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Assessing Education's Vital Role: An ARDL Study on How Government Spending Impacts Per Capita Economic Growth in Bangladesh

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Abstract

This study examines how education expenditure influences Bangladesh's economic growth in the long-run. It fills a policy research gap regarding human capital investment's effectiveness, but the study tests whether the chosen macroeconomic variables would be I(0) and I(1) to show long-run stable, cointegrating relationships. Unit root tests [Augmented Dickey-Fuller (ADF) test and KPSS] were conducted on time-series data from 1998-2024, showing a mixed order of integration, where variables are I(0) and I(1). Thus, Autoregressive Distributed Lag (ARDL) Bounds Testing for cointegration is appropriate. ARDL is an appropriate test for mixed orders of integration and smaller sample sizes. The null hypothesis of long-run cointegration is confirmed at the .05 level by the F-statistic value of 10.52 (greater than the critical bounds value). Furthermore, the elasticity derived from education expenditure is statistically significant across all models at almost 0.99, which means that when education expenditure increases by one percent, GDP per capita increases by one percent in the long-run. Furthermore, a statistically significant Error Correction Term (ECT) value of −0.048 confirms that the error term is sustainable, meaning the economy corrects for 4.8 percent of its disparity every year. Therefore, these results provide extensive empirical support for the long-run approach of increased education expenditure as a valid approach to Bangladesh's economic growth in the future. This increases the likelihood that policymakers may want to move forward with increased education efforts to both level up and increase quality and quantity for best results.

Keywords: *ARDL model, economic growth, education expenditure, cointegration, Bangladesh.*

1. Introduction

1.1 Background

Education plays a crucial role in building human capital. Thus, it is considered as an investment, not just consumption. Based on the works of Schultz [1] and Becker [2] on "Human Capital Theory" it is established that there is a direct link between individual skills and knowledge to national productivity and economic output. Bangladesh being one of the developing countries, education spending becomes even more pivotal. To find a long-run economic relationship between education spending and economic growth, we face the challenge of non-stationarity and spurious regression. There for we need advanced models as Ordinary Least Squares (OLS) becomes inadequate. Thus, we need to conduct the cointegration test. Previous studies found mixed results and varied across countries. This study aims to provide a clear, stable, and recent estimate for Bangladesh. Autoregressive Distributed Lag (ARDL) is idea because it allows mixture of I(0) and I(1) variables and a small sample size. Using it we

are able to find both short run and long run dynamics between education spending and GDP per capita.

1.2 Literature Review

1.2.1 Theoretical Framework

The conceptualization of education within development economics has evolved substantially. It began as a view of social consumption. It has since become a rigorous framework of capital accumulation. Schultz initiated this shift [1]. He argued that the acquisition of useful skills and knowledge is not a current expenditure. It is a deliberate, high-return investment in human capital. He further posited that this form of capital predominantly explains the productive superiority of technically advanced nations. Omitting it from growth models, he argued, means ignoring the central driver of modern economic performance. Becker extended this argument [3]. He characterized human capital as an embodied asset that cannot be separated from the individual. Consequently, all associated costs must be treated as capital outlays. This includes the significant opportunity cost of foregone earnings. These outlays are intended to raise future monetary income and psychic income alike.

A significant theoretical bifurcation exists in the empirical growth literature. It separates the neoclassical and endogenous growth paradigms. Makiw, Romer, and Weil made the defining neoclassical contribution [4]. They augmented the textbook Solow model by incorporating human capital as a distinct factor of production. Their framework retains the assumption of decreasing returns to capital. But it demonstrates that variation in human capital accumulation, alongside physical capital and population growth, explains approximately 80 percent of international variation in per capita income. This established a powerful empirical benchmark for subsequent country-level studies.

Lucas and Romer proposed a fundamentally different mechanism [5, 6]. Their endogenous growth models treat human capital as the primary engine of permanent technological progress. Lucas emphasized in the internal and external effects of human capital accumulation [5]. The average skill level of a population generates productivity externalities that raise the output of all factors of production. Romer refined this argument by introducing the role of the research sector [6]. He argued that human capital is the essential scale variable that drives the production of non-rival technological designs. These designs are necessary for unbounded long-run growth. The distinction from the Mankiw-Romer-Weil framework is important. If the Lucas-Romer mechanism operates in Bangladesh, then education spending sustains growth rates permanently rather than merely shifting the income level to a higher steady state.

For a developing economy like Bangladesh, education serves a dual purpose beyond factor accumulation. Nelson and Phelps identified a second mechanism: technological diffusion and catch-up growth [7]. They argued that educated individuals possess the information-processing capacity required to receive, decode, and understand new technological knowledge. This capacity shortens the adoption lag between global best-practice technology and its application in practice. Therefore, the return to education is highest in technologically progressive environments. In this view, education spending does not merely raise Bangladesh's productive capacity. It also accelerates convergence by enabling faster absorption of technology developed elsewhere.

1.2.2 Empirical Studies on Education and Growth

There have been several studies which addressed the issue of human capital while taking factors like Gross Domestic Product (GDP), economic growth, etc. into consideration. Ahsan [8] observed nine crucial economic factors that affected GDP per capita over 31 years (1992–2022). He found five variables to be statistically significant: GDP, GDP growth rate, Gross

Savings rate, Inflation rate, and Poverty rate. As pert he findings economic growth and GDP per capita had a positive correlation. Whereas, inflation rate and poverty rate had negative correlation. Due to high R-square value (0.998769) it covers almost all the variation of the dependent variable. But in the long-run relation a deeper picture comes into lights in terms of the relation between human capital investment and economic outcomes.

Chowdhury et al. [9] strong positive relation between human capital and economic growth. Life expectancy had the most significant impact. But surprisingly paper also found negative coefficients public health and public education expenditure. In another similar research, Rahman [10] found bidirectional causal link between education expenditure and GDP. But in the long run, a significant negative impact of education expenditure on GDP was found. In his article, Mukit [11] found in the long 1 percent increase in public expenditure on education leads to 0.34 percent rise in per capita GDP. Lastly, in terms of from income inequality perspective, Karim [12] found spending on tertiary education is regressive. It favors the richest 40 percent who capture about 87 percent of the benefits in that sector.

2. Methodology

2.1 Data Sources and Variable Construction

This study uses 27 annual observations from 1998 to 2024. All the variables and data were collected from World Development Indicators (WDI). All non-ratio variables were transformed into their natural logarithmic form in order to deal with the issue of heteroskedasticity and facilitate direct interpretations of the long-run coefficients. Data sources are presented in Table 1.

2.2 Data Analysis Methods

This study aims to find short-run relation and long-run equilibrium dynamics between government education expenditure and economic growth in Bangladesh. To do so, it employs three consecutive steps consisting unit root test, the Autoregressive Distributed Lag (ARDL) Bounds Test, and Error Correction Modeling. All tests were conducted using Python programming.

Table 1: Data Sources

Variable (log form)	Description	Source	Original Data Series
logGPDpc	Log of Real GDP per capita (constant 2015 US$)	WDI	NY.GDP.PCAP.KD
logEduSpend	Log of Government Expenditure on Education, total (% of GDP)	WDI	SE.XPD.TOTL.GD.ZS
logGCF	Log of Gross Capital Formation (% of GDP)	WDI	NE.GDI.TOTL.ZS
logLaborPart	Log of Labor Force Participation Rate, total (% of total population ages 15+)	WDI	SL.TLF.TOTL.ZS
logTrade	Log of Trade (% of GDP) (Exports + Imports of goods and services)	WDI	NE.TRD.GNFS.ZS
logSecEnroll	Log of Secondary Education Enrollment Rate, gross (%)	WDI	SE.SEC.ENRR

2.2.1 Unit Root Tests

Before conducting cointegration analysis, it is essential to determine the stationarity properties of the variables to ensure that none are integrated of order two, i.e., I(2), as the ARDL bounds test is invalid in the presence of I(2) variables. To this end, Augmented Dickey-Fuller (ADF) Test has been applied. It is used to test the null hypothesis of a unit root (non-stationarity) against the alternative of stationarity. It allows for a definitive

determination of whether the variables are purely I(0), purely I(1), or a mixture of both.

2.2.2 ARDL Bounds Testing Approach

Given the relatively small sample size (N=27) and the mixed order of integration found in the preliminary tests (variables are a mix of I(0) and I(1)), the Autoregressive Distributed Lag (ARDL) bounds testing approach proposed by Pesaran et al. [13] was selected over the Johansen cointegration method. The ARDL model is specified as shown in equation (1):

$$\Delta InGDPpc_t = \propto_0 + \sum_{i=1}^{p} \beta_{1i} \Delta InGDPpc_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta InEduSpend_{t-i} + \sum_{i=0}^{q} \beta_{ki} \Delta InX_{t-i} + \lambda_1 InGDPpc_{t-1} + \lambda_2 InEduSpend_{t-1} + \lambda_k InX_{t-1} + \epsilon_t \quad (1)$$

Here, Δ represents the first difference operator, InX represents the vector of control variables (Capital Formation, Labor Participation), β coefficients represent the short-run dynamics, λ coefficients represent the long-run relationship, and ϵt is the white noise error term.

An F-statistic is computed to test the joint null hypothesis of no cointegration ($\lambda_1 = \lambda_2 = \ldots = \lambda_k = 0$). The calculated F-statistic is compared against two sets of critical values (Lower Bound I(0) and Upper Bound I(1)). The null hypothesis is rejected when F-statistic exceeds the upper bound. This confirms the presence of a long-run relationship.

2.2.3 Error Correction Model (ECM) and Diagnostics

First step is to establish cointegration. Then, speed of adjustment towards the equilibrium is figured via estimation with use of an Error Correction Model (ECM). Based on the coefficient of Error Correction Term (ECTt-1) we get percentage of disequilibrium connected in each period. The reliability of the estimates is ensured by use of diagnostic tests for serial correlation, heteroskedasticity, and structural stability.

3. Results

3.1 Descriptive Statistics

Table 2 provides the summary statistics. Here, we find the average per capita GDP is around 1100 USD in the selected time frame. Whereas, average education spending is about 2 percent. As per the standard deviation, labor force participation has been the most consistent variable.

3.2 Unit Root Analysis

The study used Augmented Dickey-Fuller (ADF) test for determining stationarity and order of integration. As it can be seen from Table 3, education spending and trade are stationary at level form, I(0). Whereas, GDP per capita, capital formation, and labor participation have unit roots and stationarity is achieved after first-differencing, I(1). Due to the mix of integration levels, study used ARDL bounds test for analysis.

3.3 ARDL Bounds Test for Cointegration

Cointegration analysis has been presented in Table 4. We found F-statistic (10.52) to be significant at 1 percent significance level. This is greater than upper critical bound (4.66). Thus, we can reject the null hypothesis of no long-run relationship between variables. Therefore, education, capital, and labor have long-run relation with per capita GDP.

3.4 Long-Run and Short-Run Estimates

Table 5 provides a comprehensive idea about short-run dynamics and long-run elasticities. As for education investment and GDP, we found elasticity as 0.99, significant at 5 percent significance level. Thus, percentage-point growth in education spending leads to almost one-to-one long-term economic growth. Another significant variable is gross capital formation. Here, elasticity is 5.3905 at 1 percent significance. In terms of short-run dynamics, Error Correction Term (ECT) is statistically significant with −0.048 as the coefficient. So, the model corrects nearly 5 percent of annual deviations back toward the long-run equilibrium.

Table 2: Descriptive Statistics (1998-2024)

Variable	Obs	Mean	Std.Dev.	Min	Max
GDPpc (USD)	27	1100.31	431.84	584.45	1941.28
EduSpend (% GDP)	27	2.01	0.25	1.13	2.20
GCF (%GDP)	27	27.65	3.08	22.12	32.21
LaborPart (%)	27	58.59	1.53	56.09	61.89
Trade (% GDP)	27	34.58	7.01	26.27	48.11

Note: GDPpc is constant 2015 USD

Table 3: Augmented Dickey-Fuller (ADF) Unit Root Test Results

	Level		First Difference		
Variable	t-statistic	Prob.	t-statistic	Prob.	Result
InGDPpc	2.1889	0.9989	−3.0931	0.0271**	I(1)
InEduSpend	−3.2326	0.0182**	−3.8010	0.0029***	I(0)
InGCF	−1.7777	0.3916	−3.8479	0.0025***	I(1)
InLaborPart	−2.7666	0.0632*	−3.5475	0.0068***	I(1)
lnTrade	−3.2541	0.0171**	−4.2924	0.0005***	I(0)

Note: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively

Table 4: ARDL Bounds Test for Cointegration

Test Statistic	Value	Result
F-statistic	10.5175***	Cointegration Exists
k (Regressors)	3	
Critical Values (Pesaran et al. [13])		
Significance	Lower Bound I(0)	Upper Bound I(1)
1%	3.65	4.66
5%	2.79	3.67
10%	2.37	3.20

Note: Critical values are based on Case III (unrestricted intercept and no trend)

Table 5: Long-Run Coefficients and Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic
Panel A: Long-Run Coefficients			
InEduSpend	0.9903**	0.350	2.82
InGCF	5.3905***	1.420	3.79
InLaborPart	−2.9169	2.020	−1.44
Panel B: Short-Run Dynamics & ECM			
ΔInEduSpend	0.0056	0.011	0.52
ΔInGCF	0.2922***	0.094	3.11
ΔInLaborPart	0.1428	0.164	0.87
ECT_{t-1}	−0.0484**	0.021	−2.31
Panel C: Model Diagnostics			

R-squared	0.781		
Adjusted R-squared	0.696		
F-statistic (Model)	9.176***		

Note: Dependent Variable: ΔInGDPpc. *** and ** denote significance at 1% and 5%, respectively

4. Discussion

The empirical findings cover the period 1998 to 2024. They reveal a long-run elasticity of 0.99 for education expenditure on GDP per capita. This near-unitary coefficient indicates an almost proportional relationship between human capital investment and economic output in Bangladesh. Contextualized with Lucas [5], such a high elasticity suggests that education may be functioning as more than a conventional factor of production. It may be activating the endogenous growth loops he described. In those loops, human capital accumulation sustains growth rates even in the absence of exogenous technological shocks.

From a methodological standpoint, the single-country time-series approach used here provides a necessary counterpoint to broader cross-country panel studies Islam demonstrated that conventional cross-sectional regressions, including those of Mankiw et al. [3], often suffer from omitted variable bias [14]. They fail to account for unobservable country-specific effects. By applying an ARDL framework to Bangladesh alone, the present study captures the nation's idiosyncratic technological level and institutional efficiency. These are features that cross-country regressions average away. The result is a cleaner isolation of how domestic education spending interacts with Bangladesh's specific economic rigidities.

But the long-run picture is only part of the story. The Error Correction Term (ECT) of −0.048 indicates a sluggish speed of adjustment toward long-run equilibrium. This implies substantial structural rigidities in the system. Three barriers like account for this slow convergence. Firstly, Nelson and Phelps noted that a positive equilibrium gap always exists between potential technology and technology in actual practice [7]. This gap is only narrowed by expanding the educated labour stock. Secondly, the present study observes that high levels of informal sector employment do not contribute proportionally to per capita value addition. Educated workers absorbed into informal roles cannot realize their full productive potential. Thirdly, Becker identified capital market imperfections and labour hoarding behaviours as persistent barriers to the optimal allocation of skilled workers [3]. Together, these frictions explain why a long-run education elasticity of 0.99 does not translate into rapid short-run adjustment. The long-run potential is substantial. But institutional and structural constraints suppress its near-term realisation. Alongside education spending, the study also found high elasticity of gross capital formation (5.39). It signifies physical infrastructure still plays the pivotal role in growth dynamics. Lower relative impact of human capital can be explained by surplus labour in agriculture and high level of informal sector employment, which does not contribute proportionally to per capita value addition. In last two decades, Bangladesh has witnessed immense progress in the literacy rates and school enrollment. Therefore, education spending should be considered as a productive investment, not just a mere cost.

One of the key downside of the study is 27-year dataset. This led to reduced number of degrees of freedom. Furthermore, after preliminary analysis, the study excluded school enrollment and trade variables in particular to address the issue of multicollinearity and ensuring a stable parsimonious model. The study can be further improved by using quarterly data to include variable like institutional quality to explore the link between education and growth.

4. Conclusion

The study established the link between education spending and economic growth in Bangladesh between 1998 and 2024. It employed ARDL bounds test as the primary tool due to diversity in the integration levels of the data. The three key findings are human capital have near-unitary relation as the driver of per capita income. Secondly, physical capital still remains as the main force in that matter. Thirdly, there is a sluggish recovery speed hinting structural hurdles. Therefore, a strong empirical mandate for increasing and safeguarding the national education budget is warranted.

Declaration of Generative AI Use

The author clearly states AI was used as a secondary tool for language polishing and structural refinement. All the research design, data gathering, and execution of the ARDL model were done by the author. All the interpretations, discussions, and policy recommendations are based on author's own analysis. Therefore, author takes full responsibility for the final content and the accuracy of the findings presented.

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