UC San Diego, School of Global Policy and Strategy

Term Paper, Quantitative Methods in International Relations

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The Impact of Primary School Enrollment on GDP per Capita in Developing Countries

1. Context

The importance of education as a driver of economic development, especially in developing countries facing poverty and inequality, is well-documented. Access to primary education is seen as both a fundamental right and a key factor in promoting economic growth and improving quality of life. Research by Glewwe et al. (2014) and Kobzev et al. (2018) established a causal relationship between education and economic outcomes, showing that higher educational attainment correlates with increased income levels and economic growth. Glewwe et al. (2014) specifically reviewed evidence from Sub-Saharan Africa (SSA). Barro (1991) used Penn World Tables data to identify "empirical regularities," finding that primary and secondary school enrollment rates significantly impact GDP per capita.

This paper examines the relationship between primary school enrollment rates and GDP per capita in African countries, hypothesizing that higher enrollment rates enhance economic performance. The research is relevant for (i) providing empirical evidence to establish causal relationships, aiding policymakers in designing effective education interventions, and (ii)

guiding governments and development partners in allocating resources efficiently, particularly toward elementary education. The paper is structured into methodology, results, post-regression analysis, and policy implications.

2. Methods

i. The Conceptual Framework

Elementary education is a cornerstone of economic growth, enhancing workforce productivity and human capital, a key driver of development. Human capital theory (Becker, 1993; Mincer, 1974) posits that education investments yield returns through improved productivity and innovation. I present a conceptual framework, Figure 1, to explore the relationship between primary school enrollment and GDP per capita, incorporating control variables.

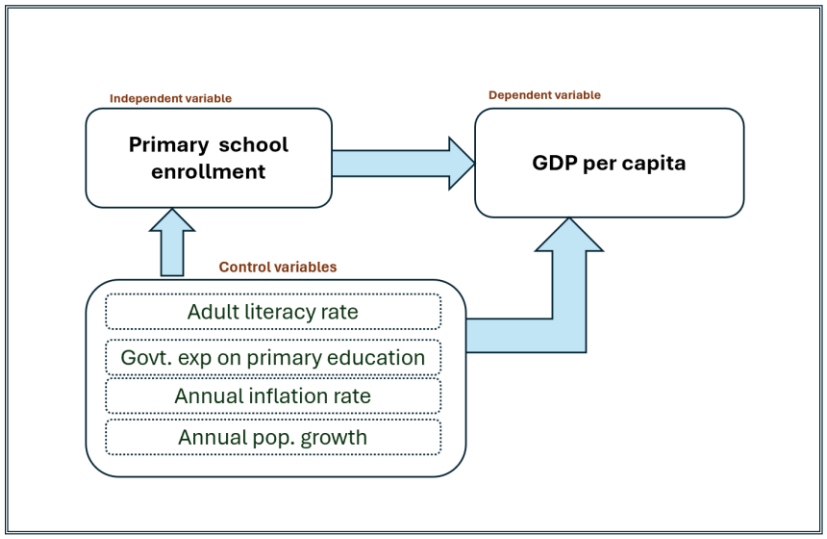

Figure 1: The conceptual framework: impact of primary school enrollment on GDP per capita. Source: Author

Primary education fosters higher educational achievements and a skilled workforce. Government spending on education, while potentially reducing disposable income, boosts enrollment by improving infrastructure. Thus, accounting for factors like government spending, population growth, and inflation is essential to understanding the causal link between enrollment and GDP

per capita. This analysis is both academically and practically significant, offering policymakers insights for sustainable development.

ii. Research Hypothesis

This research paper proposes two hypotheses:

H_0: Increased primary school enrollment rates have no effect on GDP per capita.

H_1: Increased primary school enrollment rates positively affect GDP per capita.

iii. Data Description

This analysis utilizes a comprehensive dataset from the World Bank's World Development Indicators (WDI) database (*https://data.worldbank.org/*), covering 54 African countries from 1960 to 2023. The dataset includes educational enrollment rates and GDP per capita, with the latter serving as the dependent variable to measure economic output per person. The primary variable of interest is primary school enrollment, which reflects the percentage of children of official primary school age enrolled in primary education. However, the definition of primary school age varies by country; for example, Kenya considers 6-13 years, while Ghana and Morocco use 6-11 years. The enrollment rate can exceed 100% as the numerator includes all primary school attendees, regardless of age. Control variables include adult literacy rate, government expenditure on primary education, inflation rate, and population growth rate. The dataset comprises 3456 observations, with each observation representing a "country-year" unit. Table 1 summarizes the variables used in the analysis, providing a clear overview of the data structure and key metrics. This approach leverages globally comparable indicators from the World Bank and UNESCO to explore the relationship between education and economic performance in Africa.

Table 1: Study variables of interest

Type	Name	Definition
Dependent	GDP per capita	Average economic output per person in thousands USD in a country. Computed as GDP/total population
Independent	Primary School Enrollment	Number of people enrolled in primary school in a year divided by total enrollments meeting school age limit (%)
Control	Adult literacy rate	% of people ages 15 and over who are literate
Control	Government expenditure on primary Education	Govt expenditure on prim educ per stud as a % of GDP per capita
Control	Annual inflation rate	Rate of price change in the economy as a whole, %.
Control	Population growth rate	Rate at which population growths, from time time(t) to time (t+1) as %

Note: Enrollment % can exceed 100% because the denominator accounts for school going age only, yet the numerator can have adults in primary, examples: Kenya: Primary 6-13, Ghana/Algeria/Morocco: 6-11. Data source: The World Bank.

iv. Missing sample observations

The dataset includes six variables for comparative analysis across African countries, but significant missing data exists, particularly in adult literacy (91% missing) and government expenditure on primary education (89% missing), with primary school enrollment missing at 34%. Data system limitations in developing countries contribute to these gaps, potentially introducing bias. To address this, I performed multiple imputation for missing values and conducted regression analyses before and after imputation to assess its impact. Figure 2 visualizes the missing data in the sample.

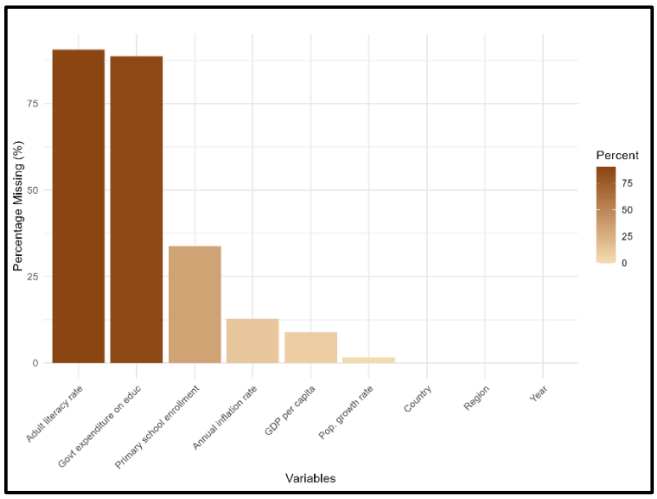

Figure 2: Missing data in key variables of interest. Data source: World bank.

v. Exploratory Data Analysis (EDA)

This subsection begins with a descriptive summary of the variables of interest, presented in Table 2. These descriptives reveal several insights including: that the average GDP per capita for African countries is about USD 1,350, way below the current average estimates of about USD 2,300, an indication of a systemic missing data issue. However, some countries have high GDP per capita values while some are as low as USD 35, an indicator of a skewed distribution evidenced in Figure 3. The sample reveals an average primary school enrollment of 86 percentage points, with some countries posting as high as over 150% enrollment rates. The statistics are consistent with current estimates. Adult literacy rate from the sample is slightly lower from the current 67% whereas inflation and growth rate is consistent with current rates.

Table 2: Descriptive summary of variables of key variables.

Variable	Mean	SD	Min	Max
GDP per capita "000" USD	1351.27	2220.77	35.36	19141.51
Enrollment in pry School	86.06	30.22	6.94	156.8
Adult literacy	60.37	21.71	5.4	96.2
Govt. exp on education	12.75	5.93	3.03	41.81
Annual inflation rate	28.54	509.25	-31.57	26762.02
Population growth rate	2.51	1.36	-17.99	16.75

Note: Descriptive summary of 6 variables of interest from the WDI data, 1960-2023, a total of 3456 observations. Data source: The World Bank.

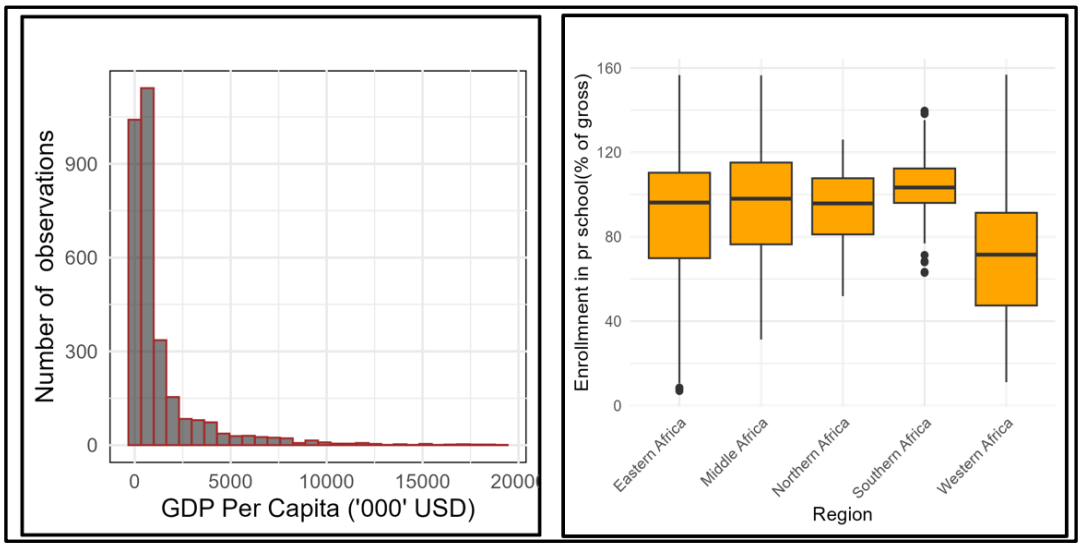

Figure 3: Distribution of raw GDP per capita for (L) and median primary school enrollment (R) for 54 African countries in the period 1960-2023. Data source: The World Bank.

vi. Data Transformation

As evidenced in Figure 3, left pane, the GDP per capita data exhibited a high degree of skewness, and to address this before regression analysis, I conducted a logarithmic transformation, ensuring all values are within USD 4-10 thousand range. The rest of the variables are used in their original scale. Further exploratory data analysis after transforming the main outcome of interest revealed a strong positive correlation between GDP per capita and primary school enrollment rates, presented using Figure 4. The analysis indicated that at lower levels of enrollment, GDP per capita was also low; conversely, higher enrollment levels were associated with increased GDP per capita. Additionally, the visual plot reveals a linear relationship between GDP per capita and primary school enrollment, findings that signal a need for further investigation of causality using regression analysis.

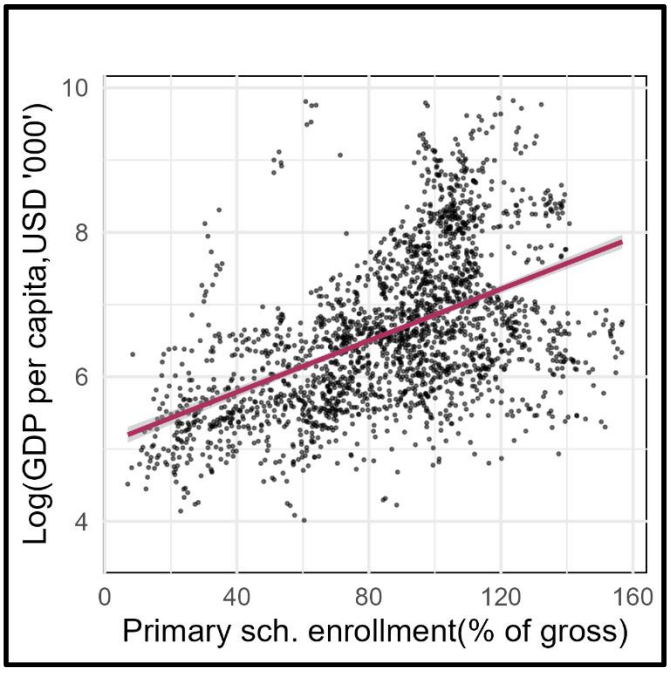

Figure 4: Relationship between Log (GDP per capita) and primary school enrollment rate for 54 African countries in the period 1960-2023. Data source: The World Bank.

vii. Estimation method

To examine the proposed hypotheses quantitatively, multiple regression models will be employed. The initial regression will assess the relationship between primary school enrollment rates and GDP per capita. Control variables will include inflation rates, government expenditure on education, adult literacy rates, and demographic factors such as population growth and urbanization rates. Moreover, I control decadal and regional effects.

$$GDP\ per\ capita = \beta_0 + \beta_1(Primary\ enrollment) + \beta_2(Adult\ literacy) + \beta_3(Government\ expenditure) + \beta_4(Inflation) + \beta_5(Population\ growth\ rate) + \Omega K + \epsilon$$

Where β coefficients represent the marginal effects of each independent variable on GDP per capita and ϵ is a random noise. K is a vector of decade and region variables. To investigate the effects, I follow a clear analysis strategy, where: (i) I conduct regression analysis before conducting imputation and report the results in Table 3. (ii) I conduct regression analysis post imputation and report the results in Table 4.

3. Results, Discussion and Limitations.

Table 3: Prior to multiple imputation. Ordinary least squares (OLS) regression estimation results: Effect of primary school enrollment on GDP per capita

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	5.075***	5.314***	6.208***	6.604***	6.262***
	-0.059	-0.189	-0.5	-0.466	-0.729
Primary school enrollment (% of gross)	0.018***	−0.005·	−0.014**	−0.015***	−0.014**
	-0.001	-0.002	-0.005	-0.004	-0.004
Adult literacy (%)		0.035***	0.038***	0.040***	0.038***
		-0.003	-0.004	-0.004	-0.006
Government expenditure on education (% of GDP per cap on student			0.007	−0.007	−0.022
			-0.015	-0.014	-0.015
Annual inflation (%)				−0.043***	−0.031**
				-0.01	-0.01

Population growth rate (%)					−0.063
					-0.089
Decade Effects					Yes
Region Effects					Yes
Observations	2230	276	89	89	89
R^2	0.253	0.45	0.495	0.584	0.704
R^2 Adj.	0.252	0.446	0.477	0.565	0.661

*Note:· imply p < 0.1, * p < 0.05, ** p < 0.01 and *** p < 0.001 respectively. The outcome variable has been log-transformed.*

In Model 1 (Table 3), a 1% increase in school enrollment is associated with a statistically significant 1.8 percentage point rise in GDP per capita. However, introducing controls (e.g., adult literacy, government expenditure, inflation, population growth, and fixed effects) reduces the effect size, and by Model 5, the direction changes, potentially misleading. Observations also drop significantly, from 2,230 in Model 1 to 89 in Model 5, raising robustness concerns.

After imputing missing data (Table 4), Model 1 shows a 1% enrollment increase corresponds to a 1.7% GDP per capita rise, remaining stable and significant across Models 2–4. In Model 5, the effect decreases to 1% but stays significant, aligning with prior research (Barro, 1991; Hanushek & Wössmann, 2015) on education's role in economic growth.

Table 4: Post multiple imputation. Ordinary least squares (OLS) regression estimation results: Effect of primary school enrollment on GDP per capita

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Constant	4.906***	3.950***	3.421***	3.889***	3.391***
	-0.059	-0.158	-0.192	-0.198	-0.162
Primary school enrollment (% of gross)	0.017***	0.016***	0.017***	0.016***	0.010***
	-0.001	-0.001	-0.001	-0.001	-0.001
Adult literacy		0.017***	0.017***	0.015***	0.012***
		-0.003	-0.003	-0.003	-0.002
Government expenditure on education (% of GDP per cap on student			0.041***	0.038***	0.025***
			-0.008	-0.008	-0.006
Annual inflation (%)			−0.000·	−0.000	−0.000·
			0	0	0

Population growth rate				−0.120***	−0.065***
				-0.014	-0.011
Decade Effects					Yes
Region Effects					Yes
Observations	3272	3272	3272	3272	3272
R2	0.169	0.18	0.186	0.204	0.533
R2 Adj.	0.169	0.179	0.185	0.203	0.531

*Note: · imply p < 0.1, * p < 0.05, ** p < 0.01 and *** p < 0.001 respectively. 184 outliers dropped. The outcome variable has been log-transformed.*

i. Robustness Analysis

The results in Table 4 may vary with changes to variables, model specifications, or country exclusions. To test robustness, I modified observations, excluding the top five wealthiest countries by GDP per capita, as their higher education investments might skew the relationship between enrollment and GDP. After rerunning the analysis, findings remained consistent: a 1% increase in primary school enrollment correlated with a statistically significant 0.8% rise in GDP per capita. This robustness analysis, detailed in Appendix A, confirms the model's reliability.

ii. Post estimation analysis

Post-estimation analysis is crucial for interpreting statistical model results and understanding their practical implications. While regression coefficients indicate strong positive relationships, post-estimation techniques, such as calculating predicted values by varying predictors, provide deeper insights. These methods help quantify key variable impacts, explore non-linear relationships, detect interactions, and translate findings into actionable insights. In this analysis, when all predictors are set to their mean values, the model predicts a GDP per capita of USD 170,000 with high precision (standard error of 0.0355) and statistical significance ($p<0.001$). Further, increased government education spending was linked to significantly higher predicted outcomes, with potential increasing returns at higher expenditure levels, while holding primary school enrollment constant at 100%. Figure 5 visualizes these predicted values, showing higher

precision (narrower confidence intervals) at lower spending levels and lower precision (wider intervals) at higher levels, likely due to fewer countries spending at those extremes.

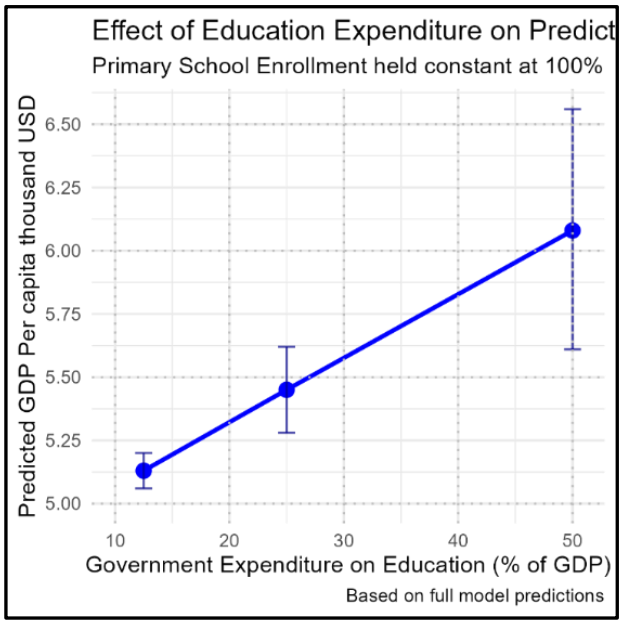

Figure 5: Post Estimation predictions based on the final model estimating the effect of primary school enrollment on GDP per capita for 54 countries, drawing from data from WDI , 1960-2023.

iii. Addressing Limitations

This study acknowledges limitations like omitted variable bias and outliers, addressed via multiple imputation and Cook's distance threshold respectively. Despite precautions, further research is needed to refine causal inferences, control for confounders, and address simultaneity in the education-economic performance relationship.

4. Conclusion and Policy Recommendations

The results of this study carry significant implications for policymakers in developing countries. The positive causal relationship identified between primary school enrollment rates and GDP per capita indicates that increased investment in primary education is likely to yield substantial economic returns. These findings underscore the importance of prioritizing access to education

as a key strategy for fostering sustainable economic growth. Governments should view education funding as an essential component of their economic policy, as enhancing educational access and quality can play a crucial role in breaking the cycle of poverty and inequality.

In conclusion, higher primary school enrollment rates have the potential to positively influence GDP per capita in developing nations. This research highlights the necessity for ongoing investment in education as a means of facilitating economic growth and development. Future studies should build on these findings by examining the long-term effects of educational access on various socio-economic outcomes, ensuring that the benefits of education reach beyond immediate economic gains.

References

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Appendices

Appendix A: Robustness analysis. Ordinary least squares (OLS) regression estimation results: Effect of primary school enrollment on GDP per capita

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	4.935***	3.973***	3.433***	3.768***	3.381***
	-0.057	-0.151	-0.189	-0.196	-0.151
Primary school enrollment (% of gross)	0.016***	0.016***	0.016***	0.016***	0.008***
	-0.001	-0.001	-0.001	-0.001	-0.001
Adult literacy		0.017***	0.017***	0.016***	0.012***
		-0.003	-0.003	-0.003	-0.002
Government expenditure on education (% of GDP per cap on student			0.041***	0.039***	0.025***
			-0.009	-0.009	-0.006
Annual inflation (%)			−0.000+	−0.000	−0.000
			0	0	0
Population growth rate				−0.085***	−0.013
				-0.014	-0.01
Decade Effects					0.586***
Region Effects					-0.042
Observations	3110	3110	3110	3110	3110
R2	0.168	0.18	0.187	0.197	0.581
R2 Adj.	0.168	0.18	0.186	0.195	0.579

Notes: This regression analysis does not include the five richest countries in Africa according to GDP per capita namely; Seychelles, Libya, Gabon, Gabon and Mauritius.

Appendix B: additional figure

Figure 6: Distribution of primary school enrollment (L) and trend in average enrollment rate (R)