Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10, 1649-1658
2025
Publisher: Learning Gate
DOI: 10.55214/2576-8484.v9i10.10728

Threshold regression analysis of public education spending policy on economic growth in Lebanon

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Abstract: This research investigates the nonlinear effect of public education spending on economic growth in Lebanon and tests for threshold effects that can change this relationship. We use annual time-series data from 1993 to 2023 and employ threshold regression analysis following Hansen's procedure, as well as the Autoregressive Distributed Lag (ARDL) approach. The determinants in the analysis are Gross Domestic Product per capita (GDPPC), education expenditure (EDUCEXP), secondary school enrollment (ENROL), total labor force (TLF), and fixed capital formation (FBCF). The Hansen test indicates a statistically significant threshold effect. Below the identified threshold, education expenditure has no significant impact on economic growth. However, expenditure above the threshold shows a strong negative correlation with economic growth (coefficient: -0.466, p-value: 0.044). The ARDL bounds test confirms the absence of long-run cointegration between the variables. The relationship between economic development and education spending in Lebanon is nonlinear and depends on the level of expenditure. The findings oppose traditional linear hypotheses and show that excessive spending at high levels is harmful. Policymakers should focus on enhancing the productivity of education expenditure instead of increasing the budget. Inefficiencies in the structure must be addressed, institutional standards increased, corruption addressed, and educational output aligned with labor market demand so that the productivity of education investment in Lebanon is enhanced.

Keywords: *ARDL, Economic growth, Education, Lebanon, Public expenditures, Threshold regression.*

1. Introduction

Education investment is widely regarded as a driver of economic growth, especially in developing countries facing severe challenges, such as Lebanon [1, 2]. While standard economic theory often assumes a linear, positive relationship between education spending and economic performance [3], new evidence indicates that this effect is nonlinear, featuring a "threshold effect" where the rate of return on expenditure shifts qualitatively after a tipping point.

The study contributes to world literature by refining the linear hypothesis approach to examine threshold impacts in Lebanon, a country experiencing unprecedented economic stress. The main goal is to identify a critical threshold level for government spending on education, beyond which its elasticity or effect on economic growth diminishes or turns negative. Using threshold regression on time-series data from 1993 to 2023 for EDUCEXP, ENROL, TLF, and FBCF as independent variables, with GDP per capita as the dependent variable, we analyze short- and long-term behaviors via the ARDL method. Our key finding identifies a threshold: below this level, spending has no significant impact, but surpassing it is associated with a negative effect on growth. This emphasizes that successful educational policy depends not only on input resources but also on the level of expenditure.

History: Received: 19 August 2025; Revised: 13 October 2025; Accepted: 17 October 2025; Published: 27 October 2025
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2. Literature Review

The relationship between government spending on education and economic growth is the subject of theoretical and methodological debate. According to Olayungbo and Olayemi [4] analysis of Nigerian data from 1981 to 2015 using a vector error correction model indicates that government spending has a negative and significant impact on economic growth in both the long and short run Rajkumar and Swaroop [5] show that the positive impact of spending on productivity is significantly reduced when the quality and infrastructure of institutions are underdeveloped. Kilic and Ertugrul [6] found a positive relationship between economic growth and education spending. Suwandaru et al. [7] examined the link between economic growth and education spending and found no significant relationship between public education spending in the short and long term. Obaid and Bahari [8], using data from Kuwait, identified a one-way causal relationship between spending and economic growth. According to Psacharopoulos and Patrinos [9], spending on education can be ineffective when it is not targeted toward areas that generate economic growth, especially when the focus is on theoretical education at the expense of technical and vocational training. Using the ARDL model and data from 1981 to 2017, Onifade et al. [10] found that capital expenditure has a negligible positive influence on GDP, whereas recurrent expenditure harms the nation's output. Barlas [11] used the ARDL technique to analyze data from Afghanistan from 2004 to 2019 and discovered that investments in infrastructure and education positively impact economic growth, while security expenditures have a negative effect. Law et al. [12] conducted a seminal examination of data from over 100 nations from 1980 to 2015 using a panel threshold regression model. Their analysis found a definite barrier for education spending as a percentage of GDP. Below this threshold, additional spending had a statistically minor and economically insignificant impact on economic growth. Wang and Zhao [13] studied a specific Chinese province, where additional education funding was allocated to provinces with fiscal capacity below a predetermined government threshold. They conducted a rigorous resource allocation analysis to isolate the causal effect of the increased spending. Their results confirmed a sharp discontinuity in subsequent GDP growth rates at this level and provided quasi-experimental evidence so strong that it was possible to conclude that the injection of education capital directly positively influenced economic performance.

Gemmell et al. [14] offered a sound empirical basis for their case that the education-growth relationship is conditional. Their meta-analysis suggests that more sophisticated models, such as Hansen's Threshold Regression models, should be used to estimate such changing effects rather than linear models with a constant relationship. Zhou et al. [15] suggest that the effect of education spending depends on reaching a critical threshold. Using advanced non-linear econometric techniques, their study found that spending must exceed 4.5% of GDP before it becomes effective. They argue that spending below this level is insufficient to cover fixed costs and address system inefficiencies, resulting in diminishing returns. As highlighted by the World Bank [2], despite the Middle East and North Africa's high levels of spending, the region still struggles to turn such investment into real economic outcomes due to issues related to the quality, relevance, and governance of education systems. This means that simply investing more money without fixing core structural problems will not produce the expected economic benefits and could even cause short-term harm. Based on a World Bank [16] Lebanon panel threshold model study under which education expenditure has varied and been below the neighboring average of around 4.5% of GDP, the report concluded that low long-term investment could be the major cause of lackluster economic returns. Current studies also highlight the nonlinear relationship between education spending and economic growth. World Bank [17] emphasizes that in crisis contexts like Lebanon, education spending needs to be carefully calibrated rather than increased through broad hikes. IMF [18] confirms that public spending efficiency is especially important in fragile states, where institutional weaknesses can negate the benefits of increased expenditures. UNESCO [19] underscores regional challenges in the Middle East, where education outcomes remain weak despite significant investments due to systemic issues. El Khoury and Andari [20] explore Lebanon's situation and conclude that education quality mediates the relationship between spending and

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10: 1649-1658, 2025
DOI: 10.55214/2576-8484.v9i10.10728

economic growth. Abdallah and Nehme [21] also, in Arab transition economies, the effectiveness of education expenditure depends on institutional quality and governance structures.

2.1. Hypotheses Research

To empirically test the possibility of a nonlinear relationship, this study uses a threshold regression model based on Hansen [22]. The model adjusts regression coefficients depending on whether a specified threshold variable exceeds or falls below an estimated threshold level (γ).

The formal hypotheses for testing the presence of a threshold effect are as follows:

Null Hypothesis (H_0): There is no threshold effect. The relationship between government expenditure and economic growth is linear.

Alternative Hypothesis (H_1): There is a single threshold effect. The relationship between government expenditure and economic growth is nonlinear and exhibits significant changes at an estimated threshold value[22].

3. Methodology

Using a regression threshold, the study will assess the impact of education spending on economic growth in Lebanon. As a result, annual time series data from 1993 to 2023 were predominantly sourced from the World Bank (accessed in May 2023). The study utilized the Stata program to formulate equations and accurately estimate the results in analyzing the relationship between the economic variables.

These variables are: GDPPC: Gross Domestic Product per capita (in constant 2015 dollars); ENROL; EDUCEXP; TLE; FBCF.

3.1. Method

The Keynesian concept of economic growth emphasizes the role of government spending in driving long-term economic growth. According to the Keynesian paradigm, increased government expenditure supports long-term economic growth. The study model is as follows:

$$Y = f(EDUCEXP, EDUCEXP^2, ENROL, TLF, FBCF). \quad \text{Threshold Model [15, 23].} \quad (1)$$

Y represents GDP per capita. The model function's version is shown as follows:

$$Y = \beta_0 + \beta_1 EDUCEXP + \beta_2 EDUCEXP^2 + \beta_3 ENROL + \beta_4 TLF + \beta_5 FBCF + \mu. \quad (2)$$

The model is given in nonlinear form in (2); hence, in (3), the model is linearized to allow estimation, as described below:

$$Yt = \beta_0 + \beta_1 EDUCEXPt + \beta_2 EDUCEXPt^2 + \beta_3 ENROLt + \beta_4 TLFt + \beta_5 FBCFt + \mu \quad (3)$$

The natural logarithm is applied to all variables, and the model equation, assuming linearity, yields:

$$LnYt = \beta_0 + \beta_1 EDUCEXPt + \beta_2 EDUCEXPt^2 + \beta_3 ENROLt + \beta_4 TLFt + \beta_5 FBCFt + \mu \quad (4)$$

In this study, the ARDL test is employed as a more precise and efficient estimation technique. Pesaran and Shin [23] mentioned this approach in 1996. They developed this test, a cointegration method for the frontier technique for long-run connections, particularly when a single cointegration vector cannot be used, and they ignored the degree of stationarity.

3.1.1. Stationarity – Unit Test

Granger [24] demonstrates that when variables of different ordering are integrated, cointegration analysis fails. Even though the ARDL technique does not require prior testing for unit roots, each series' stationarity criteria must be evaluated as a first step in estimating the model. Non-stationary time series are stochastic processes that contain unit roots or structural breakdowns. Nonetheless, unit roots are a major cause of non-stationarity.

Edelweiss Applied Science and Technology
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Table 1.
ADF and PP Tests**,** without a constant test.

Variable	Series						Series in first difference					
	Test-Statistic	(ADF) Dickey-Fuller critical value (5%)	P-value	Test-Statistic	(PP) Phillips–Perron critical value (5%)	P- value	Test-Statistic	Dickey-Fuller critical value (5%)	P- value	Test-statistic	Phillips–Perron critical value (5%)	P-value
GDPPC	-1.967	-3.584	0.6192	-0.950	-3.580	0.9505	-3.253	-3.588	0.0744*	-3.142	-3.584	0.0966*
ENROL	-3.695	-3.584	0.0227**	-3.233	-3.580	0.0780*	-3.460	-3.588	0.0439**	-5.981	-3.584	0.0000***
EDUCEXP	-3.058	-3.584	0.1165	-3.560	-3.580	0.0334**	-4.195	-3.588	0.0045***	-8.453	-3.584	0.0000***
EDUCEXP ^{2}	-3.070	-3.584	0.1137	-3.618	-3.580	0.0284	-4.171	-3.588	0.0050	-8.808	-3.584	0.0000***
TLE	-1.711	-3.584	0.7461	-0.833	-3.580	0.9628	-2.721	-3.588	0.2276	-3.218	-3.584	0.0809*
FBCF	-1.436	-3.584	0.8499	-2.299	-3.580	0.4346	-2.106	-3.588	0.5429	-4.950	-3.584	0.003***

Note: *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% thresholds.

Edelweiss Applied Science and Technology
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Table 1 reveals that the variables are not stationary according to the ADF and PP tests, except for ENROL and EDUCEXP at the 5% level.

Based on these tests, the variables exhibit varying degrees of stationarity at the first level; however, it is evident that no integration exists among the given variables. All series are integrated at the first level. This indicates that they have a unit root in their original form but become stationary after being differenced once.

This finding is significant since it demonstrates that the variables meet the fundamental requirements for applying the ARDL modeling approach. The ARDL framework is effective in analyzing cointegration and long-term correlations between combinations of I(0) and I(1) variables, making it the most suitable methodological choice for this study.

3.1.2. Optimum Lag Length Selection

This table is crucial for time series modeling and choosing the best ARDL model. It is more than just a simple table; it is a vital initial step that guarantees the correctness and dependability of all subsequent outcomes.

Table 2.
Maximum number of Lags.

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	119.598	-	-	-	8.9e-12	-8.41464	-8.32901	-8.12668
1	227.71	216.23	36	0.000	4.6e-14	-13.7563	-13.1569	-11.7406
2	326.801	198.18	36	0.000	6.7e-16	-18.4297	-17.3165	-14.6861
3	431.739	209.88	36	0.000	1.9e-17	-23.5362	-21.9093	-18.0649
4	2295.53	3727.6*	36	0.000	**1.8e-73***	**-158.928***	**-156.788***	**-151.729**

Note: Bold values indicate optimal delay selection.

Table 2 shows the maximum possible latency using the Schwartz Information Criterion (SBIC), HQIC, AIC, and FPE. The best latency is 4 (1.8e-73* for FPE, -158.928* for AIC, -156.788* for HQIC, and -151.729* for SBIC). After determining the maximum lag length for each variable (as indicated in Table 2), the next step is to choose the best lag structure for the ARDL model. This step is crucial for ensuring that the model is properly specified and accurately reflects dynamic relationships. AIC or SBC was used to select the optimal lag model among a large number of potential combinations. The model with the lowest AIC value was chosen. As a result, the ARDL (1,1,0,1,1,0) model was selected as the best fit for our analysis. Table 3 presents the outcomes of this specific model estimation.

3.1.3. ARDL Model & Bound Test

Table 3.
ARDL (1,1,0,1,1,0) regression.

Prob > F = 0.0000		R^2 = 0.9376		Log likelihood = 54.467535	
Variable	**Coefficient**	**Std. err**	**t**	**P>|t|**	**[95% conf. interval]**
LGDPPC1	0.8501871***	0.1514634	5.61	0.000	0.53424 to 1.166134
LENROL1	0.1006229	0.2633767	0.38	0.706	-0.4487713 to 0.650017
L1.LENROL1	-0.334458	0.2452379	-1.36	0.188	-0.8460153 to 0.1770993
LEDUCEXP1	1.73122*	0.8481233	2.04	0.055	-0.0379337 to 3.500375
LEDUCEXP2	-0.4661026**	0.2164253	-2.15	0.044	-0.9175578 to -0.0146474
L1.LEDUCEXP2	-0.0355817**	0.0168468	-2.11	0.047	-0.0707234 to -0.0004399
LFBCF1	0.0156748	0.0177509	0.88	0.388	-0.021353 to 0.0527026
L1.LFBCF1	-0.0250945	0.0165448	-1.52	0.145	-0.0596063 to 0.0094174
LTLF1	0.0651273	0.0853982	0.76	0.455	-0.1130102 to 0.2432647
Cons	2.165046	2.582707	0.84	0.412	-3.222387 to 7.552479

With Cons: is the constant in the regression equation
Note: *, **, *** denote significance at 10%, 5%, and 1% levels respectively.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10: 1649-1658, 2025
DOI: 10.55214/2576-8484.v9i10.10728

The results of the ARDL model confirm a threshold effect on the economic growth rate in Lebanon and suggest a complex relationship between educational spending and economic growth in Lebanon. The evidence indicates that there exists a statistically significant short-run negative relationship: an increase in the educational expenditure variable (LEDUCEXP2) corresponds to a declining economic growth rate.

The coefficient for the variable EDUCEXP^2 is negative [LEDUCEXP^2 = -0,0466] and significant at the 5% level (p-value = 0.044 < 0.05). This implies that in the short run, growth in this specific measure of education spending can fail to achieve the desired positive effect on the economy and may even be negative; hence, accepting H_1 is warranted [22].

Table 4.
ARDL Bound test.

Test Statistic	Significance Level	Lower Bound I(0)	Upper Bound (1)	Conclusion
F-Statistic	10 %	2.26	3.35	Cointegration
	5 %	2.62	3.79	Cointegration
	2.5%	2.96	4.18	Cointegration
	1%	3.41	4.68	Cointegration
T-Statistic	10%	-2.62	-3.35	No cointegration
	5%	-2.62	-3.79	No cointegration
	2.5%	-2.96	-4.18	No cointegration
	1%	-3.41	-4.68	No cointegration

Note: F= 2.948 t= -0.989.

The ARDL Bound test is a valuable method for examining economic relationships, as it confirms long-run relationships between variables and tests for cointegration. It improves economic forecasting models and enhances understanding of economic variable relationships.

Both the F and t test results are not statistically significant at the 5% level. This indicates no significant evidence of a long-run equilibrium relationship between variables in the model.

The Bound test indicates strong evidence of cointegration. This confirms the use of the ARDL model and enables us to interpret the long-run coefficients and the error correction term (ECM).

After the estimation of the ARDL model, its statistical integrity must be examined to ensure that it is free from standardization problems that might undermine the validity of the findings. To this end, a series of diagnostic tests was conducted, as reported in the subsequent tables.

3.1.4. Diagnostic Tests of the Model

3.1.4.1. Autocorrelation Tests

Autocorrelation tests compute the autocorrelation between successive values in a time series. The autocorrelation test can be utilized to improve forecasting models and reveal patterns in time series.

Table 5.
Test for autocorrelation

Test	Lags (p)	chi2	df	Prob > chi2
Breusch–Godfrey	4	10.422	4	0.0339

With: chi2: chi-square (χ^2) test statistic.
df: Degree of freedom.
Hypothesis:
H_0: no serial autocorrelation
H_1: There is serial autocorrelation
If p-value < 0.05 = α H_0 is rejected and H_1 is accepted
If p-value > 0.05= α H_1 is rejected and H_0 is accepted
p-value = 0.0339 < 0.05, then H_0 is rejected.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10: 1649-1658, 2025
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Then there is serial autocorrelation.

3.1.4.2. Heteroscedasticity Test

The heteroscedasticity test helps determine whether the variances of the errors are constant. This test can verify results, improve regression models, and assist in identifying sources of variance in data.
H_0: There is Homoskedasticity
H1: There is Unrestricted heteroscedasticity

Table 6.
Heteroscedasticity Test.

Source	chi2	df	p
Heteroskedasticity	30.00	29	0.4140
Skewness	17.02	9	0.0484
Kurtosis	0.46	1	0.4985
Total	47.48	39	0.1654

With: chi2: chi-square (χ^2) test statistic
df: Degree of freedom,
p-value=0.1654 > 0.05, then H0 is accepted.
Then there is Homoscedasticity. This means that the model is good and has no problems.

3.1.4.3. Stability Test

The stability test is used to ensure that variables remain stable over time, such as time series [25].

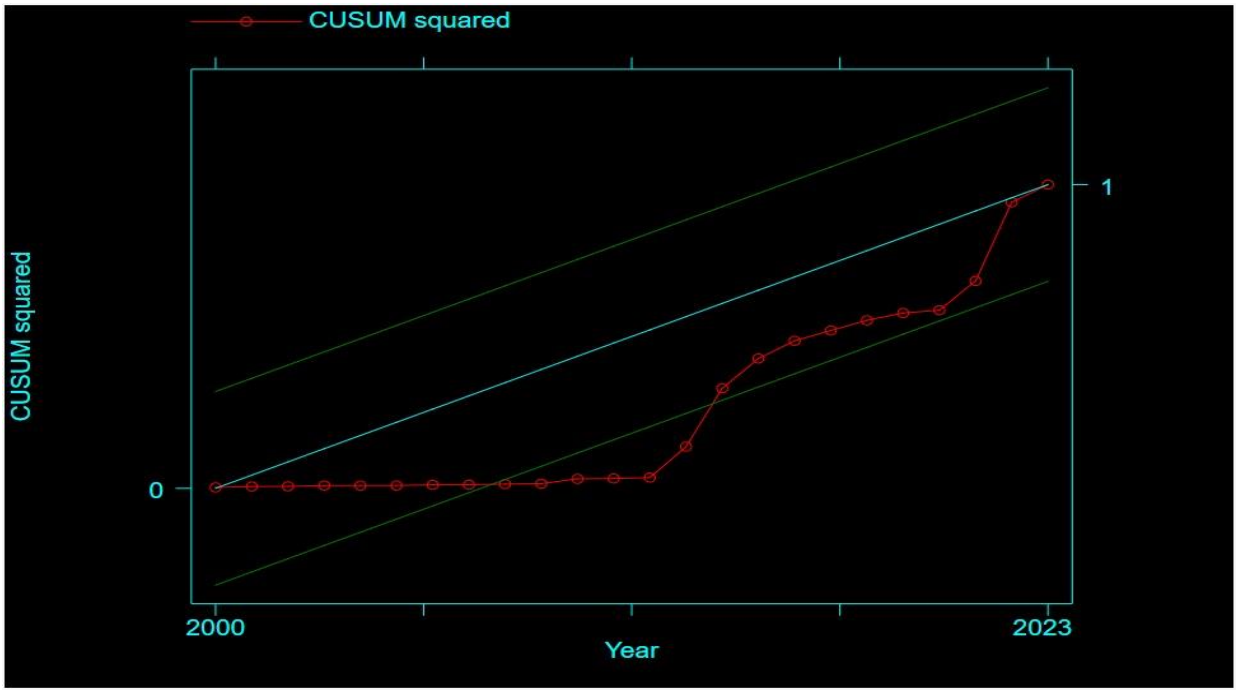

Figure 1.
CUSUM Stability test of ARDL (1,1,0,1,1,0) model.

The CUSUM (Cumulative Sum of Recursive Residuals) test is a statistical test used primarily to detect structural change in the coefficients of a regression model over time.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
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Figure 1 shows that the blue line (statistical trajectory) remained within the red confidence limits (acceptable region) throughout the study period. This indicates:

a. Stable Variance: The variance of the model errors (residuals) is stable and constant over time from 1999 to 2023. There was no significant structural change in the variability or accuracy of the model's predictions.

b. Model Reliability: This indicates that the estimated ARDL (2, 1, 2, 2, 2) model is reliable and valid for analysis and prediction over an entire time period, as its statistical properties have not changed [26].

c. Lack of Structural Change: No shocks or events (at least those affecting the model's variance) were sufficient to cause a break in the model's structure.

In short: The model is stable. Its prediction accuracy has not changed randomly or dangerously over time, so its results can be trusted.

4. Discussion

According to most economic studies and theories, spending on education has a positive impact on economic growth. Chang [27] believes that public funding for research and development is critical for long-term economic prosperity.

According to Mankiw et al. [28], economic growth and education are positively related. A study by Mushtaq and Khan [29] on Pakistan, which examines the Solow model of extended growth, it is suggests that secondary education contributes significantly to the real GDP per capita.

The study's findings reveal that increased government spending on education has a detrimental impact on Lebanon's economic growth, as seen in Table 3.

According to this table, the coefficient value for the variable $EDUCEXP^2$ is negative [$LEDUCEXP^2$ = -0.0466] and statistically significant at the 5% level, meaning it has an inverse relationship with economic growth. This result is consistent with broader concerns about the efficiency of public investment in education in the Middle East [2] and contradicts the fundamental Keynesian economic theory that increased government spending is significantly positively associated with economic growth.

5. Conclusion

This study employs a threshold regression analysis to examine the non-linear impact of public education spending on economic growth in Lebanon from 1993 to 2023. After confirming stationarity with the ADF and PP tests, an ARDL model was estimated. The data reveal a complex and significant relationship: initial increases in education spending have a favorable but statistically small effect, whereas beyond a certain threshold, additional spending exerts a considerable negative influence on economic growth. The coefficient for $LEDUCEXP^2$ is -0.466 (p-value 0.044), and the first lag is -0.035 (p-value 0.047), indicating a negative long-term effect.

This paradoxical outcome is consistent with economic literature, which suggests that simply increasing budgetary allocation is insufficient to promote growth [30]. The negative return is attributed to several institutional and qualitative failures prevalent in Lebanon, including:

- The mismatch between education outcomes and labor market requirements prevents the effective exploitation of increased human capital in the productive sectors of the economy [30].
- Ineffective spending: spending on education that is not directed toward areas that create economic growth, such as focusing on theoretical education at the expense of technical and vocational education [9].
- Quality of education: Increasing spending on education without improving quality and keeping pace with scientific developments may not lead to improved graduate skills and scientific research.
- The role of educational institutions: When the quality of institutions and their infrastructure is underdeveloped, the impact of spending on education on productivity declines [5].

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ISSN: 2576-8484
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- The widespread corruption in many government sectors, including education, makes any spending ineffective [5].

Based on these findings, the effectiveness of investing in education relies not on its quantity but on surpassing the minimum requirements while maintaining quality. To promote sustainable growth, the Lebanese government must continue investing in education and work to bridge existing gaps. For many years, the government has allocated large sums to education without achieving tangible results. The primary reason for this is the failure to address corruption and implement necessary reforms. Hence, the government must combat corruption in the education sector and enhance its performance to stay aligned with global standards. This involves upgrading curricula to fit the needs of the current economy and emphasizing improvements in technical and vocational education to bridge skills gaps and boost employment opportunities.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Acknowledgements:

The author extends his gratitude to Dr. Hanadi Taher at Beirut Arab University for her valuable insights and constructive comments during the development of this manuscript. I extend special thanks to the anonymous reviewers whose suggestions greatly improved the quality of this research paper. Any remaining errors are the authors' sole responsibility.

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Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 10: 1649-1658, 2025
DOI: 10.55214/2576-8484.v9i10.10728