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The relationship between education and economic growth: A cross-country analysis

A relação entre educação e crescimento econômico: Uma análise entre países

La relación entre educación y crecimiento económico: Un análisis entre países

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Abstract
This study investigates the effects of education on economic growth in 89 low, middle, and high-income countries using an index of human capital developed by Penn World Table and economic growth data from the World Bank's World Development Indicators. This study specifies a growth accounting empirical model to examine the effects of education on economic growth. Using systems Generalized Method of Moments estimation technique on annual data covering the periods from 2002 to 2020, the results show that education significantly enhances economic growth. On average, an increase in the education index by 0.1 increases the growth of real GDP per capita by 0.8 percentage points. The results also show that education does have higher returns for low- and middle-income countries compared to high-income countries. The results of this study lend credence to the argument that poor countries should focus and pool adequate resources towards education as a means to achieving growth.
Keywords: Economic growth; Education; Systems generalized method of moments; Low-middle-and-high-income countries.

Resumo
Este estudo investiga os efeitos da educação no crescimento econômico em 89 países de baixa, média e alta renda usando um índice de capital humano desenvolvido pela Penn World Table e dados de crescimento econômico dos Indicadores de Desenvolvimento Mundial do Banco Mundial. Este estudo especifica um modelo empírico de contabilidade de crescimento para examinar os efeitos da educação sobre o crescimento econômico. Usando a técnica de estimativa de sistemas Generalized Method of Moments em dados anuais que cobrem os períodos de 2002 a 2020, os resultados mostram que a educação aumenta significativamente o crescimento econômico. Em média, um aumento de 0,1 no índice de educação aumenta o crescimento do PIB real per capita em 0,8 pontos percentuais. Os resultados também mostram que a educação tem retornos mais altos para países de baixa e média renda em comparação com países de alta renda. Os resultados deste estudo dão credibilidade ao argumento de que os países pobres devem concentrar e reunir recursos adequados para a educação como um meio de alcançar o crescimento.
Palavras-chave: Crescimento econômico; Educação; Método dos momentos generalizados por sistemas; Países de renda baixa, média e alta.

Resumen
Este estudio investiga los efectos de la educación en el crecimiento económico en 89 países de ingresos bajos, medios y altos utilizando un índice de capital humano desarrollado por Penn World Table y datos de crecimiento económico de los Indicadores de Desarrollo Mundial del Banco Mundial. Este estudio especifica un modelo empírico de contabilidad del crecimiento para examinar los efectos de la educación en el crecimiento económico. Usando la técnica de estimación del Método Generalizado de Momentos de los sistemas sobre datos anuales que cubren los períodos de 2002 a 2020, los resultados muestran que la educación mejora significativamente el crecimiento económico. En promedio, un aumento en el índice de educación de 0,1 aumenta el crecimiento del PIB real per cápita en 0,8 puntos porcentuales. Los resultados también muestran que la educación tiene mayores retornos para los países de bajos y medianos ingresos en comparación con los países de altos ingresos. Los resultados de este estudio dan credibilidad al argumento de que los países pobres deben enfocarse y aunar recursos adecuados hacia la educación como un medio para lograr el crecimiento.
Palabras clave: Crecimiento económico; Educación; Sistema generalizado método de momentos; Países de ingresos bajos, medianos y altos.

1. Introduction

Theoretically, education is a key component that enhances the productivity of human capital which in turn affects economic growth. There is a general consensus that on average, high-income countries tend to have a more educated population than other countries with relatively lower average incomes. However, one cannot directly pinpoint the direction of causality. It is possible that countries experiencing faster economic growth invest more in education than countries with relatively lower growth rates. It could also be the case that countries with higher levels of education are on average more productive than countries with lower levels of education. On the theoretical front, the 'new growth theories' and the augmented 'Solow neo-classical model' provide a conceptual basis for how education impacts economic development at the macroeconomic level.

Many researchers have studied the impact of education on economic growth[1]. The results often vary based on the methods and sample data used. The proxy used to measure education also plays a huge part in the type of results obtained. Possible measures of education include average years of education, completed years of schooling per adult of age twenty-five (25) years or older, percentage of the labor force that attained primary, secondary, or tertiary education, and enrolment rates. However, this study uses an index of education from the Penn World Table developed by Cohen and Leker (2014) to investigate the effect of education on economic growth. This index of human capital measures education based on the average years of education and the rate of return to education. Economic growth is based on the growth of average real per capita Gross Domestic Product (GDP).

Therefore, this study investigates the impact of education on economic growth in a sample of countries from Sub-Saharan Africa, the Middle East, North Africa, South Asia, East Asia, the Pacific, Latin America, and the Caribbean. The sample includes data on 89 countries between 2002 and 2020. This study did not include European and North American countries since many of these are high-income countries and that may impact the results of this study. High-income countries in the sample, based on world bank 2019-2020 classifications of income levels, are excluded in order to check the robustness of our main results.

The theoretical settings explaining the impact of education on economic growth can be classified under two broad categories; the augmented 'Solow neo-classical model' and the 'new growth theories'. Solow (1957) explained that differences in incomes across countries are due to differences in savings rate and the rate of population growth. However, Solow's model failed to explain the sources of approximately 85 percent of the differences in cross-country growth rates. This part that is unattributed to factor inputs such as labor and capital is known as the residual. Later studies improved on Solow's model by accounting for the quality of inputs used in production such as investment in education which improves human capital (Griliches, 1996). Education can however impact on growth through many other channels such as by increasing investment or inducing an increase in the labor force participation which is not captured in the neo-classical approach. The 'new growth theories' posit that economic growth is endogenously determined. Education impacts on growth through the accumulation of human capital and through the stock of human capital. A one-off policy that enhances education affects growth by temporarily (one-off) increasing economic growth through the former channel but permanently increases the rate of output growth in the latter (Sianesi & Reenen, 2003). As such, an increase in say, the average years of education permanently changes the rate of economic growth when it is taken as a stock of human capital.

Many studies have investigated the impact of education on output growth. While many have done empirical investigations, some have been theoretical studies. Hanushek and Woessmann (2008) explain that education can have a positive influence on growth by enhancing human capital which in turn enhances the productivity of labor while in endogenous models, education affects growth by increased innovation, improved knowledge, research and development.

[1] In this study, the terms "education" and "human capital" are used interchangeably.

Benis and Zotou (2014) using a meta-regression analysis applied to 57 studies and 989 estimates find that the results for the effects of education on economic growth vary widely. According to their study, this is primarily due to the different measures of education used in different studies as well as model specification differences, data, and the type of publishing outlet used to disseminate the content of research. Lee (2010) investigated the impact of education on income growth using cross-country data. The study finds that compared to other countries, an increase in the initial years of education by 1 impact more positively on income growth for countries in East Asia and the Pacific, the Middle East and North Africa, and South Asia. Lee and Lee (1995) using secondary school science achievement awards find that an increase in the initial stock of human capital has a positive influence on growth of output per capita.

As already explained in the theoretical background section, education can also affect growth indirectly. Education was found to impact on growth in Africa indirectly via the reduction of infant mortality, strengthening institutions, consolidating stability and physical capital expansion (Appiah & McMahon, 2002). In another study by Benhabib and Spiegel (1994), education was found to be insignificant in determining growth of output per capita. However, education was found to have a significant effect on growth of total factor productivity, which in turn affects growth of output per capita. Therefore, education does seem to affect growth of income per capita indirectly through its effect on growth of total factor productivity.

Agasisti and Bertoletti (2022) focused their research on a largely developed region by investigating how education impacts growth in 284 regions within Europe. Their study reveals that the number of universities, their size, and quality of research output positively influences average income growth. Coman et al. (2022) in a study of former Communist States in Europe find mixed outcomes in how public education expenditure affects economic growth. Maneejuk and Yamaka (2021) specified a non-linear kink model in their study of ASEAN-5 (Association of South-East Asian Nations) countries. Enrollment levels at both secondary school and university levels enhanced output growth for individual countries while regionally, growth doubles when enrollment rates exceed a certain threshold. An influential cross-country study on the determinants of economic growth is Barro (1991). In his study, the stock of human capital as proxied by the school enrolment rate of 1960 was positively and significantly related to growth of output per capita. Many subsequent studies on cross-country growth determinants including the role of education in growth have relied on Barro-style regressions. Barro and Sala-i-Martin (2003) use educational attainment and health levels to proxy for human capital. They find that human capital has a positive and significant relationship with economic growth. Bassanini and Scarpetta (2001) use formal educational attainment among the working age population to proxy for human capital. The results of their study show that for OECD countries, education is a key determinant of economic growth. Bhattacharyya (2009) uses dynamic panel data methods to investigate the macroeconomic returns to education via its role or otherwise in determining economic growth. The study finds that human capital enhances economic growth for the sample countries. Gemmell (1996) distinguishes between the impact of human capital stock and human capital accumulation in his study. He finds that human capital stock in 1960 positively affects output growth both in the short run and in the long run. Furthermore, human capital as proxied by primary, secondary, and tertiary education attainment levels also positively affect growth. Primary and secondary school attainment levels more positively affect income growth in low and high-income least-developed countries respectively while tertiary education is more important for growth in developed countries.

The literature highlighted so far has estimated the returns to education at the macroeconomic level. However, estimating the returns to education for the average individual provides a more plausible option. Harmon et al. (2003) use data from the “International Social Survey Programme” and find large positive effects of education on individual earnings. The size of the effect is greater than returns derived from similar investments. Kalaitzidakis et al. (2001) use semi-parametric estimation techniques to account for possible non-linearities in the education-growth relationship. Using average years of education, the

study finds that the education-economic growth relationship is non-linear. Education at low levels has adverse effects on growth of income, while no effect is recorded when average years of education exceed 4.4.

My study differs from the previous literature discussed above by investigating the effect of education on economic growth by using an index of human capital based on mean years of education and returns to education. Therefore, my study estimates the effects of education on income growth by relying on the accumulation rather than the stock of human capital in contrast to many other studies. Furthermore, my study relies on dynamic panel data methods by using the systems generalized method of moments (GMM) estimator to isolate the causal effect of education on growth of per capita income.

The rest of this paper is organized into three parts. Part two explains the data sources including the measures of the main variables; and the empirical methodology by outlining an empirical model and method of analysis. Part three presents the results and discussion, and part four concludes.

2. Data and Methodology

The study relies on data from the World Bank's World Development Indicators (WDI) database and the Penn World Table version 10.0. All data except those on total factor productivity, and human capital index are from the World Bank. The sample for this study covers 89 countries and 19 years starting in 2002 and ending in 2020.

One of the reasons for the varying results from studies on the returns to education could be the measure of education that is used. In this study, the proxy on education is the human capital index of the Penn World Table. The human capital index measures the average years of education and the returns to education for around 150 countries. The index is based on the measure of human capital developed by Barro and Lee (2013) for the average years of education, the Cohen and Leker (2014) CSL (Cohen-Soto-Leker) data for the average years of schooling, and assumed rates of return to education from estimating Mincer equations in different countries globally (Psacharopoulos, 1994).

The index is constructed with the assumption of diminishing returns to education; that is the returns to education are higher for individuals with lower levels of education and it continues to decrease as the average years of education increase.

$$\emptyset(s) = \{0.134 \,.\, s \qquad if\ s \leq 4 \tag{1}$$

$$\emptyset(s) = \{\, 0.134 \,.4 + 0.101\ (s-4) \quad if\ 4 < s \leq 8 \tag{2}$$

$$\emptyset(s) = \{0.134 \,.4 + 0.101 \,.4 + 0.068\ (s-8)\ if\ s > 8 \tag{3}$$

The human capital index is constructed using the above equations and it is unit free. The term s represents the mean years of education.

The data on total factor productivity, just like the human capital index is got from the Penn World Table. It describes the rate of return to factors of production per unit of input. It is a measure of the efficiency of productive resources. It is calculated using constant 2017 national prices.

The data from the world bank covers variables including growth of real per capita GDP, real per capita GDP, gross capital formation (domestic investment), government consumption expenditure, inflation, labor force participation, foreign direct investment, life expectancy, political stability, rule of law, and voice and accountability.

The proxy for economic growth which is growth of real per capita GDP is the mean annual growth of real per capita GDP measured in constant national prices; it is denoted in percentage. GDP per capita is average annual real GDP per capita measured at purchasing power parity rates; it is denoted in constant 2017 international US dollars. Gross capital formation refers to net changes in inventories and expenditure on new additions to a country's fixed assets, measured as a percentage of GDP. Gross capital formation, formerly known as gross domestic investment, does not include deductions towards the depreciation of the economy's fixed assets. Government consumption expenditure, the proxy for government spending, refers to current government outlays, denoted in percentage of GDP. It does not include outlays on fixed assets. Inflation measures

the average annual rise in the price level denoted by the growth, in percentage, of the implicit GDP deflator. Labor force participation measures the share of the total population with age of at least 15 years that are actively engaged in economic activities. It is denoted in percentage. Foreign direct investment refers to net inflows of investment spending put towards the acquisition of at least a 10 percent stake in the voting stock and management of a business enterprise operating in an economy other than that of the investor. Life expectancy at birth refers to the number of years a newly born infant is expected to live, holding fixed the mortality rate at the time of his/her birth. It serves as a proxy for the health of the population. Rule of law refers to the perception about the confidence people have in institutions and the extent to which they respect the rules of society including rules governing property rights, contract enforcement, among many others. It is measured in standard normal distribution scores ranging from approximately -0.25 to 0.25. Voice and accountability refer to perceptions people in a country have about press freedom, freedom of expression and association, and transparency of elections and other democratic practices. Like the rule of law index, the voice and accountability index is denoted in units of a standard normal distribution ranging from -0.25 to 0.25. the two indices, rule of law, and voice and accountability are included in this study to account for quality of institutions that may have influence on human capital and economic growth. Political stability measures the perceptions of the likelihood of politically motivated violence and or terrorism in a country. It is measured in units of a standard normal distribution.

The descriptive statistics of the full sample data and a scatter plot showing the relationship between growth of per capita GDP and education are presented in Table 1 and Figure 1 respectively.

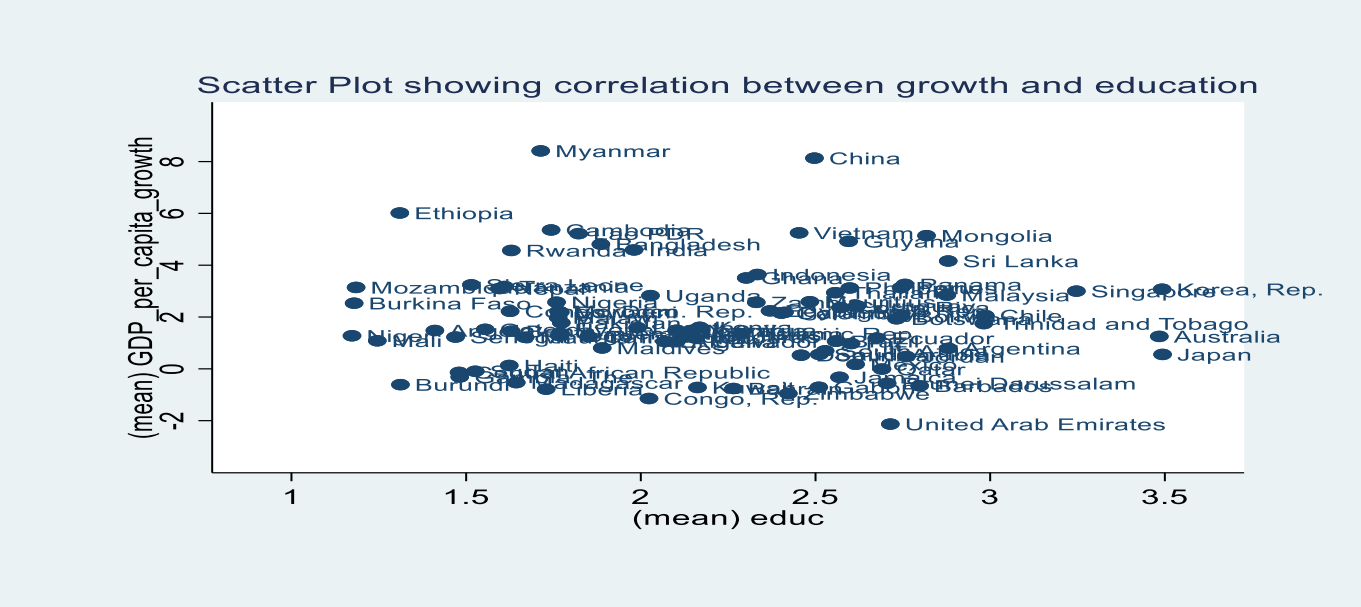
Table 1 - Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita growth	1767	1.889	4.807	-38.418	49.48
GDP per capita PPP	1767	13287.707	17896.349	715.454	99147.288
Gross capital	1631	24.41	8.67	1.525	79.401
Inflation	1767	7.521	20.375	-30.2	558.56
Life expectancy	1749	67.043	9.398	41.376	84.616
Govt spending	1610	14.213	5.294	.952	43.484
Total factor productivity	1260	.999	.161	.483	2.108
Human capital index	1674	2.187	.571	1.088	4.352
Labor force	1748	64.541	11.354	37.786	88.35
FDI	1767	4.098	6.418	-37.173	103.337
political stability	1767	-.377	.891	-3.181	1.616
Voice and accountability	1767	-.367	.775	-2.233	1.507
Rule of law	1767	-.351	.748	-1.852	1.923

Data from World Bank and Penn World Table. Source: Author's computation.

Table 1 above shows the number of observations, mean, standard deviations, and the minimum and maximum values of the variables in the sample data. The standard deviations of some variables including GDP growth, GDP per capita, inflation, life expectancy, gross capital formation, government spending, labor force, and foreign direct investment do show that they vary widely among countries in the sample data.

Figure 1 - Scatter plot showing the education-growth relationship.



Data from the World Bank and Penn World Table. Source: Author's computation.

Figure 1 shows the relationship between education and economic growth in the sample countries for the period covered in this study. It shows a positive correlation between education and growth especially for low- and middle-income countries. However, there are outliers among the sample countries.

This study specifies a growth accounting empirical model similar to that of Barro (1991) and include human capital directly as an input in the growth process.

$$gdpg_{1it} = \gamma_{11} hc_{1it} + X_{1it}\beta' + \phi_{1t} + \delta_{1r} + v_{1it} \qquad (4)$$

From equation 4, the dependent variable is average annual growth of real per capita GDP in country i at time t. The independent variable of interest is hc_{1it}, the human capital index in country i at time t. X_{1it} is vector of other independent variables including the initial level of per capita GDP to control for conditional convergence across countries; inflation, government consumption spending, gross capital formation, foreign direct investment, labor force participation, life expectancy as a measure of the health of the population, political stability, rule of law, and voice and accountability. The control variables are chosen based on the survey of the literature done by Sianesi and Reenen (2003). Furthermore, this study includes time and regional dummies in the empirical model. From equation (4), ϕ_{1t} represents year dummies to account for global business cycles while δ_{1r} represents regional dummies including dummies for Sub-Saharan Africa, South Asia, East Asia and the Pacific, Middle East and North Africa. The Latin and Caribbean American dummy is chosen as the base dummy and hence not included in the regression.

Equation (4) is firstly estimated using ordinary least squares (OLS) method. However, because there are many unobserved factors that may be correlated with our measure of human capital and also affects growth, the estimate of human capital may not yield unbiased results. Secondly, it is possible that countries that experience relatively higher growth rates spend more on education and hence accumulate a higher level of human capital making our estimates biased. Since the measure of human capital is plausibly endogenous, then OLS estimates can only provide a correlation between human capital and growth.

Consequently, this study adopts a method that isolates the causal effects of human capital accumulation on economic growth by using a dynamic panel data method that controls for the endogeneity synonymous with OLS estimation. Since

traditional fixed effects estimation techniques do not work well when a model has variables that do not change over time, this study uses the systems Generalized Method of Moments (GMM) estimator to examine the dynamic relationship between education and economic growth. Equation (4) is thus transformed as follows:

$$gdpg_{2it} = \alpha gdpg_{2it-1} + \gamma_{21} hc_{2it} + X_{2it}\beta' + \phi_{2t} + \delta_{2r} + v_{2it} \quad (5)$$

Where $v_{2it} = \tau_{2i} + u_{2it}$ (6)

The systems GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) controls for many problems including endogeneity and heteroskedasticity by establishing an endogenous equation in which the dependent variable depends on its lagged value(s) as in equation (5) above. The system GMM can also account for both time-fixed effects and geographic fixed effects at the same time. In equation (6) above, the error component is composed of both time invariant country fixed effects τ_{2i}, and other unobserved factors that change over time and across countries.

System GMM in contrast to difference GMM designates two equations; a levels equation and a difference equation. In the levels equation, lagged differences are used as instruments. Conversely, lagged levels are used as instruments in the difference equation.

To reduce concerns about instrument proliferation, the maximum number of lags of the endogenous variables used as instruments is restricted to five. Ideally, the number of instruments should not exceed the number of cross-sectional groups in system GMM. In addition to addressing the concerns about weak instruments encountered in difference GMM, system GMM is ideal when the number of cross-sectional groups is relatively larger than the number of periods in the study (Blundell & Bond, 1998).

System GMM is more ideal because the sample data covers 19 years and 89 countries. In addition, because of the unbalanced data, many observations will be lost from a difference GMM estimation.

To confirm the robustness of the results from GMM estimation, the study conducts tests for serial correlation and over-identification tests to examine validity of instruments.

In the test for serial correlation, the study relies on the Arellano-Bond (AR) tests for first order and second order serial correlation. The null hypothesis of no serial correlation is expected to be rejected in AR(1). For any robust findings, however, the null hypothesis of no serial correlation should not be rejected at the 5 percent level in the second order AR(2) test for serial correlation.

To test for the over-identification of instruments, this study relies on the Hansen (1982) J statistic. For the results to be valid, the instruments in the model should exceed the number of endogenous variables. The null hypothesis of over-identification should not be rejected at the 5 percent significance level for any result to be considered acceptable.

3. Results and Discussion

The study uses both OLS and system GMM estimation techniques to examine the effect of education on economic growth. The findings from the study are presented in this section. Table 2 below presents OLS estimates of equation (4) in four models. Column 1 provides estimates of our main equation without the inclusion of year dummies and region dummies; column 2 provides results with year dummies but no region dummies; column 3 shows results with only region dummies but no year dummies; and the last column provide estimates by including both year and region dummies. Robust standard errors are used to reduce the impact of heteroskedasticity on the results. The coefficient of human capital is significant at the 1 percent level in both columns 1 and 2 but insignificant in columns 3 and 4 when region dummies are included.

Table 2 - Results of OLS estimation.

(Dependent variable is growth of average annual real per capita GDP)

VARIABLES	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Initial GDP per capita	-0.000102***	-0.000113***	-9.52e-05***	-0.000102***
	(1.42e-05)	(1.32e-05)	(1.30e-05)	(1.25e-05)
Gross capital	0.107***	0.115***	0.0929***	0.0927***
	(0.0169)	(0.0166)	(0.0186)	(0.0183)
Inflation	-0.00939	-0.0137	-0.00571	-0.0107
	(0.0116)	(0.00961)	(0.0111)	(0.00977)
Life expectancy	-0.0212	-0.000184	-0.0923***	-0.0252
	(0.0210)	(0.0214)	(0.0297)	(0.0380)
Government spending	-0.113***	-0.0746**	-0.0846**	-0.0530
	(0.0335)	(0.0343)	(0.0339)	(0.0355)
TFP	5.511***	5.655***	6.477***	6.467***
	(1.252)	(1.249)	(1.299)	(1.317)
Human capital	0.832***	1.129***	-0.0384	0.340
	(0.315)	(0.317)	(0.368)	(0.389)
Labor force	0.0385***	0.0448***	0.0294**	0.0353***
	(0.0136)	(0.0127)	(0.0128)	(0.0121)
FDI	0.0503**	0.0368	0.0433*	0.0399
	(0.0239)	(0.0227)	(0.0253)	(0.0253)
Political stability	-0.117	-0.120	0.0186	0.0415
	(0.275)	(0.261)	(0.260)	(0.246)
Voice and account.	-0.275	-0.361**	-0.165	-0.167
	(0.186)	(0.174)	(0.252)	(0.244)
Rule of law	1.050***	0.915***	1.012**	0.607
	(0.306)	(0.301)	(0.412)	(0.462)
Year dummies	NO	YES	NO	YES
Region dummies	NO	NO	YES	YES
Constant	-5.804**	-8.688***	1.049	-5.622
	(2.314)	(2.537)	(2.954)	(3.984)
R-squared	0.120	0.210	0.159	0.233
Observations 1,190				

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Author's computation using Stata 16.

Even though the results from Table 2 represents an OLS estimation and may suffer from issues relating to endogeneity; nonetheless, it indicates a signifcantly positive relationship between education and growth. Results from OLS estimation can be problematic because education can be regarded as an endogenous variable. It is not practically possible to include every single variable that can affect education and is related to economic growth in the empirical model. There is also the possibility that education affects growth positively as is shown in the OLS results because, the richer countries become, due to higher levels of economic growth, the more they invest in education leading to relatively higher levels of education. Consequently, due to factors including endogeneity inherent in OLS techniques, the study estimates equation (5) using dynamic system GMM and presents the results in Table 3.

In both columns 1 and 2 of Table 3, human capital is statistically significant at the 5 percent and 1 percent levels respectively confirming that education does significantly enhance economic growth. The estimate of human capital in column 2 is approximately twice as large as that in column 1; an increase in the human capital index by 1 increases growth by 8.1 percentage points on average. In the test for second order serial correlation, the null hypothesis of no serial correlation is not rejected at the 5 percent level suggesting that the estimates do not suffer from second order serial correlation.

Table 3 - Results from system GMM estimation.

(Dependent variable is growth of average annual real per capita GDP)

VARIABLES	GMM (1)	GMM (2)
GDP per capita growth (-1)	-0.00226	-0.0509
	(0.122)	(0.104)
Initial GDP per capita	-0.000192***	-6.94e-05
	(4.61e-05)	(0.000315)
Gross capital	0.142*	0.240***
	(0.0839)	(0.0897)
Inflation	-0.0284***	-0.0263
	(0.00952)	(0.0164)
Government spending	-0.0496	0.253
	(0.168)	(0.197)
TFP	8.076***	11.91**
	(2.791)	(4.659)
Human capital	4.247**	8.107***
	(1.644)	(3.002)
Labor force	0.214	0.248
	(0.153)	(0.360)
FDI	0.0842*	0.0498
	(0.0479)	(0.0700)
Voice and account.	-1.345	-5.526
	(0.825)	(6.354)
Rule of law	1.056	-0.475
	(0.949)	(3.653)
Year dummies	YES	YES
Region dummies	NO	YES
Constant	-31.59**	-52.02**
	(13.35)	(25.04)

Observations 1,125; Hansen Statistic$_1$ (p=0.174) 48.25; Hansen Statistic$_2$ (p=0.081) 48.41; AR(2) Serial correlation$_1$ (p=0.283) -1.07; AR(2) Serial correlation$_2$ (p=0.133) -1.50. N*umbers in subscript indicate column number. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Author's computation using Stata 16.*

Roodman (2009) suggests that the Hansen test can suffer from the proliferation of instruments leading to very high probability values that approach 1. As a result, he suggests that desirable probability values from the Hansen test normally do not exceed 0.25 and the null hypothesis of over-identification is rejected at the 5 percent level. From Table 3, the null hypothesis of over-identification of instruments is not rejected at the 5 percent level confirming that the instruments are valid.

The results of the findings presented in Tables 2 and 3 for the effect of education on economic growth are tested to check whether they hold when the sample only includes low- and middle-income countries. As a result, 13 high-income countries based on World Bank 2019-2020 classifications are removed from the original sample.

Table 4 presents OLS estimates of equation (4) using the smaller sample while Table 5 presents system GMM estimates. The estimates of human capital in Table 4 are similar to those in Table 2 in terms of the signs and significance. The estimates of human capital in Table 4, however, are slightly larger than those in Table 2, suggesting that the returns to education might be higher in low- and middle-income countries compared to high-income countries. This is probably because on average, there are relatively lower levels of education in low- and middle-income countries making the returns from getting educated in those countries greater in terms of its relative impact on economic growth.

Table 4 - Results of OLS estimation of sample excluding high-income countries.

(Dependent variable is growth of average annual real per capita GDP)

VARIABLES	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Initial GDP per capita	-0.000136***	-0.000225***	-9.39e-05*	-0.000172***
	(4.42e-05)	(3.95e-05)	(5.18e-05)	(4.37e-05)
Gross capital	0.103***	0.107***	0.0912***	0.0880***
	(0.0186)	(0.0186)	(0.0203)	(0.0201)
Inflation	-0.0105	-0.0113	-0.00643	-0.00843
	(0.0118)	(0.0105)	(0.0113)	(0.0106)
Life expectancy	-0.0143	0.0168	-0.0938***	-0.00483
	(0.0222)	(0.0235)	(0.0314)	(0.0467)
Government spending	-0.109***	-0.0694*	-0.0823**	-0.0471
	(0.0400)	(0.0409)	(0.0413)	(0.0441)
TFP	5.254***	6.804***	6.996***	8.078***
	(1.887)	(2.067)	(2.028)	(2.267)
Human capital	0.981***	1.539***	-0.0358	0.622
	(0.373)	(0.357)	(0.419)	(0.400)
Labor force	0.0397***	0.0360**	0.0369**	0.0297**
	(0.0147)	(0.0143)	(0.0143)	(0.0142)
FDI	0.0419	0.0170	0.0313	0.0180
	(0.0279)	(0.0271)	(0.0293)	(0.0289)
Political stability	-0.121	-0.0421	0.00907	0.0698
	(0.287)	(0.260)	(0.253)	(0.230)
Voice and account.	-0.249	-0.232	-0.107	0.0217
	(0.193)	(0.184)	(0.281)	(0.293)
Rule of law	1.200***	0.981**	1.193*	0.616
	(0.396)	(0.411)	(0.639)	(0.749)
Year dummies	NO	YES	NO	YES
Region dummies	NO	NO	YES	YES
Constant	-6.018**	-9.849***	0.364	-7.870
	(2.851)	(3.291)	(3.821)	(5.658)
R-squared	0.111	0.200	0.150	996
Observations 996				

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Author's computation using Stata 16.

Table 5 presents GMM estimates of the impact of education on low and middle-income countries. The estimates of human capital in columns 1 and 2 are significant at the 5 percent and 10 percent levels respectively. The Hansen statistic confirms the over-identifcation of the instruments. In the test for the presence of second order serial correlation, the null hypothesis of no serial correlation is not rejected.

Table 5 - Results from system GMM estimation of sample excluding high-income countries.

(Dependent variable is growth of average annual real per capita GDP)

VARIABLES	GMM (1)	GMM (2)
GDP per capita growth (-1)	-0.0145	-0.0947
	(0.129)	(0.104)
Initial GDP per capita	-0.000772**	-0.00114
	(0.000316)	(0.00112)
Gross capital	0.180**	0.211
	(0.0695)	(0.143)
Inflation	-0.0208**	-0.00643
	(0.00818)	(0.0239)
Government spending	0.0567	0.540
	(0.206)	(0.338)
TFP	15.56**	25.61***
	(6.835)	(9.190)
Human capital	8.238**	10.17*
	(3.181)	(5.487)
Labor force	-0.0453	0.0246
	(0.170)	(0.506)
FDI	0.0628*	0.0195
	(0.0328)	(0.0951)
Voice and account.	-0.781	8.236
	(1.104)	(9.069)
Rule of law	0.137	-12.26
	(1.764)	(8.829)
Year dummies	YES	YES
Region dummies	NO	YES
Constant	-30.54*	-64.36**
	(15.75)	(28.06)

Observations 942; Hansen Statistic$_1$ (p=0.160) 30.78; Hansen Statistic$_2$ (p=0.178) 25.65; AR(2) Serial correlation$_1$ (p=0.275) -1.09; AR(2) Serial correlation$_2$ (p=0.134) -1.50. N*umbers in subscript indicate column number. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Author's computation using Stata 16.*

The estimates of human capital are both positive and greater in Table 5 compared to those in Table 3, confirming our findings that education has a greater impact on economic growth in low-income and middle-income countries compared to high-income countries. In column 1 of Table 5, an increase in the human capital index by 1 increases the growth of per capita GDP by 8 percentage points, on average. In column 2 when regional dummies are included, the estimate of human capital is even higher, standing at 10.17 percentage points, and significant at the 10 percent level.

The economic significance of our results is as relevant as their statistical significance. In Table 3 for instance, an increase in the human capital index by 1 leads to an 8 percentage points increase in economic growth on average. Since the minimum and maximum values of the human capital index are 1.088 and 4.352 respectively; it may take considerable effort and time for a country to increase their standing in the index by 1. Alternatively, economic growth rises by 0.8 percentage points on average when the human capital index increases by 0.1. This is an impressive growth rate in real terms, allowing average incomes to rise more rapidly. In column 2 of Table 5, when developed countries are excluded from the study, an increase in the human capital index by 0.1 increases economic growth by 1.017 percentage points on average. This means that a developing country that manages to increase its human capital index by 0.1 can see their growth of total output increase from say 3 percent to 4 percent, or from 5 percent to 6 percent on average, holding all other relevant factors fixed. The results from this study confirm the theory that education can be the catalyst for countries to achieve higher growth rates, transforming themselves from low-income countries to high-income countries.

The findings in this study also confirm the predictions of the theoretical models; namely the augmented "Solow neo-classical model" and the 'new growth theories". Both models posit that education positively affects growth by serving as an investment that improves the quality of human capital and by increasing the labor force participation rate for instance.

4. Conclusion

This study has investigated the effects of education on economic performance in 89 countries globally relying on macroeconomic data covering the years 2002 to 2020. My findings using OLS showed a positive correlation between education and economic growth. Due to the limitations of OLS techniques, the empirical model was estimated using the systems GMM estimator. The study found that foreign aid has a strong positive effect on economic growth. On average, an increase in the education index by 1 causes an 8 percentage points increase in economic growth and this is statistically significant at the 1 percent level. Put in another way, an increase in the education index by 0.1 increases economic growth by 0.8 percentage points on average and this is statistically significant. The results are robust when high-income countries are excluded from the sample.

The result of this study confirms the theory that education impacts positively on growth. Similarly, the results also confirm the findings of many empirical studies that education has positive effects on economic growth. Education is a key determinant of economic growth. All countries including low-income and middle-income countries can achieve higher growth rates and income levels by raising the level of education. At the policy level, many governments are now putting more attention on education. The government of Sierra Leone, for instance, increased budgetary allocation to education in 2018 to cater for free pre-university education in public schools. Some countries have also instituted programs such as school-feeding to keep students from disadvantaged backgrounds in school. Low- and middle-income countries are therefore especially advised to invest more in education with a view to increasing economic growth.

Despite the results and conclusions of this study, other areas related to the education-growth relationship remain under-studied. In the future, researchers can focus on the individual contributions of different fields of education to growth in developing countries. The role of technical education in economic development of developing countries is an interesting area for future research. Researchers can also explore the impact of technical education in developing countries at the micro level by using experimental methods, like a difference-in-differences approach to analyze the impact of education policies on average incomes by comparing regions with similar socio-economic and demographic backgrounds.

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