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The Impact of Investment in Human Capital on Economic Growth in Algeria over the Period 2000–2022

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Abstract

This paper investigates the impact of investment in human capital on economic growth in Algeria over the period 2000–2022. The Autoregressive Distributed Lag (ARDL) bounds-testing approach is used to capture the short-run and long-run dynamic relationship between the share of government expenditure allocated to higher education and scientific research, the share of government expenditure allocated to basic education, and the growth rate of Gross Domestic Product (GDP). The empirical results reveal a statistically significant negative long-run relationship between government spending on higher education and scientific research and GDP growth, while no statistically significant long-run relationship is found between spending on basic education and GDP growth. The error-correction term is negative and highly significant, confirming that short-run deviations are corrected rapidly toward long-run equilibrium. The paper concludes that raising the efficiency — not merely the volume — of public education spending, and aligning it more closely with labour-market requirements, is essential for translating human-capital investment into measurable economic growth in Algeria.

Keywords: Investment in human capital; economic growth; Algeria; ARDL methodology.

1. Introduction

Investment in human capital is widely regarded as one of the most important drivers of sustained economic growth. The term “human capital” refers to the stock of skills, knowledge, and experience embodied in individuals, which raises their capacity for production and innovation (Becker, 1964; Schultz, 1961). Spending on education, training, and health can therefore be understood as an investment that builds these productive capacities in the same way that spending on machinery builds physical capital.

A large body of growth theory suggests that countries which invest more heavily in human capital tend to experience higher and more durable rates of economic growth, because a better-educated and healthier workforce is more productive, more innovative, and better able to adopt new technologies (Lucas, 1988; Romer, 1990; Mankiw et al., 1992). At the same time, realising these gains requires more than simply increasing expenditure: it requires a long-term strategic commitment, a policy environment that channels investment toward the skills the economy actually needs, and a labour market able to absorb and reward the resulting human capital (Psacharopoulos, 1994).

It is against this background that the present study asks the following central research question:

1.1 Research Problem

What is the impact of investment in human capital on economic growth in Algeria over the period 2000–2022?

1.2 Sub-questions

- What is the nature of the relationship between the share of government spending on higher education and scientific research and economic growth in Algeria?
- What is the nature of the relationship between the share of government spending on basic education and economic growth in Algeria?

1.3 Research Hypotheses

- H1: There is a positive and direct relationship between the share of government spending on higher education and scientific research and economic growth in Algeria over the study period.
- H2: There is a positive and direct relationship between the share of government spending on basic education and economic growth in Algeria over the study period.

1.4 Significance of the Study

- Testing the extent to which investment in human capital affects economic growth in Algeria;
- Estimating the direct dynamic relationship between human capital and economic growth in Algeria, distinguishing the short run from the long run.

1.5 Research Method and Tools

The study relies on a descriptive method for the literature review, drawing on books and peer-reviewed journal articles related to the topic. For the empirical part, the study uses EViews software and the Autoregressive Distributed Lag (ARDL) bounds-testing methodology to estimate the short- and long-run impact of human-capital spending on economic growth.

2. Literature Review

2.1 Human Capital: Concept and Theoretical Foundations

Human capital can be defined as the stock of knowledge, skills, competencies, and experience embodied in individuals that enables them to create economic value (Becker, 1964). Schultz (1961) was among the first economists to formalise the idea that expenditure on education and training is a form of investment rather than pure consumption, because it generates a stream of future returns — higher productivity and higher earnings — in exchange for a present cost. Becker (1962, 1964) subsequently developed a rigorous micro-economic theory of human-capital investment, distinguishing between general training, whose benefits are portable across employers, and firm-specific training, whose returns are captured mainly by the employing firm.

Investment in human capital can accordingly be defined as any expenditure — public or private — directed at developing individuals' knowledge, skills, and health, undertaken in the expectation that the resulting gains in productivity, creativity, and innovative capacity will exceed the initial cost (Becker, 1964; Mincer, 1974). At the macroeconomic level, this investment is important for at least three reasons. First, it raises workers' capacity to generate and adopt new ideas, expanding an economy's innovative capacity. Second, an economy with a large stock of well-trained human capital is better able to sustain a durable competitive advantage, because knowledge-based advantages are harder for competitors to imitate than advantages based on physical assets alone. Third, human-capital accumulation supports entrepreneurship and the diffusion of new technologies and working methods across firms and sectors (Psacharopoulos, 1994).

The determinants of human-capital investment are commonly organised around three complementary dimensions: (i) planning — identifying the skills a population or workforce will need and the means of providing them; (ii) development — building the educational and training institutions able to deliver the required knowledge and competencies; and (iii) employment — ensuring that labour markets can absorb and productively use the resulting stock of skills. When any one of these three dimensions is weak, the return on human-capital spending tends to fall, regardless of how much is spent (Baldacci et al., 2008).

The importance of human-capital investment is amplified in resource-dependent developing economies such as Algeria, where natural-resource revenues can, for a time, sustain growth without a commensurate improvement in the productive skills of the workforce. In such economies, human capital is often described as the principal channel through which a country can diversify its productive base away from dependence on a single export sector, because a more skilled and adaptable workforce is better placed to move into manufacturing, services, and knowledge-intensive activities as natural-resource revenues fluctuate (Baldacci et al., 2008). This makes the question of whether, and through which channel, human-capital spending actually translates into measurable growth — the empirical question at the heart of Section 3 of this paper — of particular policy relevance for Algeria specifically, rather than a purely academic exercise.

2.2 Forms and Measurement of Human Capital Investment

Human-capital investment is not confined to formal schooling; the literature generally identifies several complementary channels through which individuals and societies build human capital. The first and most studied channel is education — pre-school, basic, secondary, and higher education, together with vocational and technical training — which builds cognitive skills and occupation-specific competencies. The second channel is health: expenditure on nutrition, preventive care, and healthcare raises life expectancy and the number of productive years an individual can work, and is treated by Becker (1964) and Mincer (1974) as a full-fledged component of human capital in its own right rather than a mere welfare expense. The third channel is on-the-job and firm-based training, through which workers accumulate experience-based, often firm- or sector-specific, productive knowledge after they leave the formal education system. A fourth, frequently overlooked channel is labour mobility and information search — the resources individuals and firms spend moving to where their skills are better rewarded, or searching for the employment match that makes the best use of their existing human capital (Becker, 1964).

Because human capital is not directly observable, empirical researchers rely on a small number of proxy measures, each with well-known strengths and limitations. The cost-based approach measures human capital by cumulating past expenditure on education and health, on the logic that money spent on building human capital is analogous to money spent building physical capital; the budget-share variables used later in this paper's empirical model (PGHE and PGE) fall within this tradition. The income-based approach, associated with Mincer's (1974) earnings-function methodology, infers the stock of human capital from the wage premium that additional years of schooling or experience command in the labour market. The stock-based approach measures human capital directly through indicators such as average years of schooling, literacy rates, or school-enrolment ratios, and underlies large cross-country datasets such as that of Barro and Lee (2013), which several of the empirical studies reviewed in Section 2.6 use as an alternative to spending-based measures. Each approach captures a different facet of human capital — the resources invested in it, the return the market places on it, or its accumulated stock — and, as discussed in Section 2.8, the choice of proxy is itself one of the main reasons the empirical literature on Algeria has produced results that differ in sign and magnitude.

2.3 Economic Growth: Concept, Types, and Measurement

A further useful distinction, common in applied growth analysis, is between the sources of growth on the supply side of the economy: growth accounting typically decomposes output growth into the separate contributions of physical-capital accumulation, growth in the quantity of labour, growth in the quality of labour (i.e., human capital), and a residual usually interpreted as total factor productivity growth. This decomposition matters for the present study because it clarifies precisely which channel — the quality-of-labour channel — investment in human capital is theoretically expected to work through, as distinct from the physical-capital and raw-labour channels that are the focus of more traditional growth analysis.

Economic growth is generally defined as a sustained, continuous increase in an economy's real output over time (Solow, 1956). It is important to distinguish growth in aggregate output from growth in output per person: an increase in real GDP that is matched or exceeded by population growth does not raise average living standards, even though aggregate output has technically "grown" (Barro, 1991).

Two broad types of growth are usually distinguished in the literature. Extensive growth occurs when output expands at roughly the same rate as the population, so that income per capita remains essentially unchanged. Intensive growth occurs when output expands faster than the population, so that income per capita rises — this is the type of growth associated with rising living standards and structural transformation.

Economic growth is typically measured in two complementary ways: (a) the growth rate of national output (real GDP), usually expressed in a common international currency to allow cross-country comparison; and (b) the growth rate of income per capita, which better captures changes in individual material welfare because it relates output growth to demographic change (Barro & Lee, 2013).

2.4 The Evolution of Growth Theory: From Exogenous to Endogenous Models

Early classical economists such as Adam Smith and David Ricardo already recognised that the skill and dexterity of the labour force — what Smith called the "acquired and useful abilities" of a nation's inhabitants — contributed directly to a country's wealth, and Smith explicitly listed such abilities alongside land and physical capital as a component of the capital stock of a nation. However, classical economics lacked a formal mechanism linking the accumulation of these abilities to a sustained rate of growth, and it was not until the mid-twentieth century that growth theory was formalised mathematically enough to make this link precise.

Modern growth theory developed in three broad waves, and human capital moved from the margins to the centre of the analysis as the theory evolved. Classical economists treated growth mainly as the outcome of capital accumulation, labour, and land, with diminishing returns eventually bringing growth to a halt unless offset by technological improvement. The neoclassical growth model of Solow (1956) formalised this idea rigorously: with a fixed technology and diminishing returns to capital, an economy converges to a steady state in which further capital accumulation alone cannot sustain growth in output per worker, and only continuous, exogenously given technological progress can generate permanent growth in living standards.

The main limitation of the Solow framework is precisely this treatment of technological progress as exogenous — as a factor that falls, in effect, from outside the economic system rather than being explained by it. Empirically, this meant that a large share of observed growth differences across countries had to be attributed to an unexplained residual (total factor productivity), which economists could measure but not account for within the model itself. It was to close this gap that the endogenous-growth theories of the late 1980s and 1990s were developed, with human capital and knowledge accumulation playing the central explanatory role that exogenous technology had played in the Solow model.

2.5 The Theoretical Link between Human Capital and Economic Growth

The formal integration of human capital into growth theory dates to this endogenous-growth literature. Lucas (1988) modelled human-capital accumulation through schooling as an engine of sustained long-run growth: in his two-sector framework, individuals divide their time between producing current output and accumulating human capital, and the resulting stock of human capital generates external effects on the productivity of the whole economy that prevent the diminishing returns predicted by the Solow model. Romer (1990) placed human capital, rather than raw labour, at the centre of the innovation process: in his model, the stock of human capital employed in a dedicated research sector determines the flow of new ideas and designs, so that economies with a larger pool of skilled researchers innovate — and hence grow — faster. Aghion and Howitt (1992) extended this logic within a Schumpeterian framework of "creative destruction," in which skilled labour drives a continuous sequence of quality-improving innovations that displace older technologies, so that the pace of growth again depends on the economy's stock of research-capable human capital.

A complementary perspective, associated with Nelson and Phelps (1966), reframes the role of human capital away from the direct production of new knowledge and toward what is often called "absorptive capacity" or the catch-up hypothesis: in economies that are technologically behind the frontier, the principal growth pay-off from education is not that it generates brand-new innovations, but that it raises a country's ability to understand, adapt, and implement technologies and management practices already developed elsewhere. This perspective is particularly relevant for a developing, resource-dependent economy such as Algeria, where the immediate growth challenge is arguably less about generating frontier innovation than about building the human capital needed to absorb and diffuse existing technology across sectors. Barro (1990) added a further mechanism, showing that productive public expenditure — including expenditure on education — can itself be growth-enhancing when it is efficiently financed and allocated, directly motivating the empirical focus, in Section 3 below, on the composition of Algeria's public education budget rather than on its aggregate size alone. Mankiw, Romer and Weil (1992) then translated these insights into an empirically tractable framework by augmenting the standard Solow growth model with human capital, and found that doing so substantially improves the model's ability to explain cross-country differences in income levels, underscoring the centrality of education in explaining why some economies grow faster than others.

A separate strand of the literature has focused on estimating the private and social rates of return to education rather than on formal growth models. Psacharopoulos (1994) showed, using cross-country data, that returns to education are generally positive but vary considerably by level of education and by level of a country's development, which helps explain why the growth effect of education spending is not automatic and depends heavily on the composition and quality of that spending, not merely its volume. Building on this, Barro (1991) and later Barro and Lee (2013) documented, using large cross-country panels, that initial levels of human capital — measured through school enrolment and average years of schooling — are systematically associated with subsequent growth in per-capita income, even after controlling for the initial level of income itself, giving one of the most widely cited pieces of cross-country evidence that human capital is not merely correlated with growth but plausibly helps cause it.

Taken together, this body of theory yields a central, testable prediction: an increase in the human capital embodied in a country's workforce — whether generated through schooling, health, training, or absorptive capacity — should be associated with a higher sustainable rate of economic growth, both because it raises current productivity and because it strengthens an economy's capacity to generate or absorb new technology. Whether this theoretical prediction holds specifically for Algeria, and for which components of public education spending, is precisely the empirical question this paper investigates in Section 3.

2.6 Previous Empirical Studies

Before turning to the individual studies, it is worth noting why the developing-country literature is the most relevant comparison group for Algeria, rather than the cross-country studies of advanced economies discussed above. Advanced-economy studies such as Mankiw et al. (1992) and Barro (1991) typically rely on stock-based human-capital measures (average years of schooling) over long historical panels spanning several decades and dozens of countries, which is well suited to identifying broad cross-country regularities but says little about how a specific country's public-spending decisions translate into growth in a given period. Single-country ARDL studies such as those summarised below instead use annual, spending-based data over a policy-relevant time horizon, which is far closer in spirit, method, and data structure to the empirical strategy adopted in Section 3 of this paper.

A growing empirical literature has used the ARDL bounds-testing approach of Pesaran, Shin and Smith (2001) to estimate the short- and long-run impact of human-capital spending on economic growth in developing economies. Five closely related studies are summarised below.

- Issolah, Djemaci and Kertous (2021) examined the relationship between human development, education, health, and economic growth in Algeria over 1986–2017 using an ARDL model. They found a positive long-run relationship between primary and secondary school enrolment and economic growth, together with a negative long-run effect of health spending on growth.
- Bentoumi and Gaidi (2020) analysed the impact of human capital — proxied by mean years of schooling and life expectancy — on economic growth in Algeria over 1990–2018 using the ARDL bounds-testing approach. They reported a significant positive long-run relationship, with a one percent increase in mean years of schooling raising GDP by about 0.28 percent and a one percent increase in life expectancy raising GDP by about 3.36 percent.
- Ramli, Boutayeba and Nezai (2022) used an ARDL approach to assess the effect of public investment in human capital on economic growth in Algeria, highlighting that the short-run and long-run effects of education and health expenditure diverge, and that the efficiency of public spending matters as much as its level.
- Gautam (2022) applied the ARDL approach to Nepal and found that government education expenditure was inversely related to real GDP in the period studied, while health and social

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expenditure showed mixed short- and long-run effects, a result the author attributed to the long gestation period of human-capital investment.

- Wegari, Whakeshum and Mulatu (2023) used an ARDL bounds-testing model for Ethiopia (1980–2020) and found that, in the long run, gross capital formation and health-related human capital were the strongest contributors to real GDP growth, with education-related human capital exerting a smaller, though still positive, effect.

Table 1. Summary of the Five Previous Studies Reviewed

Study	Country / Period	Method	Key Finding
Issolah et al. (2021)	Algeria, 1986–2017	ARDL	Positive long-run effect of school enrolment; negative long-run effect of health spending
Bentoumi & Gaidi (2020)	Algeria, 1990–2018	ARDL bounds test	Positive long-run effect of schooling years and life expectancy on GDP
Ramli et al. (2022)	Algeria, n/a	ARDL	Short- and long-run effects of education/health spending diverge; efficiency matters
Gautam (2022)	Nepal	ARDL	Education spending inversely related to real GDP; mixed effects of health/social spending
Wegari et al. (2023)	Ethiopia, 1980–2020	ARDL bounds test	Capital formation and health human capital strongest contributors; education effect positive but smaller

Source: prepared by the authors based on the studies cited.

Reading these five studies side by side highlights two recurring patterns that motivate the present paper’s design. First, the ARDL bounds-testing approach is the dominant methodology in this strand of the literature precisely because it can handle the mixture of I(0) and I(1) series that human-capital and growth variables typically display, and because it estimates short- and long-run coefficients jointly rather than in two separate steps. Second, the sign of the estimated relationship between education spending and growth is far from uniform: it is positive in Bentoumi and Gaidi (2020) and Wegari et al. (2023), but negative or insignificant in Gautam (2022) and, for health spending specifically, in Issolah et al. (2021). This lack of consensus is not a weakness of the ARDL methodology itself but a reflection of genuine cross-country and cross-measure heterogeneity, which is precisely why a study focused specifically on Algeria, using a disaggregated and up-to-date specification, remains empirically warranted.

2.7 Conceptual Framework and Hypotheses Development

The theoretical discussion in Sections 2.1 to 2.5 can be distilled into a simple conceptual framework that links two policy-controlled inputs — the share of government spending on higher education and scientific research (PGHE) and the share of government spending on basic education (PGE) — to the outcome of interest, the rate of economic growth (PIB). Endogenous-growth theory, and in particular the Lucas (1988) and Romer (1990) frameworks, predicts that PGHE should raise growth mainly through its effect on the stock of research-capable human capital and hence on the pace of technology absorption and innovation, consistent with the Nelson and Phelps (1966) catch-up mechanism discussed above. Basic-education spending (PGE), by contrast, is expected by human-capital theory (Becker, 1964; Mincer, 1974) to raise growth mainly through its effect on the productivity of the general workforce, an effect that most of the theoretical and empirical literature — including Mankiw et al. (1992) — treats as operating with a longer transmission lag than the direct research-driven channel associated with higher education.

On this basis, the study's two hypotheses set out in Section 1.3 can be restated as direct empirical translations of the theory reviewed above: H1 tests the Lucas–Romer–Nelson-Phelps prediction that higher-education and research spending raises growth through innovation and absorptive capacity; H2 tests the Becker–Mincer prediction that basic-education spending raises growth through general workforce productivity. Testing both hypotheses within a single, disaggregated ARDL model — rather than testing a single aggregate "education spending" variable, as most of the previous studies summarised in Table 1 do — is what allows Section 3 to determine not simply whether human-capital spending matters for growth in Algeria, but specifically which category of spending matters, and over what time horizon.

2.8 Research Gap

Taken together, the existing literature confirms that the ARDL bounds-testing approach is well suited to modelling the dynamic relationship between human-capital spending and economic growth, and that results for developing economies — including Algeria — are frequently mixed, with education spending sometimes exerting a weak, insignificant, or even negative effect on growth in the short run. However, three gaps remain. First, the Algeria-specific studies available (Issolah et al., 2021; Bentoumi & Gaidi, 2020) end their coverage in 2017–2018 and therefore do not capture the post-2018 period, marked by a sharp fiscal consolidation following the decline in oil revenues, which plausibly changed the composition and efficiency of public education spending. Second, most existing studies — in Algeria and elsewhere — treat "education spending" as a single aggregate variable, without separating spending on higher education and scientific research from spending on basic education, even though these two categories differ substantially in their expected time horizon of return and their link to the labour market. Third, few studies combine both spending categories within a single ARDL model together with a full battery of post-estimation diagnostics (serial correlation, heteroskedasticity, normality, functional-form, and structural-stability tests), which is necessary to establish the robustness of the estimated relationship. The present study addresses these three gaps by extending the analysis to 2022, disaggregating public education expenditure into a higher-education/scientific-research component and a basic-education component, and subjecting the resulting ARDL model to a comprehensive diagnostic and stability-testing procedure.

3. Econometric Study: The Impact of Human Capital Investment on Economic Growth in Algeria (2000–2022)

This section presents the empirical analysis of the impact of investment in human capital on economic growth in Algeria over the period 2000–2022.

3.1 Study Variables and Data Sources

To analyse the impact of investment in human capital on economic growth in Algeria, the study relies on annual time-series data drawn from the World Bank database and Algeria's finance laws. Table 2 defines the study variables.

Table 2. Definition of the Study Variables

Variable	Variable Type	Series	Symbol
Investment in human capital	Independent	Share of government expenditure on higher education and scientific research	**PGHE**

	Independent	Share of government expenditure on basic education	**PGE**
Economic growth	Dependent	GDP growth rate	**PIB**

Source: prepared by the authors.

3.2 Unit Root Test (Augmented Dickey–Fuller Test)

To determine the order of integration of the model's variables, the Augmented Dickey–Fuller (ADF) unit-root test is applied to each series, as shown in Table 3.

Table 3. Unit Root Test Results

Stationarity Test		**PGHE**	**PGE**	**PIB**
Level I(0)				
With constant	t-Statistic	-4.0377	-3.7626	-3.2924
	Prob.	**0.0055 *****	**0.0102 ****	**0.0278 ****
With constant & trend	t-Statistic	-4.1220	-4.1714	-4.3229
	Prob.	**0.0192 ****	**0.0173 ****	**0.0127 ****
Without constant/trend	t-Statistic	0.6344	-0.5573	-1.0765
	Prob.	0.8457 (n0)	0.4636 (n0)	0.2454 (n0)
First difference I(1)				
With constant	t-Statistic	-4.1982	-7.6217	-7.3841
	Prob.	**0.0044 *****	**0.0000 *****	**0.0000 *****
With constant & trend	t-Statistic	-4.2066	-7.4553	-7.1916
	Prob.	**0.0177 ****	**0.0000 *****	**0.0000 *****
Without constant/trend	t-Statistic	-4.1924	-7.7929	-7.5760
	Prob.	**0.0003 *****	**0.0000 *****	**0.0000 *****

*Source: prepared by the authors based on EViews 10 output. *** significant at 1%; ** significant at 5%; n0 = not significant.*

The results in Table 3 show that the variables representing investment in human capital are stationary after first differencing, and that the series representing economic growth is likewise stationary at first difference at the 1% significance level. Since none of the series is integrated of order higher than one, and the orders of integration are mixed between I(0) and I(1), these results justify the use of the ARDL bounds-testing methodology.

3.3 The ARDL Methodology

The ARDL (Autoregressive Distributed Lag) approach was introduced by Pesaran, Shin and Smith (2001) as a means of estimating the cointegrating relationship between a dependent variable (Y) and a set of independent variables (X) in both the long run and the short run, according to the following general specification:

$$\Delta Y_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 Y_{t-1} + \sum_{i=0}^{k1} \beta_1 \Delta X_{t-i} + \sum_{i=1}^{k2} \beta_2 \Delta Y_{t-i} + e_t$$

Compared with other cointegration techniques, the ARDL approach offers three main advantages: it can be applied regardless of whether the underlying variables are integrated of order I(0), I(1), or a mixture of both, without requiring that all series share the same order of integration; it estimates the long-run and short-run parameters simultaneously within a single equation; and it corrects for residual autocorrelation, which makes the resulting estimates efficient and unbiased.

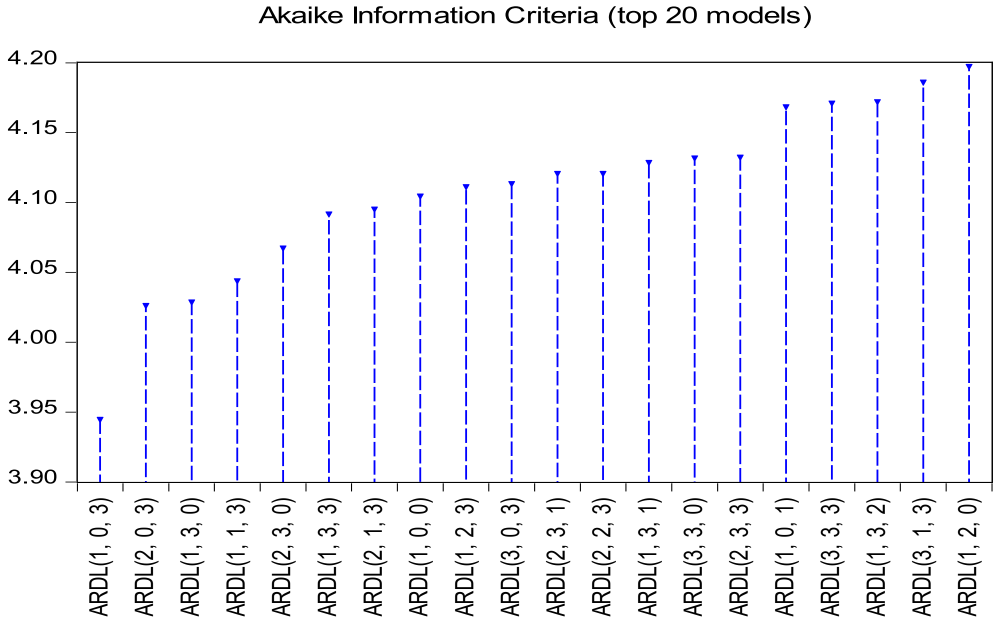
The main steps of the ARDL procedure are as follows:

- Test the stationarity of the time series to confirm that all variables are integrated of order I(0) or I(1);
- Determine the optimal lag length for each variable;
- Test for cointegration using the bounds test;
- Estimate the model in the long run and the short run;
- Conduct post-estimation diagnostic tests to assess the quality of the model.

3.4 Optimal Lag Selection

Before estimating the short- and long-run relationships, the optimal lag length for each variable must be identified using the Akaike Information Criterion (AIC). As shown in Figure 1, the optimal lag structure selected is (1, 0, 3), corresponding to the variables in sequence.

Figure 1. Optimal Lag Length According to the Akaike Criterion



Source: prepared by the authors based on EViews 10 output.

3.5 Cointegration Test: The Bounds Test

The bounds-testing procedure, based on the Fisher (F) statistic, is used to test for the existence of a long-run cointegrating relationship among the model's variables, as shown in Table 4.

Table 4. Bounds Test Results for Cointegration

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
F-statistic	**13.35395**	10%	2.63	3.35
k	2	5%	3.10	3.87
		2.5%	3.55	4.38
		1%	4.13	5.00

Source: prepared by the authors based on EViews 10 output.

The computed F-statistic (13.35395) exceeds the upper critical bound at the 1% significance level. This leads to a rejection of the null hypothesis (H_0) of no cointegration in favour of the alternative hypothesis (H_1), confirming the existence of a cointegrating relationship among the explanatory variables — that is, a long-run equilibrium relationship.

3.6 Short-Run Estimates: The Error-Correction Model

Having confirmed the existence of a long-run equilibrium relationship via the bounds test, the short-run parameters and the error-correction coefficient (ECM) are estimated, as reported in Table 5.

Table 5. Short-Run Error-Correction Model (ECM) Estimates

Variable	Coefficient	t-Statistic	Probability
D(PGE)	73.52578	3.163230	0.0075
D(PGE(-1))	71.54185	2.872081	0.0131
D(PGE(-2))	67.69396	3.158842	0.0075
CointEq(-1)*	**-1.422065**	-8.108178	**0.0000**

Source: prepared by the authors based on EViews 10 output.

The error-correction coefficient is negative (−1.42) and highly significant ($p = 0.0000$) at the 1% level. This confirms that short-run deviations from the long-run equilibrium path are automatically corrected over time, and that the adjustment toward long-run equilibrium is very rapid — in fact, the coefficient's absolute value exceeding one indicates an oscillatory but fast-converging adjustment process, meaning that any short-run shock to the growth rate is fully absorbed within a single period.

3.7 Long-Run Estimates

Table 6. Long-Run Parameter Estimates

Variable	Coefficient	t-Statistic	Probability
PGHE	-361.3221	-6.719172	**0.0000**
PGE	27.71991	0.838543	**0.4169**
C	21.40088	3.816580	0.0021

Source: prepared by the authors based on EViews 10 output.

The long-run estimates in Table 6 show the following:

- Government spending on higher education and scientific research (PGHE) has a statistically significant negative long-run relationship with GDP growth (coefficient = −361.32, $p < 0.05$). This result can be explained by a mismatch between the outputs of higher education and the needs of the Algerian labour market, and by the fact that higher-education policy has not been sufficiently aligned with the sectors capable of absorbing skilled graduates productively.
- Government spending on basic education (PGE) shows no statistically significant long-run relationship with GDP growth (coefficient = 27.72, $p = 0.4169 > 0.05$). This suggests that, over the period studied, the Algerian state has not relied primarily on the outputs of the basic-education sector as a direct lever for raising the rate of economic growth, which may reflect the long transmission lag between basic-education investment and its eventual labour-market payoff.

These findings are consistent with several of the studies reviewed in Section 2.6 (see also Table 1) — notably Gautam (2022) for Nepal, who likewise found an inverse short-run relationship between education spending and GDP, and are only partially consistent with Bentoumi and Gaidi (2020), whose Algeria-specific, schooling-years-based measure of human capital yielded a positive long-run effect. This divergence underlines the point raised in the research gap (Section 2.8): the sign and

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significance of the human-capital–growth relationship in Algeria appear to depend heavily on how human capital is measured (spending shares versus stock-based indicators such as mean years of schooling) and on the specific sub-period examined.

3.8 Diagnostic Tests

To assess the statistical quality of the estimated model, the following diagnostic tests are conducted: the Breusch–Godfrey serial-correlation LM test, the ARCH heteroskedasticity test, the Jarque–Bera normality test, and the Ramsey RESET functional-form test. Results are reported in Table 7.

Table 7. Diagnostic Tests of Model Quality

Test	Statistic	Value	Probability
Breusch–Godfrey Serial Correlation LM Test (H_0: no serial correlation)	F-statistic	0.088739	0.9157
	Obs*R-squared	0.317563	0.8532
ARCH Heteroskedasticity Test (H_0: homoskedasticity)	F-statistic	1.131998	0.3022
	Obs*R-squared	1.186188	0.2761
Jarque–Bera Normality Test (H_0: normal distribution)	Jarque-Bera	0.685485	0.709821
Ramsey RESET Test (H_0: model correctly specified)	t-statistic	1.718093	0.1114
	F-statistic	2.951843	0.1114

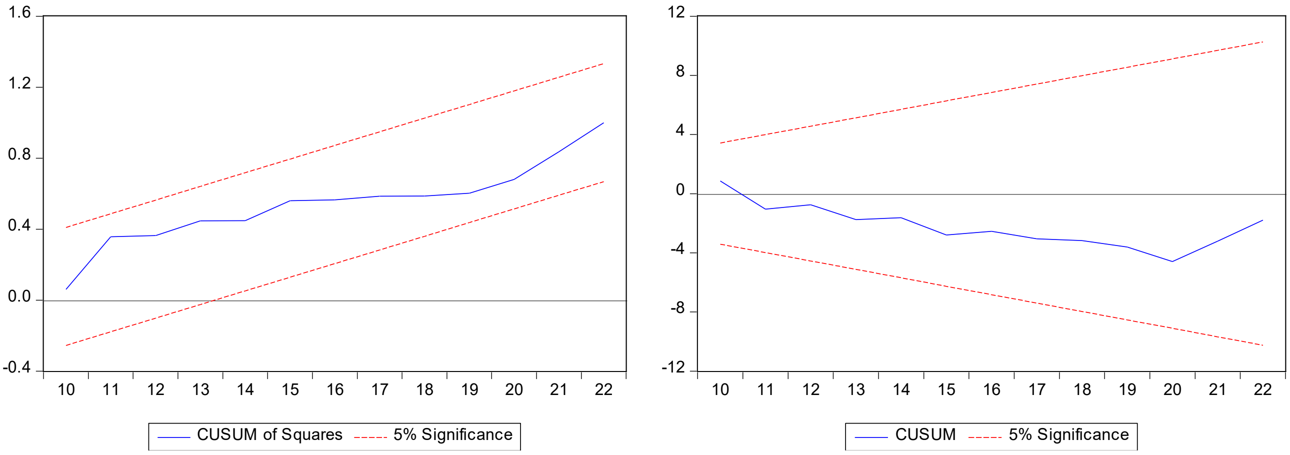
Source: prepared by the authors based on EViews 10 output.

All four diagnostic tests support the adequacy of the estimated model. The Breusch–Godfrey test probability (0.9157) is well above 5%, so the null hypothesis of no residual serial correlation cannot be rejected. The ARCH test probability (0.3022) likewise exceeds 5%, indicating homoskedastic residuals. The Jarque–Bera probability (0.709821) confirms that the residuals are normally distributed. Finally, the Ramsey RESET probability (0.1114) confirms that the model's functional form is correctly specified. Taken together, these results indicate that the estimated ARDL model is statistically well behaved and that its coefficients can be interpreted with confidence.

3.9 Structural Stability Test (CUSUM and CUSUMSQ)

To verify that the estimated model is free of structural breaks over the study period, the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests are applied.

Figure 2. CUSUM and CUSUMSQ Structural Stability Tests



Source: prepared by the authors based on EViews 10 output.

Both plots show the cumulative sum lines remaining within the 5% critical bounds throughout the study period, indicating that the model is structurally stable and that there is consistency between the short-run and long-run results. No evidence of structural change in the underlying data is detected over 2000–2022.

4. Conclusion

This paper examined the impact of investment in human capital on economic growth in Algeria over the period 2000–2022, focusing on government expenditure on higher education and scientific research, government expenditure on basic education, and the GDP growth rate, using the ARDL bounds-testing methodology. The empirical analysis found a statistically significant negative long-run relationship between the share of government spending on higher education and scientific research and GDP growth over the period studied, while no statistically significant long-run relationship was found between the share of government spending on basic education and GDP growth. The error-correction coefficient was negative, large, and highly significant, confirming rapid short-run adjustment toward long-run equilibrium, and the full battery of diagnostic and stability tests confirmed that the estimated model is statistically robust.

By extending the study period beyond the coverage of earlier Algeria-focused ARDL studies and by disaggregating public education spending into its higher-education/research and basic-education components, this paper also helps to explain why the existing literature on Algeria has produced mixed results: the sign and strength of the human-capital–growth relationship appear to depend on both the specific measure of human capital used and the sub-period examined, with the post-2018 fiscal-consolidation years plausibly reinforcing the negative long-run effect of higher-education spending identified here.

5. Recommendations

- Reform the education system away from rote-based, traditional approaches toward a modern, open curriculum that fosters critical and independent thinking and produces self-directed learners capable of generating knowledge through inquiry and discussion rather than memorisation alone.
- Strengthen the links between higher-education specialisations and economic institutions, so that the economy is supplied with the human capital it actually needs — thereby raising productivity and boosting GDP growth.
- Consider strategies that raise the labour-market returns to university graduates, as a means of lifting the economic growth rate.
- Prioritise the quality of education and training over physical infrastructure, buildings, and enrolment numbers alone.
- Encourage international cooperation and the exchange of experience in human-resource development, and draw on the experience of countries that have successfully linked education policy to economic growth.
- Treat developmental policy as an integrated whole: sustained prosperity requires not only the traditional factors of growth, but a coherent framework combining economic policy, education policy, demographic policy, and public-awareness policy.

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