.65)	-0.237* (-5.61)	6.126* (14.28)	-5.861* (-14.69)	0.95	8.35	176

t-statistics are in parenthesis
*Variables are significant at 5% or above level
[a]Low value of Hausman test statistics suggests random effect model fits the data better

V. SUMMARY AND CONCLUSIONS

This study attempts to address one of the most common criticisms related to cross-country growth regressions in the literature: the lack of consistent evidence for a strong and positive correlation between economic growth and human capital. The absence of such evidence often leads the critics to cast doubts on the effectiveness of such research on public policy for developing countries. This study claims that carefully arranged data that appropriately measure educational quality of the population provides a strong and consistent relationship between economic growth and human capital. In order to generate comparable results with the past researchers the current study uses same range of countries, time period, and conditioning variables. Various specifications of the cross-country growth regressions that include initial per capita income (Table 3, column 5-9) convincingly provide consistent evidence for conditioning convergence implying countries with higher initial income tend to grow more slowly.

The educational attainment variable when included in the regression, although, found statistically significant (Table 3, column 3) but lost its explanatory power when educational quality index is included (column 4). The educational quality variable remains statistically significant with a magnitude that is unchanged across model specifications in column 4-6, in Table-3. The stability of the cross-country estimates is demonstrated through a wide range of alternative specifications. However, there is a growing concern in the literature whether the sample of countries and years of observations heavily influence the results, and also whether the educational quality index influences the estimates. Table 4 conducts a simple sensitivity analysis and demonstrates that the overall results are not driven by any specific subset of countries. The results are consistent with the benchmark growth regression and holds for all 4 regional subgroups. The magnitude of educational quality variable though marginally higher for developing countries the statistical significance does not vary substantially. Unlike Hanushek and Woessmann (2008), this study does not find any evidence to conclude that the social return on education in developing countries is higher than industrial countries.

The panel estimation of the simple production function confirms the basic relationship between long-run output per worker and several determinants of growth including a quality enhanced measure of education. Overall this study shows a large portion of the cross-country variation in economic growth over the past 43 years can be related to the differences in several initial conditions (Table 3). For the panel estimation, economic growth is modeled as a function of stock variables in the absence of initial conditions (Table 5).

In conclusion, a strong evidence of correlation between educational quality and economic growth for both cross-section and panel data regressions suggests that the educational quality rather than quantity is a significant determinant of economic growth in this study. The quality of education is generally measured by cognitive skills, which are also influenced by family, peers, and other non-cognitive skills. Since it is well established in the education production function literature that one of the major sources of cognitive skills is the educational institutions hence, any policy to improve educational attainment through investment in education would improve economic growth as long as it improves educational quality and human capital.

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APPENDIX 1
Variable Definition and the Sources of Data

Variables used in cross country growth regression	
Growth of output per worker	Log change in output per worker over relevant period (x100); as defined in text
Growth of physical capital per worker	Log change in contribution of physical capital per worker over relevant period (x100); as defined in text
Growth of human capital per worker	Difference between the growth of capital per worker augmented by physical and human capital and growth of physical capital per worker (author created)
Income per capita	Income per capita relative to United States, initial value; WDI in national currencies adjusted by PWT6 benchmark year 1996 for international prices, population figures from WDI
Life Expectancy	Life expectancy, initial value; WDI
Average educational attainment age 15+	Average educational attainment in population 15+, initial value; Barro and Lee (2000) and Cohen and Soto (2001)
Log of population In 1960	Population for each country in 1960, natural log, Source:PWT6.3 (author)
Growth rate of population	Population growth rate, average log change of annual data (x100); Source: WDI
GDP per capita In 1960	GDP per capita in PPP for 1960 from WDI, natural log (author)
Educational quality Index (BC)	Educational quality index, cross-sectional value, reconstructed from test scores; Hanushek and Kimko 2000, WDI, and Institutions (GADP) (Bosworth and Collins (2003)
Average years of Schooling 15+(CS)	Average years of schooling from Cohen-Soto (2007) paper for 75 matching countries
Average years of Schooling 15+(LU)	Mean years of schooling data from Lutz et al. (2007) paper for 73 matching countries
Measure of cognitive skill (HW)	Average cognitive skill data from Hanushek and Woessmann (2009) paper for 50 matching countries
Variables used for panel data regression	
Output per worker Index	Output per worker index, 1960=1
GDP Index	GDP index, 1960=1
Labor force Index	Labor force index, 1960=1
Capital stock Index	Capital stock index 1960=1
Education Measure	The education measure is an average of the estimates from Barro-Lee and Cohen-Soto, and it incorporates a 7 percent rate of Return to each year of education.

Source: Bosworth and Collins (2003)

APPENDIX 2
List of Countries in Regional Grouping

Industrial Countries (22)

Australia
Austria
Belgium
Canada
Switzerland
Germany
Denmark
Spain
Finland
France
United Kingdom
Greece
Ireland
Iceland
Italy
Japan
Netherlands
Norway
New Zealand
Portugal
Sweden
United States

East Asia (8)

China
Indonesia
Korea
Malaysia
Philippines
Singapore
Thailand
Taiwan

Mid. East and N. Africa (9)

Algeria
Egypt
Iran
Israel
Jordon
Morocco
Tunisia
Turkey
Cyprus

South Asia (4)

Pakistan
Bangladesh
India
Sri Lanka

Latin America (22)

Argentina
Bolivia
Brazil
Chile
Columbia
Costa Rica
Dominican Rep.
Ecuador
Guatemala
Guyana
Honduras
Haiti
Jamaica
Mexico
Nicaragua
Panama
Peru
Paraguay
El Salvador
Trinidad & Tobago
Uruguay
Venezuela

Sub-Sahara Africa (19)

Cote d' Ivoire
Cameroon
Ethiopia
Ghana
Kenya
Madagascar
Mali
Mozambique
Mauritius
Malawi
Nigeria
Rwanda
Senegal
Sierra Leone
Tanzania
Uganda
South Africa
Zambia
Zimbabwe

APPENDIX 3
Measure of Education Quality

The original analysis by Hanushek and Kimko (2000) estimated a statistical relationship between their index of educational quality and a set of indicators from the Barro-Lee (1993) data for 30 countries who participated in the testing. This relationship was then used to predict educational quality for an additional 49 countries, 36 of which are in our sample. That relationship is reported in column 1 of table A2-1. Bosworth and Collins (1993) expanded the 30-country sample to include Chile because they wanted to have at least two countries, Chile and Brazil, on which to base the placement of Latin American countries. In the Hanushek-Kimko series the Latin America measures are all relative to Brazil and appeared to be too high. The result of that addition is shown in column 2.[1] The right-hand-side variables, except population growth and educational attainment; they updated from the 2002 World Development Indicators and are average values over the period of 1970-2000. Population growth and the average years of schooling are both measured over the period of 1960-2000. The authors also were able to add China, Mozambique and Nigeria for which data were not reported in the Barro-Lee data set. The resulting equation that we used to construct the revised index of education quality is reported in column (3). Finally, because of the correlation reported in the text between the measure of education quality and the quality of government institutions, the authors show in column 4 a regression for the 34-country sample that includes the measure of institutional quality. It is highly significant, but it alters and reduces the role of several other variables.

The index of educational quality was extended to the remaining countries in their sample using the equation shown in column (3) and data drawn from the WDI. Two of the countries in the 34-country sample, Swaziland and Hong Kong, are not in their sample. In table A2-2, they show the original Hanushek-Kimko index in column (1). For those countries that were not in their sample, the authors show estimates provided by Wöessman (2000). His estimates are based on countries that are similar in region and income level. Column (2) reports our estimates based on equation 3 of table A2-1. Finally, the estimate of school quality using the quality of government institutions is in column (3).

1 The Hanushek and Kimko study excluded Chile because the test score data came from an Earlier decade.

Source: Bosworth and Collins (2003)